

CASE REPORT

The Effect of High-intensity Interval Training on Initial Claudication and Absolute Walking Distance in Peripheral Artery Disease Patient: A Case Report

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ABSTRACT

Introduction: Peripheral arterial disease (PAD) causes substantial functional impairment due to the manifestation of intermittent claudication (IC) during physical activities. Evidence showed that aerobic exercise improves walking ability and performance in PAD patients.

Case Persentation: A 55-year-old man subjected to phase II cardiac rehabilitation (CR) complained about moderate IC during physical activity. Extended CR was administered to improve initial claudication, absolute walking distances, and physical activity level through a hybrid-CR program. Supervised high-intensity interval training (HIIT) and home-based moderate-intensity aerobic exercise were administered 2 and 3 times a week, respectively. After 2 weeks, there was an increase in initial claudication and absolute claudication distance of 23 and 91 meters from the baseline, respectively.

Discussion: Aerobic exercise in PAD patients increased walking distance due to collateral flow improvement, nitric oxide-dependent vasodilatation, inflammatory mediators, endothelial damage, oxygen delivery to working muscles, contraction efficiency, and pain tolerance, as found in previous literature.

Conclusion: The 2 weeks of HIIT improved initial claudication and absolute walking distance in the PAD patient subjected to phase II CR.

Keywords: Exercise, Intermittent Claudication, Muscle, Peripheral Artery Disease, Walking

ABSTRAK

Pendahuluan: Penyakit arteri perifer (PAP) menyebabkan gangguan fungsional yang cukup signifikan akibat manifestasi klaudikasio intermiten (KI) selama aktivitas fisik. Bukti menunjukkan bahwa latihan aerobik meningkatkan kemampuan berjalan dan kinerja pada pasien PAP.

Deskripsi kasus: Seorang pria berusia 55 tahun yang menjalani rehabilitasi jantung (RJ) fase II mengeluhkan KI intensitas sedang selama aktivitas fisik. Program RJ yang diperpanjang diberikan untuk meningkatkan klaudikasio awal, jarak berjalan absolut, dan tingkat aktivitas fisik melalui program RJ hybrid. Latihan interval intensitas tinggi (LIIT) yang diawasi dan latihan aerobik intensitas sedang di rumah diberikan masing-masing 2 dan 3 kali seminggu. Setelah 2 minggu terjadi peningkatan jarak klaudikasio awal dan klaudikasio absolut masing-masing sebesar 23 dan 91 meter dari nilai awal.

Diskusi: Latihan aerobik pada pasien PAP meningkatkan jarak berjalan karena perbaikan aliran kolateral, oksida nitrat tergantung dilatasi, mediator inflamasi, kerusakan endotel, pengiriman oksigen ke otot yang bekerja, efisiensi kontraksi, dan toleransi nyeri, seperti yang ditemukan pada literatur sebelumnya.

Kesimpulan: Latihan aerobik dalam bentuk LIIT dan intensitas sedang pada program RJ *hybrid*, memperbaiki klaudikasio awal dan jarak berjalan absolut pada pasien PAD ini.

Kata kunci: Jalan, Klaudikasio Intermiten, Latihan, Otot, Penyakit Arteri Perifer

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INTRODUCTION

Peripheral arterial disease (PAD) is a cardiovascular disease (CVD) causing significant functional impairment due to the presence of intermittent claudication (IC) during activities.^{1,2} The presence of PAD increases the probability of development of coronary artery

disease (CAD).³ Previous research showed that patients with CAD have a higher probability of experiencing IC. Activity restrictions lead to a decrease in cardiorespiratory fitness, muscular fitness, physical activity, and quality of life.^{1,4,5} The presence of IC is also associated with psychological disorders such as anxiety and depression.^{2,6} The problems are related to recurrence of symptoms and unsuccessful treatment.⁷ Aerobic exercise has been shown to improve function in patients with PAD because of the physiological effects on the cardiovascular and other systems. Hospital-based or home-based exercise can lead to an increase in walking ability.^{1,8,9} The optimal prescription as suggested by the American Heart Association is an exercise with moderate intensity administered 3 times a week with a session duration of at least 30 minutes for 12

weeks.⁵ This case reported a patient experienced IC during exercise while attending phase II cardiac rehabilitation (CR) due to CAD after coronary artery bypass graft (CABG) surgery by given high-intensity interval training (HIIT) combined with moderate-intensity continuous aerobic exercise with a short program duration.

CASE DESCRIPTION

A 55-year-old man suffered from CAD and was subjected to CABG surgery and congestive heart failure with New York Heart Association (NYHA) functional class II. IC was felt on both calf and thigh when the patient climbed stairs for approximately 2 floors and walked uphill for 250 meters at a fast pace for 7-8 minutes. The level of pain decreased and disappeared after 5 minutes. Meanwhile, the intensity of IC was mild to moderate with a claudication pain scale of 3-4. Pain also occurred during treadmill walking exercises and commenced to feel within 2 weeks of phase II CR.

