Exercise-based Rehabilitation Improves Hemodynamic Responses after Lower Limb Arterial Blood Flow Surgery

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Authors’ contributions

This work was carried out in collaboration between all authors. Authors EJ and DV wrote the protocol and the first draft of the manuscript. Authors EJ, RK, LV and LL managed the analyses of the study. Author JV performed the statistical analysis. Authors EJ and EM managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

Aim: The aim of this study was to evaluate the effectiveness of exercise rehabilitation programmed (ERP) on hemodynamic responses and functional status in patients after lower limb bypass surgery.

Place and Duration of the Study: The study included 70 patients, who were treated in
the Hospital Lithuanian University of Health Sciences between the period of May 2012 and June 2013.

**Methodology:** Forty seven patients were selected for this study. They were allocated to two groups. While the rehabilitation group (n=25, mean age: 68.6±1.6 years) completed ERP for six months, the control group (n=22, mean age: 68.8±2.4 years) did not have any supervised physical activity during this period. Patients were assessed at baseline and 6 months after intervention. Walking distances were evaluated by a 6-minute walking test (6 MWT), hemodynamic response was measured by ankle-brachial indices (ABI).

**Results:** As a result of ERP, a significant improvement was observed in the total distance walked in the rehabilitation group after 6 months ($P=.01$) compared to the control group. Also a significant progression was observed in pain-free walking (PFW) distance in the rehabilitation group ($P=.02$) compared to the control group after 6 months. Furthermore, ERP significant improved hemodynamic responses such as heart rate ($P=.00$), systolic ($P=.008$) and diastolic blood pressure ($P=.007$).

**Conclusion:** ERP is an effective therapy to significantly improve functional capacity and hemodynamic response in patients after lower limb bypass surgery.

**Keywords:** Rehabilitation programme; lower limb bypass surgery; hemodynamic; functional capacity.

### 1. INTRODUCTION

Peripheral arterial disease (PAD) is strongly associated with older age. PAD has an estimated worldwide prevalence of 10%, rising to 24% in people over 70 years of age [1,2]. The incidence of PAD is high among smokers [3], people with hypertension [4], diabetes and dyslipidemia [5]. Peripheral arterial disease patients have an extensive high-risk for cardiovascular ischemic events, regardless of their symptomatic status [6,7].

Patients who develop symptoms of PAD usually present with intermittent claudication, which is defined as reproducible lower extremity muscular pain induced by exercise and relieved by rest [8]. Symptoms are determined by the site of the disease, and since PAD most commonly affects the superficial femoral artery, the pain of intermittent claudication is frequently localized to the calf.

Despite major improvements in surgical endovascular techniques, PAD is still associated with high mortality and significant morbidity including major limitations in mobility, physical functioning and decreased quality of life [9,10]. Impaired functional performance is associated with poor quality of life and increased exercise endurance has been shown to positively affect quality of life [11,12].

People with severe symptoms that are inadequately controlled are often referred to secondary care for assessment of endovascular testing, surgical revascularization and amputation. Bypass surgery to treat people with severe lifestyle-limiting intermittent claudication should only be considered when angioplasty has been unsuccessful or is unsuitable [13].

Complete cardiovascular rehabilitation that includes exercises training combined with comprehensive secondary prevention has the potential to benefit patients with PAD by preserving or improving functional capacity and reducing cardiovascular events. Secondary
prevention programmes integrate exercise into the overall treatment plan that includes lipid management, blood pressure control, smoking cessation, nutrition education, weight reduction, and diabetes mellitus treatment [14,15]. Exercise has been shown to have the effect on an increase in collateral flow and mitochondrial biogenesis in animal models, improvement of nitric oxide – dependent vasodilation as well as mitochondrial energetics. It also contributes to a decrease of systemic inflammation markers [14].

Since there was not adequate evidence about the effects of exercise rehabilitation on patients after lower limb bypass surgery, the purpose of this study was to evaluate the effectiveness of exercise rehabilitation on functional status and some hemodynamic responses such as systolic (SBP) and diastolic blood pressure (DBP), heart rate (HR), and ankle-brachial indices (ABI).

