Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Case Report

Evidence-based case report: effects of exercise-based cardiac rehabilitation in repaired tetralogy of Fallot

Muhamad Elfitra Salam[1], Bima Lesmana Putra[2]

[1] Department of Physiology, Master of Biomedical Sciences, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2] Physiotherapy Study Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia

ABSTRACT

Background: *Several sequelae may persist following corrective surgery for tetralogy of Fallot (ToF), including reduced exercise capacity, compromised vascular and cardiac autonomic function, and diminished quality of life. While exercise-based cardiac rehabilitation is commonly implemented for patients with congenital heart disease, there remains a lack of comprehensive understanding regarding the optimal frequency, intensity, duration, and type of exercise. This evidence-based case report aims to evaluate the effectiveness of physical exercise on exercise capacity and quality of life in patients who have undergone ToF repair.*
Method: *A literature search was conducted in PubMed, Cochrane, and Google Scholar databases in September to December 2024 using keywords "exercise," "cardiac rehabilitation," and "tetralogy of Fallot." Studies were included if they involved human subjects with tetralogy of Fallot, were published in English within the past fifteen years, and provided primary data. Studies were excluded if they were duplicates, had unavailable full texts, were research protocols, or review articles.*
Results: *Six articles met the established inclusion and exclusion criteria. Data extraction revealed that various studies consistently demonstrated significant improvements ($p<0.05$) in peak oxygen uptake (VO_2 peak) and quality of life (QoL), particularly in the mental and social domains.*
Conclusion: *Exercise-based cardiac rehabilitation can be beneficial for patients post-ToF repair. However, it is essential to consider factors such as the duration since corrective surgery, the appropriate dosage of exercise, and the specific types of exercise prescribed.*

ARTICLE HISTORY
Received :18 April 2025
Revised :12 May 2025
Accepted : 9 June 2025
Avaliable Online : 10 August, 2025
Published : 25 August 2025

KEYWORDS
Exercise-based Cardiac Rehabilitation, Exercise Capacity, Quality of Life, Repaired ToF, Tetralogy of Fallot

CONTACT

Muhamad Elfitra Salam
elfitrasalam2@gmail.com
Department of Physiology, Master of Biomedical Sciences, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

Cite this as: Salam, M. E., & Putra, B. L. (2025). Evidence-based case report: effects of exercise-based cardiac rehabilitation in repaired tetralogy of Fallot. *Gaster*, *23*(2). https://doi.org/10.30787/gaster.v23i2.1878

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

INTRODUCTION

Tetralogy of Fallot (ToF) represents the most prevalent cyanotic congenital cardiac malformation, comprising 5% to 7% of all congenital heart defects. This complex condition impacts blood oxygenation and poses unique challenges in pediatric cardiology (Horenstein et al., 2024). The cardinal features of ToF consist of four anatomical abnormalities: ventricular septal defect (VSD), right ventricular outflow tract obstruction (RVOTO), overriding aorta, and right ventricular hypertrophy. Patients with ToF typically undergo complete corrective surgery before the age of six months to prevent further complications. The surgical management encompasses multiple procedures: patching the VSD, separating the aorta from the left ventricle, removing obstructive muscle tissue from the right ventricular outflow tract, and addressing pulmonary valve stenosis (Miller et al., 2023; Wilson et al., 2019).

Following corrective surgery, ToF patients can generally lead relatively everyday lives (Novaković et al., 2018). The surgical management of ToF has demonstrated remarkable progress, with studies reporting a 91% survival rate at 30-year follow-up for both corrective surgery and palliative shunt procedures (Varkoly et al., 2024). However, certain sequelae might persist in some patients, including reduced exercise capacity and impaired vascular and cardiac autonomic function, which can limit participation in physical activities (Novaković et al., 2018). Exercise capacity, defined as the maximum amount of physical exertion an individual can sustain, in this population averages around 70-85% of that seen in the general population and tends to decline with age (Ávila et al., 2016; Gong et al., 2021). Additionally, patients with repaired ToF exhibit impaired pulmonary function and reduced respiratory muscle strength, which contributes to their compromised exercise capacity (Gong et al., 2021; Powell et al., 2019). These physical limitations significantly impact the quality of life for individuals with ToF, affecting their physical, social, mental health, and emotional well-being in daily activities (Simeone et al., 2022). A nationwide study in Taiwan revealed that patients with ToF have a nearly 3-fold higher risk of psychiatric disorders, specifically increased risk for anxiety, depression, bipolar, and sleep disorders (Hsu et al., 2021).