At the beginning of phase II CR (November 28th, 2022), the patient was given light-intensity continuous aerobic exercise using a treadmill and there was no complaint of leg pain. After 2 weeks, the exercise intensity was increased to moderate intensity continuous aerobic and leg pain was experienced by the patient with a claudication scale of 3-4. The pain increased and occurred at the first 10 minutes of exercise at the end of phase II CR. Subsequently, the patient was consulted by the cardiovascular department for the diagnosis. A Doppler examination reported multiple plaques on the bilateral common femoral artery with decreased blood flow and was diagnosed with

PAD. The patient's place of work was located on the 4th floor but was always forced to rest on the 2nd floor due to leg pain. Another activity was walking 30 meters from the office to the mosque to pray twice a day. At present, the daily activities require 1 to 4 metabolic equivalents (METs).

The patient suffered from CAD since 2018 and was subjected to a CABG surgery on September 29th, 2022. In addition, congestive heart failure was experienced in 2018 while furosemide and spironolactone were consumed routinely. Physical exercises were limited due to heart disease and the activities before surgery were mostly light-intensity ranging from 1 to 2 METs. The patient also consumed medicines after experiencing hypertension and diabetes mellitus 10 years ago. In addition, atorvastatin was consumed regularly due to dyslipidemia. During the COVID-19 pandemic, the patient worked from home but visited the office 6 days a week after surgery. The complaints concerning leg pain were reduced and the patient was able to walk uphill or climb stairs.

Physical examination reported no abnormality in the vital signs and head-to-toe examination, except for ankle-brachial index 0.87/0.84 showing occlusion of the peripheral artery. The body weight and height were 56 kg and 155 cm with a BMI of 23.3 (normal). Neuromusculoskeletal examination reported normal results, while echocardiography showed reduced left ventricle ejection fraction (35,7%), mild to moderate mitral regurgitation, as well as systolic and diastolic dysfunction. In addition, angiography results evaluated mild stenosis of the left main coronary artery (30%), severe stenosis at the middle of the

left anterior descending (90-95%), total occlusion right coronary artery (100%), and moderate stenosis at the left circumflex (70%). Electrocardiography showed sinus rhythm, complete left branch bundle block, as well as ST depression at lead II, III, aVF, V5, and V6. Doppler examination of the lower extremity analyzed multiple plaques at the femoral artery with the absence of chronic venous insufficiency and thrombus at superficial or deep veins. Laboratory results reported high total cholesterol (210 mg/dL), low high-density lipoprotein cholesterol (37 mg/dL), optimal low-density lipoprotein cholesterol (107 mg/dL), high urea and creatinine (67.5 mg/dL and 1.62 mg/dL), as well as high glycated hemoglobin (8.2 mg/dL).

The functional assessment did not report fatigue, depression, anxiety, and stress, as well as daily living based on Lawton-IADL. Exercise tests using the Bruce protocol showed an appropriate hemodynamic response with no

symptoms, as well as a functional capacity of 7.2 METs. Hand grip strength was 16 kg/14 kg or a total of 30 kg showing poor muscular fitness. The baseline initial and absolute claudication distances were 166 and 215 meters, respectively.

Rehabilitation problems are cardiorespiratory endurance, muscular fitness, and mobilization. During exercise, IC becomes the main problem of intolerance. In the short term (<4 weeks) we plan to increase walking distance both initial claudication and absolute walking distances as well as increase his level of physical activity. In the long term (>4 weeks) we plan to further increase walking distance, climb stairs/walk uphill without leg pain, increase his cardiorespiratory fitness, and achieve normal muscular fitness. Hospital-based and home-based CR programs were administered for 2 weeks to achieve the objective. The prescription of exercise given is presented in Table 1.

Table 1. The Prescription of Exercise

Component of Prescription	Hospital-based Aerobic Exercise	Home-based Aerobic Exercise	Hospital-based Resistance Exercise
Frequency	2times/week	3times/week	2times/week
Intensity	Exercise at 85-90% of HR max, rest with lower intensity at 50-60% of HR max	At claudication pain scale 3 (mild claudication pain) or Borg's RPE scale 11- 14 (moderate intensity)	50% of 1-RM
Time	5 bouts of 4 minutes exercise followed by 4-minute rest	30 minutes of aerobic exercise	3 sets, 10 repetitions
Type	High-intensity interval training with treadmill	Aerobic with ground walking exercise	Isotonic strengthening exercise of quadriceps, hamstring, and gastrocsoleus

HR max: maximal heart rate; RPE: rating of perceived exertion; 1-RM: one-repetition maximum

The poor muscular fitness of the patient may become a barrier to achieving the goal but the patient possesses high motivation to recover. Evaluation after 2 weeks of exercise found that the patient achieved the target of HIIT with symptoms of mild to moderate leg pain. Meanwhile, the patient climbed stairs up to the 3rd floor before the claudication occurred. The walking distance had initial and absolute claudication of 189 and 306 meters with an increase of 23 and 91 meters from baseline, respectively.