2. MATERIALS AND METHODS

The study included 70 patients hospitalized in the Department of Vascular Surgery, Hospital of Lithuanian University of Health Sciences (LUHS) (formerly – Kaunas University of Medicine), who were diagnosed with the superficial femoral artery occlusion and underwent femoral-popliteal artery bypass grafting.

Subject inclusion criteria comprised patients with disease stage II – III as defined by Fontaine and underwent femoral-popliteal artery bypass grafting surgery. Subjects were excluded if they had Fontaine stage IV (PAD associated with tissue loss), received conservative or endovascular treatment. Patients were randomized into 2 groups, control and rehabilitation, according to a random sampling approach 1:1.

Individuals in the control group received usual care and after in-patient treatment were referred to a family doctor for further treatment, whereas those assigned to the rehabilitation group continued treatment in a rehabilitation center and at home.

Subjects’ post-operative hospitalization lasted an average for 7 days and then early physical rehabilitation and the best medical treatment (BMT) were started. Clinical Cardiology Laboratory of the Institute of Cardiology of LUHS prepared the methodology of physical therapy for this group of patients. During the first 2 days static breathing exercises, relaxation, and general small light muscle training exercises were administered, the next 5 days are added for dynamic breathing exercises, physical exercises for medium size and large muscle developing and walking therapy.

2.1 Exercise Rehabilitation Programmed (ERP) for the Rehabilitation Group

The rehabilitation group from the hospital was referred to the rehabilitation center where treatment lasted for 18 days. The rehabilitation center following clinical guidelines [16,17], has introduced a new physical therapy programmed aimed at an individual physical therapy and physiotherapy. Individual physical therapists worked with the subjects and conducted 16 procedures: up to 45 minutes considering the pulse frequency according to the age; the intensity of training was based on clinical conditions and established between 60-85% of maximum HR. Individually, the procedures consisted of the following: 1) warm-up of 5–10 minutes - dynamic breathing exercises and stretching exercises (calf, hamstring, upper muscles); 2) walking therapy – treadmill or track walking; 3) cool-down period of 5–10 minutes - static and dynamic breathing exercises, stretching exercises. During each session,
resting and maximum HR and resting and maximum SBP and DBP of patients were
controlled and recorded by a physical therapist.

After 18 days of rehabilitation treatment, the rehabilitation group was assigned to an
individual physical activity at home for five months. Physical activity programmed was based
on recommendations of physical therapists. In this programme, patients were asked to walk
for at least 30 minutes a day, three to five times per week and to increase their walking time
as often as possible, including a warm-up phase of stretching the calf, hamstring and upper
limb muscles and ending with a cool-down period.

2.2 Measurements

Both groups were assessed according to the following measurements before surgery and six
months after surgery. Cigarette smoking was based on history of current smokers (smoked
within the last month). Hyperlipidemia was defined as a case history of hyperlipidemia.
Hypertension was defined by SBP of 140 mm Hg or higher, DBP of 90 mm Hg or higher or
previously diagnosed and treated high blood pressure [18]. Diabetes was defined as a case
history of diabetes. Myocardial infarction, angina or stroke were considered when diagnosed
by a physician.

2.2.1 A six-minute walk test (6 MWT)

The 6 MWT is a sub maximal test that measures the distance that a patient can quickly walk
on a flat, hard surface in a period of 6 minutes. The pain-free and total distance walked
during the test was recorded. The survey was conducted according to a standard protocol
[19], in the hallway marked walking distance and walking time measured by a stop watch.
The 6 MWT reflects the patient's level of physical fitness in daily life [20]. Before and after
the test, resting HR and blood pressure of patients were observed and recorded.

2.2.2 Ankle-brachial index (ABI)

ABI is defined as a ratio of the ankle and brachial artery systolic pressure. This is one of the
most common methods for diagnosis of peripheral arterial disease [21]. The ABI was
measured by Health care Multi Dopplex II, No. MD 2. The sensitivity and specificity of the
ABI with the Doppler technique range from 0.17 to 1.0 and from 0.80 to 1.0, respectively
[21].