Exercise-based cardiac rehabilitation, a coordinated program of structured exercise training, is widely implemented among patients with congenital heart disease and has been shown to enhance exercise capacity, alleviate symptoms, and improve overall quality of life (Gong et al., 2021; Guo et al., 2024). Moderate aerobic exercise promotes improved myocardial contraction and relaxation, enhances blood circulation and coronary blood flow, and increases cardiac functional capacity. Consequently, physical exercise is highly recommended for patients with congenital heart disease, including those who have undergone ToF repair (Novaković et al., 2018; Siraj et al., 2021). However, its implementation remains limited due to concerns about potential adverse effects on heart health, protective attitudes from parents, and insufficient encouragement from healthcare providers (Gong et al., 2021; Novaković et al., 2018). This situation often leads to a sedentary lifestyle among individuals post-ToF repair, which poses additional risks such as increased likelihood of diabetes, hypertension, and obesity; thus, addressing these barriers is crucial (Ávila et al., 2016).

A recent meta-analysis encompassing children, adolescents, and adults with ToF revealed that pulmonary training led to a significant improvement in peak oxygen uptake (VO_2 peak) (Schuermans et al., 2023). Separately, studies have also shown that training programs can improve mental health outcomes, which is particularly relevant for ToF patients who disproportionately experience from anxiety, depression, and medical post-

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

traumatic stress disorder (Deng et al., 2016; Novaković et al., 2018). Despite the documented benefits of physical exercise for ToF patients, there remains a need for comprehensive understanding regarding the optimal frequency, intensity, duration, and type of exercise necessary to enhance exercise capacity and quality of life in this population (Dulfer et al., 2014; Novaković et al., 2018). This evidence-based case report aims to evaluate the effectiveness of physical exercise on exercise capacity and quality of life in patients following ToF repair, employing a structured article selection process flow chart to ensure methodological rigor.

CASE ILLUSTRATION

A 17-year-old male patient was admitted to RSUP Dr. Kariadi on May 5, 2024, presenting with complaints of shortness of breath and fatigue that had persisted for the past year. These symptoms worsened during physical activities, particularly while playing football. The patient had a history of congenital heart disease in the form of ToF since birth, which was diagnosed at three months of age. Due to personal circumstances, the patient did not undergo the necessary surgical intervention at that time. Clinical examination revealed a diagnosis of ToF with New York Heart Association (NYHA) class II heart failure. Subsequently, the patient underwent complete corrective surgery for ToF on May 7, 2024. Following the surgery, a transthoracic echocardiogram (TTE) was performed on May 8, 2024, which indicated: (a) minimal pericardial effusion; (b) normal inferior vena cava (IVC) collapsibility with a measurement of 20/13; and (c) a poor echocardiographic window. An X-ray taken on May 12, 2024, suggested cardiomegaly and bronchopneumonia. The patient received medical therapy that included framycetin sulfate tulle 1%, paracetamol tablets (500 mg), amoxicillin tablets (500 mg), captopril tablets (12.5 mg), and furosemide tablets (40 mg). Following this, the patient was referred to a physiotherapy clinic for rehabilitation and recovery support.

The patient visited the physiotherapy clinic on May 23, 2024, where his vital signs were relatively normal. Upon examination, he appeared weak with an incision wound on his sternum. His breathing pattern was thoracoabdominal, and he demonstrated the ability to move his upper extremities independently. Palpation and percussion examinations revealed no abnormalities, with bronchovesicular lung sounds and normal heart sounds present. Functional ability was assessed using the Barthel index, yielding a score of 15, indicating mild dependence in daily activities. Additionally, the shortness of breath scale measured using the Borg scale resulted in a score of 11, suggesting that while the patient could speak, he felt as if he were running. Physiotherapists provided active range-of-motion exercises and respiratory training; however, no specific interventions were implemented to enhance the patient's exercise capacity. This lack of targeted intervention is concerning, given the patient's interest in playing football. Consequently, a clinical question arises: can physical exercise improve exercise capacity and quality of life in patients who have undergone repair for Tetralogy of Fallot?

METHOD

A comprehensive literature search was conducted in September to December 2024 to address clinical questions. The search utilized online databases, including PubMed, Cochrane, and Google Scholar. Keywords used were "exercise," "cardiac rehabilitation," and "Tetralogy of Fallot" (detailed in Table 1).

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

The selection process for relevant articles and study participants involved specific criteria. For the literature search, inclusion criteria were studies involving human subjects diagnosed with ToF, articles published in English, publications within the past fifteen years, and primary data. Exclusion criteria comprised duplicate articles, unavailable full-text articles, research protocols, or review articles. For the case selection, inclusion criteria encompassed patients with repaired ToF who were clinically stable, and had no contraindications to exercise. Exclusion criteria included patients with unstable cardiac conditions, or other medical conditions that would preclude safe participation in exercise training. The literature selection is illustrated in Figure 1, which depicts the systematic approach used to identify and screen relevant studies for this research. This research does not require Institutional Review Board (IRB) approval as it solely utilizes publicly available data and does not involve human subjects or any primary data collection.