DISCUSSION

This case presented a 55-year-old male patient who experienced IC while attending phase II CR after CABG surgery. At the beginning of phase II CR, there were no reported complaints about IC. The symptom commenced after 2 weeks of exercise due to increasing intensity from low intensity to moderate intensity. Patients with CAD have a higher risk of experiencing IC during exercise or physical activity.⁶ This caused activity restriction, decreased functional capacity, and muscular fitness as well as increased risk of atherosclerosis.⁵

The patient was subjected to phase II CR for 6 weeks. Due to increasing symptoms of IC, the CR program was extended for 2 weeks more. This ensured the safety of exercise and obtained an appropriate dose of exercise. The process was carried out to prevent the development of symptoms and other CVDs as well as the worsening of CAD and disease progression. In addition, the presence of hypertension, diabetes mellitus, and dyslipidemia in this patient should be controlled since the typical

CVD risk profile increases the complications of PAD.⁷

A hybrid phase II CR was administered with supervised HIIT and home-based moderate-intensity continuous aerobic exercise. The reason to give HIIT was evidence that this exercise has been proven to improve outcomes of patients with IC such as walking distance, VO₂peak, and quality of life.¹⁰ Another reason was to improve the functional capacity, where the intensity of aerobic exercise was proportional to VO₂ max.¹¹ The presence of IC in continuous aerobic exercise also became a consideration for HIIT. A short exercise followed by a rest interval allows recovery of the cardiovascular system to increase adaptation.¹² Aerobic energy metabolism improvement leads to peripheral adaptations characterized by increased capillary density and mitochondrial content.¹³

A supervised exercise program provides a significant and clinically relevant improvement in walking distance. The benefits include the availability of instruction, supervision of exercise and compliance, good facilities, and social interaction. However, the most successful programs combine supervised and daily exercise at home. This may be due to the development of behavior patterns to motivate adherence and increased activity continuation after supervision.⁷ In this context, the objectives of PAD treatment are to relieve symptoms, increase functional capacity, and reduce the risks of CVD.^{1,8} Smoking cessation, treatment of CVD risk factors, weight loss, pharmacological treatment, increased physical activity, and surgery are typical management. Physical exercise and enhancement of physical

activity are reliable methods to manage PAD patient.^{6,7} However, the optimal program duration to achieve the objectives varies.^{5, 7,8} According to Harwood et al., aerobic exercise should be administered for at least 12 weeks.⁶ During the six-minute walking test (6MWT), 2 weeks of HIIT and moderate-intensity continuous exercise improved initial claudication and total walking distance. This may be caused by a higher intensity and frequency, good adherence to prescribed exercises, increased physical activity, and control of calorie intake. In addition, the physiological changes achieved due to the first 6-week CR program explained the results.

The outcome of aerobic exercise is the measurement of pain-free walking distances, which includes the time to pain onset during the 6-MWT.^{7,14} This leads to an increase in walking distance due to several physiological changes.^{1,7,15} The exact mechanism of physiological changes is multifactorial and remains unclear.¹⁵ Meanwhile, regular aerobic exercise resulted in a minimal increase in collateral flow and improved nitric oxide-dependent vasodilatation.^{1,15} Inflammatory mediators associated with endothelial damage which causes the progression of the atherosclerotic process are also reduced.^{7,8,15} Exercise increases oxygen delivery to working muscles during activities such as walking.^{15,16}

Other problems reported were low cardiorespiratory fitness (VO₂ max) and muscular fitness. The patient often limits physical activity, leading to a decline in exercise performance.⁸ A low VO₂ max represents a slow oxygen uptake kinetic which provides information about metabolic control, muscle

energetics, and efficiency of skeletal muscle contraction.¹⁷ Meanwhile, the improvement of VO₂ max increases tolerance in activity and reduces PAD symptoms.⁷

The addition of resistance to aerobic exercise in patients with CVD is proven to be better at improving ADL performance, mobilization, and cardiorespiratory fitness.^{8,18} The mechanism underlying the improvement in peripheral blood flow after aerobic and resistance training is an increase in nitric oxide and the formation of neovascularization.¹⁹ Moreover, HIIT and resistance exercise are effective in producing physiological effects.^{20,21}

The 2 weeks of aerobic exercise improved walking distance and decreased the occurrence of IC. Generally, the 8 weeks of exercise-based CR showed a good result in increasing adherence to improved behaviors such as physical activity, regular exercise, and a healthy diet. The patient entered phase III CR safely since there was no adverse event during supervised and home-based exercises.

CONCLUSION

In conclusion, the 2 weeks of HIIT improved initial claudication and absolute walking distance in the PAD patient subjected to phase II CR.

CONFLICT OF INTEREST

The author declared no conflict of interest.

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The author has nothing to declare.

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