2.2.3 Blood pressure and heart rate measurements

SBP and DBP were measured in the sitting position by auscultation and
sphygmomanometer by recommendation [22]. Heart rate was measured by pulse palpation
at the neck (carotid artery) or at the wrist (radial artery). Measurements were performed after
sitting quietly for 5 minutes. Also resting blood pressure was determined from patients' blood
pressure protocols as the average of serial home blood pressure measurements.

2.3 Statistical Analysis

The study data statistical analysis was performed using the SPSS for Windows 20.0
program. To describe quantitative variables the means and the standard deviation (±SD)
were used. Quantitative indicators of the rehabilitation and control groups were compared
using Student's (t) test, the mean value ± SE (standard error) were presented; qualitative -
using Chi-square (χ²) test. Paired t-test was used for comparing results from baseline to the
end of the program (after 6 months). Verification of statistical hypotheses selected statistical
confidence level of \( P<0.05 \) (95% statistical confidence).

3. RESULTS

Out of 70 studied patients, 23 failed to complete the full study follow-up period. Of those, four
patients were re-operated, two patients had amputation above the knee, one patient had
amputation of two toes, one patient contracted lung cancer, ten patients were unable to
continue study due to health problems and five patients were lost for follow-up examination.
Similar baseline clinical characteristics were found between two groups, except that the
rehabilitation group had more patients who currently smoked (\( P=.03 \)). The two groups were
similar by age, sex, BMI, history of hyperlipidemia, hypertension, diabetes and cardiovascular disease Table 1.

**Table 1. Clinical characteristics of the rehabilitation (n=25) and control groups (n=22)**

| Variable                      | Rehabilitation group | Control group | \( P \) |
|-------------------------------|----------------------|---------------|--------|
| Age (±SD)                     | 68.6±1.69            | 68.8 ± 2.4    | .94    |
| Sex                           |                      |               |        |
| Men (%)                       | 21 (84)              | 20 (90.9)     | .49    |
| Women (%)                     | 4 (16)               | 2 (9.1)       | .49    |
| BMI, kg/m² (±SD)              | 26.9±4.4             | 28.8±4.3      | .14    |
| Current smoker (%)            | 19 (76)              | 10 (45.5)     | .03    |
| Hyperlipidemia (%)            | 6 (24)               | 5 (22.7)      | .92    |
| Hypertension (%)              | 15 (60)              | 12 (54.5)     | .71    |
| Diabetes (%)                  | 2 (8)                | 2 (9.1)       | .89    |
| **Cardiovascular disease**    |                      |               |        |
| Myocardial infarction (%)     | 2 (8)                | 2 (9.1)       | .89    |
| Angina (%)                    | 1 (4)                | 0 (0)         | .35    |
| Stroke (%)                    | 1 (4)                | 2 (9.1)       | .48    |

BMI - body mass index; SD - standard deviation

The groups were similar (\( P>.05 \)) at baseline in hemodynamic responses described in Table
2. There were no significant differences between the groups in baseline ABI, HR and blood
pressure levels.

**Table 2. Baseline hemodynamic responses of the rehabilitation (n=25)
and control groups (n=22)**

| Hemodynamic Responses P | Rehabilitation Group | Control Group |
|-------------------------|----------------------|---------------|
| ABI (±SE) .36           | 0.44±0.02            | 0.41±0.02     |
| Resting HR beat/min (±SE) .13 | 81.60±1.17        | 78.60±1.54    |
| Resting SBP mmHg (±SE) .46 | 138.00±2.08       | 135.68±2.49   |
| Resting DBP mmHg (±SE) .83 | 84.00±1.38         | 83.63±0.99    |

ABI - ankle-brachial index; HR - heart rate; SBP - systolic blood pressure; 
DBP-dia-stolic blood pressure
The peripheral hemodynamic measurements of the rehabilitation and control groups after 6 months are presented in Table 3. A statistically significant difference in ABI was observed in both groups. However, the mean resting HR, SBP and DBP level was significant improved after 6 months in the rehabilitation group as compared to the control group.