Table 1. Article search strategies using databases

Databases	Keywords	Articles Retrieved	Articles Included
PubMed	(("Exercise"[MeSH Terms] OR "Exercise Therapy"[MeSH Terms] OR "Physical Therapy Modalities"[MeSH Terms] OR "Physiotherapy"[All Fields] OR "Aerobic Training"[All Fields] OR "Cardiac Rehabilitation"[All Fields]) AND ("Tetralogy of Fallot"[MeSH Terms] OR "ToF"[All Fields])) AND (humans[Filter] AND 2010:2025[pdat] AND english[Filter])	15	4
Cochrane	Exercise OR Cardiac Rehabilitation OR Physiotherapy OR Physiotherapy Modalities AND Tetralogy of Fallot OR ToF	2	0
Google Scholar	Exercise OR Aerobic Training OR Physiotherapy OR Physiotherapy Modalities OR Cardiac Rehabilitation AND Tetralogy of Fallot or ToF	108	2

RESULTS

A total of 125 articles were identified through the literature search across various databases. After applying the inclusion and exclusion criteria, six articles were deemed relevant and included in this evidence-based case report to address the clinical question. Data extraction revealed that three articles employed randomized controlled trial designs, two used randomized non-blinded clinical trial designs, and one was a case study. All studies included patients with repaired ToF across various age groups, ranging from pediatric to adult populations (8 to ≥18 years). Siraj et al. (2021) reported on a 13-year-old male patient in India, while Hock et al. (2020) included patients aged 8-25 years from Munich. Novaković et al. (2017) and Ávila et al. (2016) focused on adult populations in Slovenia and Canada respectively. Duppen et al. (2015) and Dulfer et al. (2014) studied patients aged 10-25 years in the Netherlands. Some of the patients still maintained active lifestyles, including school attendance and participation in outdoor activities.

Several important confounders were identified across the studies. Demographic confounders included gender distribution, with most studies reporting a male predominance, and varying age ranges. Clinical confounders encompassed BMI

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

(averaging 24.8-25.1), age at surgical correction (ranging from 11.7 months to 30 months), types of surgical correction (with approximately 50% receiving transvalvular correction), and medication use (particularly beta-blockers and antithrombotic drugs). Additional confounding factors included the presence of restrictive lung function, prior palliative shunts, and permanent pacemaker use in some patients.

Study participation varied across the research. Hock et al. (2020) started with 75 recruited subjects, of whom 60 met eligibility criteria and completed the study using intention-to-treat analysis. Novaković et al. (2017) enrolled 30 patients, with 27 completing the study under per-protocol analysis. Ávila et al. (2016) maintained all 17 initial patients throughout the study. Duppen et al. (2015) and Dulfer et al. (2014) began with 93 eligible patients and concluded with 90 patients. Siraj et al. (2021) presented from a single case. These patients underwent various interventions, including aerobic exercise, respiratory training, range-of-motion (ROM) exercises, thoracic expansion exercises, or in-bed mobilization, and evaluated with outcomes related to exercise capacity, quality of life, or a combination of both. Table 2 provides a detailed summary of the data extracted from each article. The levels of evidence were classified according to the Oxford Centre for Evidence-Based Medicine guidelines.

DISCUSSION

Exercise-based cardiac rehabilitation is increasingly recognized as a crucial component in the care of patients who have undergone repair for ToF (Gong et al., 2021; Hock et al., 2022; Novaković et al., 2018). This approach addresses various challenges faced by these patients, including reduced exercise capacity and quality of life compared to healthy populations (Ávila et al., 2016; Gong et al., 2021). Even after corrective surgery, residual pulmonary valve stenosis, chronic right ventricular volume overload, and scar tissue can lead to a sedentary lifestyle and deconditioning in ToF patients (Hock et al., 2022; Yoo & Park, 2013). Implementing structured exercise programs for cardiac rehabilitation can mitigate these sequelae, improving aerobic capacity, cardiovascular and pulmonary health, and overall well-being in patients with repaired ToF (Buchanan et al., 2023; Deng et al., 2016).