Table 3. Variation of hemodynamic responses from baseline to the end of the program (after 6 months)

| Hemodynamic Responses | Rehabilitation Group n=25 | Control Group n=22 |
|------------------------|----------------------------|---------------------|
|                        | Pre           | Post          | P     | Pre           | Post          | P     |
| ABI                    | 0.44±0.02     | 0.84±0.02     | .00   | 0.41±0.02     | 0.76±0.03     | .00   |
| Rest HR (beat/min)     | 81.60±1.17    | 76.08±0.85    | .00   | 78.60±1.54    | 78.04±1.44    | .58   |
| Rest SBP (mmHg)        | 138.00±2.0     | 132.80±1.32   | .008  | 135.68±2.49   | 134.09±1.59   | .38   |
| Rest DBP (mmHg)        | 84.00±1.38    | 78.96±1.34    | .007  | 83.63±0.99    | 81.13±1.03    | .09   |

ABI - ankle-brachial index; HR - heart rate; SBP - systolic blood pressure; DBP - diastolic blood pressure

There were no differences in mean total 6 MWT and PFW distance between groups at baseline Table 4. Significant changes in functional capacity were seen during the 6 MWT between the groups after 6 months. As summarized in Table 4, the control group also had shorter a PFW and total distances than the rehabilitation group after 6 months. At 6-month of follow-up, participants in the rehabilitation group improved their 6 MWT distance compared with the control group (reported in meters) 197 to 412 vs 205 to 344 Table 4. Also participants in the rehabilitation group improved their PFW distance compared with the control group 62 to 362 meters vs 64 to 288 meters Table 4.

Table 4. Six-minute walk test measurements in rehabilitation (n=25) and control groups (n=22)

| 6 MWT       | Before operation | After 6 months |
|-------------|------------------|----------------|
| 6 MWT       | RG               | CG             | P      | RG               | CG             | P      |
| PFW distance, m | 62±8.63          | 64±10.35       | .87    | 362±23.54        | 288±20.91      | .02    |
| Total distance, m | 197±11.79       | 205±10.03      | .62    | 412±19.86        | 344±15.08      | .01    |

6 MWT - six-minute walk test; RG - rehabilitation group; CG - control group; PFW - pain-free walking

4. DISCUSSION

To our knowledge, this is the first study to directly investigate effectiveness of ERP on hemodynamic responses and functional status in patients after lower limb bypass surgery. Participants of rehabilitation group took an average of one month of supervised exercise programmers (SEP) and five months of non-supervised exercise programmed and demonstrated substantial improvements in both hemodynamic responses and functional status. This finding provides evidence that exercise induced improvement in walking ability in patients after lower limb bypass surgery.

A number of studies similarly reported that exercise training improved walking [23,24,25] and increased PFW distance by 180% in patients with PAD [26]. Exercise training has been incorporated into current guidelines for the management of PAD [14]. Supervised exercise therapy (SET) is indicated for patients with intermittent claudicating (Class I, Level A) [27], and leads to significantly greater improvements in walking performance, as compared with non-supervised exercise programmers [28].
However, to date only two randomized trials have described effects of exercise training after lower limb bypass surgery [8,29]. Badger et al. reported similar results, and showed that walking distance significantly improved in patients undergoing arterial bypass surgery after SEP. The mean increase of maximum walking distance was 3.8% in the control group (with standard preoperative and postoperative care) and 175.4% in the intervention group (with a SEP of twice-weekly treadmill assessments from 4 to 10 weeks postoperatively) ($P=0.001$) [8]. Similarly, Lundgren et al. determined that the results of symptom-free walking distance (SFWD) and maximal walking distance (MWD) after reconstruction combined with physical training of patients with intermittent claudicating are higher than in the following groups: reconstruction without physical training and physical training without reconstruction. The patients were re-examined after at least 6 months of treatment. Their training period was 6 months. The training program was comprised of three sessions per week of dynamic leg exercises, also patients were encouraged to perform the exercises during their leisure-time [29].

Similarly, other studies reported the results of angioplasty performed in patients with lower limb occlusive peripheral arterial disease and compared combined treatment (angioplasty with SEP) with angioplasty alone. Kruidenier et al. determined that SET following a percutaneous vascular intervention (PVI) was more effective and increased walking distance compared with PVI alone. These data indicate that SET is a useful adjunct to a PVI for the treatment of PAD [24]. However another study observed that percutaneous transluminal angioplasty (PTA), the SEP and combined treatment (PTA plus SEP) were all equally effective in improving walking distance for patients with intermittent claudication due to femoral-popliteal disease. SEP was carried out three times a week for 12 weeks and patients were assessed at baseline and 1, 3, 6 and 12 months after intervention [30].

According to these studies and our results, we conclude that combined treatment effectively reduced limb symptoms (SFWD) and improved exercise capacity (MWD). Many studies have determined the following benefits of exercise to patients with PAD: enhanced 6 MWD, increased walk time to pain onset, increased walk time to maximal pain, improved self-defined quality of life index, improved muscle function, enhanced metabolic response, improved inflammatory/haemostatic function, reduced morbidity and mortality risk and possibly a reduced rate of disease progression [17]. Cardiovascular rehabilitation that includes exercise training is a model for expanded delivery of secondary prevention in PAD [14]. Physical training is a recommendation in the management of hypertension, in association with medical treatment [31].

As mentioned above, our results showed the ERP had the significant effects on hemodynamic responses such as HR, SBP and DBP compared to the control group. Badger et al. observed that 6 weeks exercise programme had a significant difference in ABI indices compared to the control group with standard treatment (without SEP) [8]. Nevertheless, one study evaluated of cardiac rehabilitation programme (CRP) on blood pressure and HR in patients after coronary artery bypass graft surgery. A significant improvement in hemodynamic responses to exercise on resting and maximum SBP and DBP, resting and maximum HR. CRP consisted of exercise, nutritional, psychological consultation and risk factor management. Exercise training consisted of combined aerobic and resistance training. It was performed using the treadmills, ergo meters, steppers and stair climbing, rowing, jogging and resistance devices in the Cardiac Rehabilitation Center under supervision of a physician, an exercise physiologist and a nurse [32]. Regular physical activity develops sub maximal work tolerance through lessening contractility, reducing cardiac work and myocardial oxygen demand. Moreover, it enhances hemodynamic responses such as HR,
SBP and DBP [33,32]. A low ABI predicted a doubling of 10-year risk of mortality, cardiovascular mortality, and major coronary events at all levels of Framingham Risk Score [7]. The clinical significance of PAD derives not only from limb symptoms and functional impairment but as a marker of cardiovascular risk. So it’s very important to follow blood pressure and HR in patients with PAD.

There is one limitation of the present study. Only patients with symptomatic, unilateral femoral-popliteal arterial disease were included, thus a large number of patients with bilateral or mixed arterial disease were excluded. However, this was necessary from a scientific point of view to reduce the influence of confounders, and to provide a robust answer to the treatment controversy in this group [30].

5. CONCLUSION

The data from this study demonstrate that ERP improves hemodynamic responses such as HR, SBP, DBP and functional status in people after lower limb bypass surgery. Therefore, to improve the effectiveness of the treatment, patients who are undergoing artery bypass grafting are recommended to start ERP, which is integrated into a comprehensive treatment programmed.

CONSENT

Not applicable.