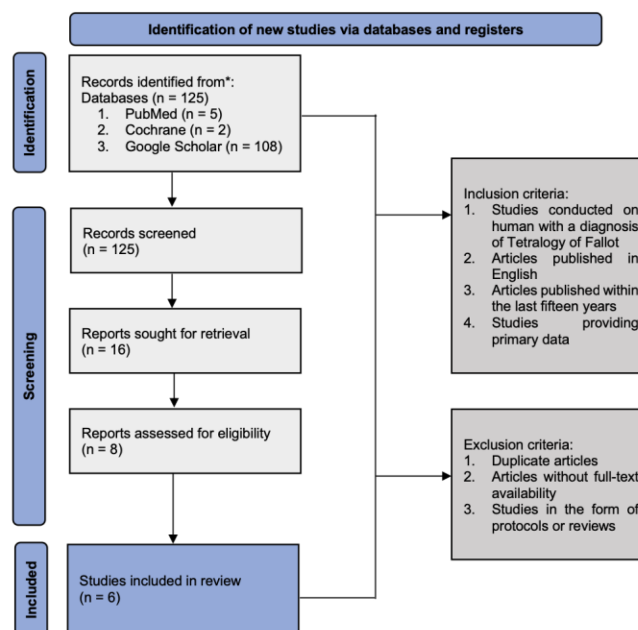


Figure 1. Flow chart of article selection process

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Data extraction from various studies consistently demonstrates significant increases in peak oxygen uptake (VO_2 peak), a crucial parameter of cardiorespiratory fitness. Duppen et al. (2015) reported a 5.0% increase in VO_2 peak ($p=0.011$) after dynamic aerobic exercise compared to minimal changes in the control group. Ávila et al. (2016) noted an 11% increase in VO_2 peak ($p=0.028$), metabolic equivalents (METs) (11%, $p=0.027$), and exercise duration (8%) in the intervention group. Similarly, Novaković et al. (2017) found that interval training significantly increased VO_2 peak, with improved mean predicted workload percentage and METs in the intervention group ($p<0.05$). Improvements were also observed in lung function parameters. Hock et al. (2020) reported significant differences in forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) ($p<0.05$) between intervention and control groups, with the intervention group showing better spirometry results after respiratory training. These findings align with previous research indicating that continuous exercise can improve VO_2 peak and lung function in patients with congenital heart disease (Duppen et al., 2015; Elliott et al., 2015).

The improvement in exercise capacity is underpinned by physiological mechanisms involving cardiovascular, peripheral vascular, and autonomic nervous system adaptations (Drakopoulou et al., 2025). Physical activity induces hemodynamic changes through increased oxygen demand and cellular metabolism, mediating improvements in cardiac output, myocardial contractility, cardiomyocyte contraction-relaxation velocities, preload volume, and reduced ventricular afterload (Drakopoulou et al., 2025; Nystoriak & Bhatnagar, 2018). This is particularly important for patients with congenital heart disease, as right ventricular dysfunction and fibrosis can limit optimal stroke volume (Nystoriak & Bhatnagar, 2018). Regular physical exercise also enhances vascular compliance and decreases total peripheral resistance through the release of metabolites such as nitric oxide, thereby improving tissue oxygenation (Drakopoulou et al., 2025; Novaković et al., 2018). Lopez et al. (2020) demonstrated that physical activity measured by accelerometry was significantly related ($r= -0.226$, $p=0.021$) to aortic stiffness in children with congenital heart disease. Additionally, physical exercise can improve the balance between sympathetic and parasympathetic activity, heart rate variability (HRV), and stabilize heart rate (Gong et al., 2021). Increased HRV and stable heart rate values have been significantly correlated with VO_2 peak values in patients with repaired ToF and Fontan circulation (Okólska et al., 2021).

Exercise-based cardiac rehabilitation not only enhances exercise capacity but also improves quality of life, particularly in mental and social domains. Novaković et al. (2017) reported significant improvements in mental health scores ($p=0.028$) after continuous training. Similarly, Dulfer et al. (2014) noted significant improvements in motor, cognitive, and social functions in ToF patients undergoing dynamic aerobic exercise. A case study by Siraj et al. (2021) further demonstrated that cardiac rehabilitation programs can reduce pain scales and limitations in daily activities. Regular physical exercise has been proven to reduce anxiety and depression while improving self-efficacy in patients with congenital heart disease (Bay et al., 2018).

Regarding safe physical activity dosage for patients with repaired ToF, various studies suggest that, in the absence of relevant contraindications, physical activity can be adjusted to match that of the general population. For instance, the Canadian 24-Hour Movement Guidelines recommend that adults with repaired ToF engage in at least 150 minutes of moderate-to-vigorous physical activity and 2 muscle strengthening activities per week (Buchanan et al., 2023). Similarly, the World Health Organization recommends at least 60 minutes of moderate physical activity daily for children and adolescents aged

e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

5-17 years and 150-300 minutes of moderate physical activity weekly for adults (Bull et al., 2020). The majority of studies in this evidence-based case report are within these dosage recommendations.