ETHICAL APPROVAL

Ethical approval was obtained from Regional Biomedical Research Ethics Committee in Kaunas (No. BE-2-22).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FGR. Inter-society consensus for the management of peripheral arterial disease. J Vasc Surg. 2007;45(1):5–67.
2. Fowler B, Jamrozik K, Norman P, Allen Y. Prevalence of peripheral arterial disease persistence of excess risk in former smokers. Aust N Z J Public Health. 2002;26(3):219–24.
3. Conen D, Everet BM, Kurth T, Creager MA, Buring JE, Ridker PM. Smoking: smoking status and risk for symptomatic peripheral arterial disease in women. A cohort study an Intern Med. 2011;154(11):719–726.
4. Aronow WS, Fleg JL, Pepine CJ, Artinian NT, Bakris G, Brown AS. Expert Consensus Document on Hypertension in the Elderly a Report of the American College of Cardiology Foundation Task Force on Clinical Expert Consensus Documents. Developed in collaboration with the American Academy of Neurology, American Geriatrics Society, American Society for Preventive Cardiology, American Society for Hypertension, American Society of Nephrology, Association of Black Cardiologists, and European Society of Hypertension. J Am Coll Cardiol. 2011;57:2037–2114.
5. Ness J, Aronow WS, Newkirk E, McDanel D. Prevalence of symptomatic peripheral arterial disease, modifiable risk factors and appropriate use of drugs in the treatment of peripheral arterial disease in older persons seen in a university general medicine clinic. J Gerontol Med Sci. 2005;60(2):255–257.

6. Cacoub PP, Abola MT, Baumgartner I, Bhatt DL, Creager MA, Liau CS, et al. Cardiovascular risk factor control and outcomes in peripheral artery disease patients in the Reduction of Atherothrombosis for Continued Health (REACH) Registry. Atherosclerosis. 2009;204(2):86–92.

7. Fowkes FG, Murray GD, Butcher I, Heald CL, Lee RJ, Chambless LE, et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. JAMA. 2008;300(2):197–208.

8. Badger SA, Soong CV, O’Donnell ME, Boreham CAG, McGuigan KE. Benefits of a Supervised Exercise Program after Lower Limb Bypass Surgery. Vascular and Endovascular Surgery. 2007;41(1):27–32.

9. Coutinho T, Rooke TW, Kullo IJ. Arterial dysfunction and functional performance in patients with peripheral artery disease: A review. Vascular Medicine. 2011;16(3):203–211.

10. Ostchega Y, Paulose-Ram R, Dillon CF, Gu Q, Hughes JP. Prevalence of peripheral arterial disease and risk factors in persons aged 60 and older: data from the National Health and Nutrition Examination Survey 1999-2004. J Am Geriatr Soc. 2007;55(4):583–589.

11. Izquierdo-Porrera AM, Gardner AW, Bradham DD, Montgomery PS, Sorkin ID, Powell CC, et al. Relationship between objective measures of peripheral arterial disease severity to self-reported quality of life in older adults with intermittent claudication. J Vasc Surg. 2005;41(4):625–630.

12. Tsai JC, Chan P, Wang CH, Jeng C, Hsieh MH, Kao PF, et al. The effects of exercise training on walking function and perception of health status in elderly patients with peripheral arterial occlusive disease. J Intern Med. 2002;252(5):448–455.

13. Michaels J, Attwood B, Beech A, Bradbury A, Ettles D, Fox M, et al. Lower limb peripheral arterial disease. Diagnosis and management. In: Knott L, Patterson R, editors. Guideline Summary. London: The National Clinical Guideline Centre at the Royal College of Physicians; 2012.

14. Hamburg NM, Balady GJ. Exercise Rehabilitation in Peripheral Artery Disease: Functional Impact and Mechanisms of Benefits. Circulation. 2011;123(1):87–97.

15. Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JM, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. Circulation. 2007;115(20):2675–2682.

16. Milani RV, Lavie CJ. The role of exercise training in peripheral arterial disease. Vasc Med. 2007;12:351–358.

17. Haas TL, Lloyd PG, Terjung RL. Exercise Training and Peripheral Arterial Disease. Compr Physiol. 2012;2(4):2933–3017.
18. Mancia G, Fagard R, Narkiewicz K, Redom J, Zanchetti A, Bohm M, et al. ESH/ESC Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Journal of Hypertension. 2013;31:1281–1357.