The patient, in this case, underwent ToF repair less than a year ago and presents with suspected cardiomegaly and bronchopneumonia. Most studies include patients who had ToF corrective surgery before the age of 2 years as a criterion for aerobic exercise, suggesting that more substantial evidence is needed to apply aerobic exercise in this particular case. However, respiratory training could be considered, as relevant studies did not include such specific inclusion criteria.

This evidence-based case report has several limitations. First, this study focuses on a single patient and while the findings can serve as a valuable reference, it may not fully represent all patients with repaired ToF. Second, there is limited high-quality research on exercise-based in congenital heart disease, particularly in patients with repaired ToF. Finally, the use of varying assessment tools across studies makes it difficult to standardize measurements of exercise capacity and quality of life, despite VO_2 peak being a commonly used metric for assessing exercise capacity.

Regarding selection bias, several studies were excluded because they did not directly measure VO2 peak and quality of life parameters, which could potentially limit the scope of the findings. Concerning risk of bias, the quality of included studies varied, which might have influenced the results. As an EBCR, the focus was on synthesizing evidence relevant to the specific clinical case rather than conducting a comprehensive risk assessment across multiple studies. Despite these limitations, this report provides valuable insights into the potential benefits of exercise-based cardiac rehabilitation for patients with repaired ToF.

CONCLUSION

Based on data extraction along with the discussion, it can be concluded that exercise-based cardiac rehabilitation demonstrates significant benefits in improving both exercise capacity and quality of life for patients with repaired ToF. However, its clinical implementation requires careful consideration of factors such as the duration since corrective surgery, the appropriate dosage of exercise, and the specific types of exercise prescribed.

ACKNOWLEDGEMENT

This evidence-based case report is supported by the Department of Physiology, Master of Biomedical Sciences, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Physiotherapy Study Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, and Indonesia Endowment Fund of Education (LPDP) under Ministry of Finance Republic of Indonesia (Kemenkeu RI). The authors state there is no conflict of interest with the parties involved in this study.

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Table 2. Data extraction for relevant literature sources

Authors	Levels of Evidence	Population	Intervention	Dose of Exercise	Results
Siraj *et al*. 2021	4	A case study of a 13-year-old male patient post-intracardiac repair for Tetralogy of Fallot, presenting with pain at the incision site, severe coughing, shortness of breath, general fatigue, and was classified as NYHA grade 3.	1. Pre-operative: Incentive spiro-metry, segmental breathing, thoracic expansion exercise. 2. Post-operative: In-bed mobilization, relaxation exercises, ROM exercises for all upper and lower extremity joints (with flexion not exceeding 90 degrees and shoulder elevation), core and scapular strengthening exercises	F: 2-4 times/day I: according to the patient's tolerance T: 5-10 mins/day	1. There was a reduction in pain scale upon discharge from the hospital, with a Visual Analog Scale (VAS) score of 2/10 during daily activities involving the upper extremities. 2. Changes were observed BP, HR, RR, and SpO2 values throughout the treatment. 3. The patient was able to perform activities with minimal limitations.
Hock *et al*. 2020	2b	A randomized, non-blinded clinical trial was conducted on 60 subjects, aged 8 to 25, who had undergone repair for ToF. Exclusion criteria included obstructive pulmonary disorders, medication use within the last three months, heart surgery within the past 12 months, NYHA grade 5, arrhythmias, and acute pulmonary infections. Subjects were randomly assigned to the intervention and control groups.	1. Intervention group: Subjects received volume-oriented inspiratory respiratory training using the Coach2 Incentive Spirometer. Training commenced at an intensity of 40% of forced vital capacity (FVC), consisting of one to three sets with 10-30 repetitions over one to two weeks. 2. Control group: Subjects began respiratory training after a follow-up period of six months and were reassessed six months later.	F: 7 times/week or daily I: based on each subject's FVC T: 5-10 mins	1. The intervention group showed a significantly greater increase in VO_2 peak compared to the control group (IG: 0.5±0.6 vs -2.1±0.9; p=0.011). 2. There were significant differences ($p<0.05$) in spirometry measure-ments for FVC and FEV1 between the intervention and control groups. 3. Daily respiratory training in patients with repaired ToF improved dynamic lung volumes as well as exercise capacity.

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

CC BY SA · OPEN ACCESS

Novaković *et al*. 2017	1a	A randomized controlled trial involving 30 subjects aged 18 years or older with repaired Tetralogy of Fallot was conducted at the outpatient clinic of the University Medical Centre Ljubljana. Exclusion criteria included atherosclerosis, unstable cardiovascular conditions (within the last three months), poorly controlled dysrhythmias, permanent atrial fibrillation, and pregnancy. Subjects were randomized into three groups: interval training, continuous training, and a control group.	1. Interval training: this regimen included 5 minutes of warm-up and 5 minutes of cool-down at 50% HRpeak. The main workout consisted of 8 cycles, each comprising 1 minute of exercise at 80% HRpeak followed by 3 minutes at 60% HRpeak. 2. Continuous training: this protocol involved 8 minutes of warm-up and 7 minutes of cool-down at 50% HRpeak. The main exercise was performed at an intensity of 70% HRpeak for 26 minutes. After the 12th and 24th weeks, both training groups exhibited a 5% increase in HRpeak.	F: 2-3 times/week I: based on each subject's HRpeak T: 42 mins	1. Both intervention groups demonstrated a significant improvement in exercise capacity ($p<0.05$), as indicated by changes in mean percentage predicted workload and METs. In contrast, no significant changes were observed in the control group. 2. Interval training significantly increased VO_2 peak ($p=0.004$). 3. Continuous training led to a significant improvement in mental health scores within the HRQoL assessment ($p=0.028$). Meanwhile, neither interval training nor the control group showed improvements in physical or mental domains ($p>0.05$).
Ávila *et al*. 2016	2b	A randomized open-label trial involving 17 subjects aged 18 years or older with repaired Tetralogy of Fallot. Exclusion criteria included contra-indications to exercise, sustained ventricular arrhythmias, and NYHA functional classes III or V. Subjects were randomly assigned to either an exercise group or a control group.	1. Exercise group: Subjects in this group engaged in moderate aerobic exercise, which consisted of warm-up including calisthenics and stretching, followed by combined dynamic resistance training, and a cool-down period over the course of 12 weeks. 2. All subjects were encouraged to perform physical activity for a minimum of 30 minutes, three days per week.	F: 1-2 times/ week I: 70-80% of maximum HR T: 1 hour (10 mins warm-up, 30-40 mins main exer-cises, 10 mins for cool-down)	1. Moderate aerobic exercise significantly improved VO_2 peak (11±19%, $p=0.028$), metabolic equivalents (11±18%, $p=0.027$), and exercise duration (8±10%, $p=0.009$) in the exercise group, while no such changes were observed in the control group. 2. There was a significant difference ($p<0.05$) in the exercise duration component between the exercise group and the control group.

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Duppen *et al*. 2015	1a	A randomized controlled trial involving 91 subjects aged 10 to 25 years with repaired ToF or Fontan circulation was conducted. Exclusion criteria included ventricular outflow tract obstruction >60 mmHg and contraindications for MRI. Subjects were randomly allocated to either an exercise group or a control group.	1. Subjects in exercise group underwent a standardized 12-week dynamic aerobic exercise program. The control group received no intervention. 2. Two weeks before and after the exercise period, all subjects underwent cardiopulmonary fitness tests to determine baseline values and HRR.	F: 3 times/ week I: resting HR + 60-70% HRR T: 1 hour (10 mins warm-up, 40 mins aerobic training, and 10 mins cool-down)	1. Dynamic aerobic exercise increased VO_2 peak by 5.0% ($p=0.011$) in the exercise group, while the control group showed no improvement in VO_2 peak. 2. There was no statistically significant difference ($p>0.05$) in VO_2 peak values between the exercise and control groups. 3. Dynamic aerobic exercise had a more significant effect ($p<0.05$) on peak work rate (Wpeak) and peak minute ventilation (VEpeak) compared to the control group.
Dulfer *et al*. 2014	1a	A randomized controlled trial involving 91 subjects aged 10 to 25 years with repaired ToF or Fontan circulation was conducted across five pediatric cardiology centers in the Netherlands. Exclusion criteria included contra-indications to exercise, MRI, mental retardation, and ventricular outflow obstruct-tion >60 mmHg. Subjects were randomly allocated to either an exercise group or a control group.	1. Subjects in exercise group underwent a standardized 12-week dynamic aerobic exercise program. The aerobic exercises included brisk walking, jogging, running, bicycle exercise, and dynamic play. The control group received no intervention. 2. Prior to the exercise period, subjects underwent an ergometer test to determine their HRR.	F: 2-3 times/ week I: resting HR + 60-70% HRR T: 1 hour (10 mins warm-up, 40 mins aerobic training, and 10 mins cool-down)	1. In subjects aged 10-15 years, aerobic exercise significantly affected ($p<0.05$) motor aspects on the TACQOL-CF and social function on the TACQOL-PF. 2. Aerobic exercise also significantly improved ($p<0.05$) cognitive function aspects on TACQOL-CF and social function on TACQOL-PF compared to the control group. 3. For subjects over 15 years, aerobic exercise led to significant improvements ($p<0.05$) in social function aspects on the SF-36 and cardiac surveillance on the TAAQOL compared to the control.