19. Crapo RO, Casaburi R, Coates AL, Enright PL, Macintyre NR, Mckay RT, et al. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111–117.

20. McDermott MM, Ades PA, Dyer A, Guralnik JM, Kibbe M, Criqui MH. Corridor-Based Functional Performance Measures Correlate Better with Physical Activity During Daily Life than Treadmill Measures in Persons with Peripheral Arterial Disease. J Vasc Surg. 2008;48(5):1231–1237.

21. Aboyans V, Criqui MH, Abraham P, Allison MA, Creager MA, Diehm C, et al. Measurement and Interpretation of the Ankle-Brachial Index: A Scientific Statement From the American Heart Association. Circulation. 2012;126:2890–2909.

22. Frese EM, Fick A, Sadowsky HS. Blood Pressure Measurement Guidelines for Physical Therapists. Cardiopulm Phys Ther J. 2011;22(2):5–12.

23. Greenhalgh RM, Belch JJ, Brown LC, Gaines PA, Gao L, Reise JA, et al. The adjuvant benefit of angioplasty in patients with mild to moderate intermittent claudication (MIMIC) managed by supervised exercise, smoking cessation advice and best medical therapy: results from two randomised trials for stenotic femoropopliteal and aortoiliac arterial disease. Eur J Vasc Endovas Surg. 2008;36(6):680–688.

24. Kruidenier LM, Nicolai SP, Rouwet EV, Peters RJ, Prins MH, Teijink JA. Additional supervised exercise therapy after a percutaneous vascular intervention for peripheral arterial disease: a randomized clinical trial. J Vasc Interv Radiol. 2011;22:961–968.

25. Murphy TP, Cutlip DE, Regensteiner JG, Mohler ER, Cohen DJ, Reynolds MR, et al. Supervised exercise versus primary stenting for claudication resulting from aortoiliac peripheral artery disease: six-month outcomes from the Claudication: Exercise Versus Endoluminal Revascularization (CLEVER) Study. Circulation. 2012;125(1):130–139.

26. Gardner AW, Poehlman ET. Exercise rehabilitation programs for the treatment of claudication pain. A meta-analysis. JAMA. 1995;274(12):975–980.

27. Tendera M, Aboyans V, Bartelink ML, Baumgartner I, Clement D, Collet JP, et al. ESC Guidelines on the diagnosis and treatment of peripheral artery diseases. The Task Force on the Diagnosis and Treatment of Peripheral Artery Diseases of the European Society of Cardiology (ESC). European Heart Journal. 2011;32:2851–2906.

28. Bendermacher BL, Willigendael EM, Teijink JA, Prins MH. Supervised exercise therapy versus non-supervised exercise therapy for intermittent claudication. Cochrane Database Syst Rev. 2006;19(2):CD005263.

29. Lundgren F, Dahllof AG, Lundholm K, Schersten T, Volkmann R. Intermittent claudication - surgical reconstruction or physical training? A prospective randomized trial of treatment efficiency. Ann Surg. 1989;209(3):346–355.

30. Mazari FAK, Khan JA, Carradice D, Samuel N, Abdul Rahman MN, Gulati S, et al. Randomized clinical trial of percutaneous transluminal angioplasty, supervised exercise and combined treatment for intermittent claudication due to femoropopliteal arterial disease. British Journal of Surgery. 2012;99:39–48.

31. Mancia G, Agabiti R, Cifkova R, DeBacker G, Erdine S, Fagard R, et al. European Society of Hypertension—European Society of Cardiology guidelines for the management of arterial hypertension. J Hypertens. 2003;21:1011–1053.
32. Ghashghaei FE, Sadeghi M, Marandi SM, Ghashghaei SE. Exercise-based cardiac rehabilitation improves hemodynamic responses after coronary artery bypass graft surgery. ARYA Atherosclerosis Journal. 2012;7(4):151–156.

33. Thompson PD, Buchner D, Pina IL, Balady GJ, Williams MA, Marcus BH, et al. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity and Metabolism (Subcommittee on Physical Activity) Circulation. 2003;107(24):3109–3116.

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