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

REFERENCES

Ávila, P., Marcotte, F., Dore, A., Mercier, L.-A., Shohoudi, A., Mongeon, F.-P., Mondésert, B., Proietti, A., Ibrahim, R., Asgar, A., Poirier, N., & Khairy, P. (2016). The impact of exercise on ventricular arrhythmias in adults with tetralogy of Fallot. *International Journal of Cardiology*, *219*, 218–224. https://doi.org/10.1016/j.ijcard.2016.06.011

Bay, A., Sandberg, C., Thilén, U., Wadell, K., & Johansson, B. (2018). Exercise self-efficacy in adults with congenital heart disease. *IJC Heart & Vasculature*, *18*, 7–11. https://doi.org/10.1016/j.ijcha.2017.12.002

Buchanan, M., Spence, C., Keir, M., & Khoury, M. (2023). Physical activity promotion among individuals with tetralogy of Fallot. *CJC Pediatric and Congenital Heart Disease*, *2*(6), 322–334. https://doi.org/10.1016/j.cjcpc.2023.08.002

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Deng, L. X., Khan, A. M., Drajpuch, D., Fuller, S., Ludmir, J., Mascio, C. E., Partington, S. L., Qadeer, A., Tobin, L., Kovacs, A. H., & Kim, Y. Y. (2016). Prevalence and correlates of post-traumatic stress disorder in adults with congenital heart disease. *The American Journal of Cardiology*, *117*(5), 853–857. https://doi.org/10.1016/j.amjcard.2015.11.065

Drakopoulou, M., Vlachakis, P. K., Apostolos, A., Tsioufis, K., & Toutouzas, K. (2025). How does regular exercise improve cardiovascular function: congenital heart disease and beyond. *International Journal of Cardiology Congenital Heart Disease*, *19*, 100542. https://doi.org/10.1016/j.ijcchd.2024.100542

Dulfer, K., Duppen, N., Kuipers, I. M., Schokking, M., van Domburg, R. T., Verhulst, F. C., Helbing, W. A., & Utens, E. M. W. J. (2014). Aerobic exercise influences quality of life of children and youngsters with congenital heart disease: a randomized controlled trial. *Journal of Adolescent Health*, *55*(1), 65–72. https://doi.org/10.1016/j.jadohealth.2013.12.010

Duppen, N., Geerdink, L. M., Kuipers, I. M., Bossers, S. S. M., Koopman, L. P., van Dijk, A. P. J., Roos-Hesselink, J. W., De Korte, C. L., Helbing, W. A., & Kapusta, L. (2015). Regional ventricular performance and exercise training in children and young adults after repair of tetralogy of Fallot. *Circulation: Cardiovascular Imaging*, *8*(4). https://doi.org/10.1161/CIRCIMAGING.114.002006

Elliott, A. D., Rajopadhyaya, K., Bentley, D. J., Beltrame, J. F., & Aromataris, E. C. (2015). Interval training versus continuous exercise in patients with coronary artery disease: a meta-analysis. *Heart, Lung and Circulation*, *24*(2), 149–157. https://doi.org/10.1016/j.hlc.2014.09.001

Gong, Y.-Q., Liu, X.-Y., Zhi, P., Wei, L.-N., Guo, F.-F., Qian, J.-Z., Wang, Y.-X., & Dong, H.-L. (2021). Exercise training in patients with corrected tetralogy of Fallot. *Medicine*, *100*(21), e26108. https://doi.org/10.1097/MD.0000000000026108

Guo, X., Si, Y., Liu, H., & Yu, L. (2024). Effects of aerobic exercise on cardiopulmonary function in postoperative patients with congenital heart disease: a meta-analysis. *Reviews in Cardiovascular Medicine*, *25*(8). https://doi.org/10.31083/j.rcm2508296

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Hock, J., Remmele, J., Oberhoffer, R., Ewert, P., & Hager, A. (2022). Breathing training improves exercise capacity in patients with tetralogy of Fallot: a randomised trial. *Heart*, *108*(2), 111–116. https://doi.org/10.1136/heartjnl-2020-318574

Horenstein, M. S., Diaz-Frias, J., & Guillaume, M. (2024). *Tetralogy of Fallot*. StatPearls Publishing.

Hsu, W.-F., Chien, W.-C., Chung, C.-H., Lee, P.-C., Wang, D.-S., Huang, S.-W., Chang, H.-A., Kao, Y.-C., Yang, S.-S., & Tzeng, N.-S. (2021). Association between tetralogy of Fallot and psychiatric disorders. *The Journal of Clinical Psychiatry*, *82*(2). https://doi.org/10.4088/JCP.19m13126

Lopez, J. R., Voss, C., Kuan, M. T. Y., Hemphill, N. M., Sandor, G. G. S., & Harris, K. C. (2020). Physical activity is associated with better vascular function in children and adolescents with congenital heart disease. *Canadian Journal of Cardiology*, *36*(9), 1474–1481. https://doi.org/10.1016/j.cjca.2019.12.019

Miller, J. R., Stephens, E. H., Goldstone, A. B., Glatz, A. C., Kane, L., Van Arsdell, G. S., Stellin, G., Barron, D. J., d'Udekem, Y., Benson, L., Quintessenza, J., Ohye, R. G., Talwar, S., Fremes, S. E., Emani, S. M., & Eghtesady, P. (2023). The American Association for Thoracic Surgery (AATS) 2022 Expert Consensus Document: Management of infants and neonates with tetralogy of Fallot. *The Journal of Thoracic and Cardiovascular Surgery*, *165*(1), 221–250. https://doi.org/10.1016/j.jtcvs.2022.07.025

Novaković, M., Prokšelj, K., Rajkovič, U., Vižintin Cuderman, T., Janša Trontelj, K., Fras, Z., & Jug, B. (2018). Exercise training in adults with repaired tetralogy of Fallot: a randomized controlled pilot study of continuous versus interval training. *International Journal of Cardiology*, *255*, 37–44. https://doi.org/10.1016/j.ijcard.2017.12.105

Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular effects and benefits of exercise. *Frontiers in Cardiovascular Medicine*, *5*. https://doi.org/10.3389/fcvm.2018.00135

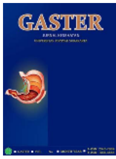
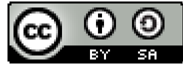
Okólska, M., Łach, J., Matusik, P. T., Pająk, J., Mroczek, T., Podolec, P., & Tomkiewicz-Pająk, L. (2021). Heart rate variability and its associations with organ complications in adults after Fontan operation. *Journal of Clinical Medicine*, *10*(19), 4492. https://doi.org/10.3390/jcm10194492

Powell, A. W., Mays, W. A., Knecht, S. K., & Chin, C. (2019). Pulmonary effects on exercise testing in tetralogy of Fallot patients repaired with a transannular patch. *Cardiology in the Young*, *29*(2), 133–139. https://doi.org/10.1017/S1047951118001920

Schuermans, A., Boerma, M., Sansoni, G. A., Van den Eynde, J., Takkenberg, J. J. M., Helbing, W. A., Geva, T., Moons, P., Van De Bruaene, A., & Budts, W. (2023). Exercise in patients with repaired tetralogy of Fallot: a systematic review and meta-analysis. *Heart*, *109*(13), 984–991. https://doi.org/10.1136/heartjnl-2022-321850

Simeone, R. M., Downing, K. F., Bobo, W. V., Grosse, S. D., Khanna, A. D., & Farr, S. L. (2022). Post-traumatic stress disorder, anxiety, and depression among adults with congenital heart defects. *Birth Defects Research*, *114*(3–4), 124–135. https://doi.org/10.1002/bdr2.1971

Siraj, S. A., Yadav, V. D., Jain, M. J., & Wadhokar, O. C. (2021). Rehabilitating case of tetralogy of Fallot undergone surgical repair with comprehensive exercise program: a case report. *Journal of Pharmaceutical Research International*, 332–336. https://doi.org/10.9734/jpri/2021/v33i53A33667

Gaster, 23(2) 2025, 198-210
https://journal.aiska-university.ac.id/index.php/gaster
e-ISSN: 2549-7006; p-ISSN: 1858-3385
DOI: https://doi.org/10.30787/gaster.v23i2.1878

Varkoly, K., Parekh, A., Ianitelli, M., Hamada, M., Lucas, A., & Forbes, T. (2024). Surgically repaired tetralogy of Fallot in the 7th decade: a late presentation of severe pulmonic regurgitation. *The Egyptian Heart Journal*, *76*(1), 46. https://doi.org/10.1186/s43044-024-00477-3

Wilson, R., Ross, O., & Griksaitis, M. J. (2019). Tetralogy of Fallot. *BJA Education*, *19*(11), 362–369. https://doi.org/10.1016/j.bjae.2019.07.003

Yoo, B. W., & Park, H. K. (2013). Pulmonary stenosis and pulmonary regurgitation: both ends of the spectrum in residual hemodynamic impairment after tetralogy of Fallot repair. *Korean Journal of Pediatrics*, *56*(6), 235. https://doi.org/10.3345/kjp.2013.56.6.235