

Physical rehabilitation training program for peripheral artery disease in patients with ischemic heart disease

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Acronyms

ABI: ankle-brachial index
AMI: acute myocardial infarction
CVD: cerebrovascular disease
LL-PAD: lower limb peripheral artery disease
MET: metabolic equivalents or energy output
MVO₂: myocardial oxygen consumption

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ABSTRACT

Introduction: The ankle-brachial index provides a simple method to diagnose peripheral artery disease; its use allows identifying patients with intermittent claudication of the lower limbs who do not successfully complete a cardiovascular stress test, which hinders their inclusion in rehabilitation programs.

Objective: To design a comprehensive rehabilitation program for patients with peripheral artery disease and ischemic heart disease.

Method: An observational, descriptive, prospective and longitudinal study was carried out with 28 patients after an acute coronary syndrome and peripheral artery disease. A training program was designed and after a three months follow up results were compared with those at the beginning of the investigation.

Results: Male predominance (67.8%), 17 of them (60.7%) had an ankle-brachial index less than 0.9 (p=0.002). The most affected age group was 55-59 years (35.7%). The primary diagnosis was acute coronary syndrome with ST segment elevation (42.85%). The most common risk factor was hypertriglyceridemia (82.1%). Smoking (75%; p=0.005) and diabetes mellitus (28.6%; p=0.001) were significantly associated with a ITB≤0.9. After three months of supervised physical activity, the ankle-brachial index improved and increased time on exercise (4:21 vs. 10:9 minutes) and onset of pain (2:31 vs. 7:6 minutes).

Conclusions: The introduction of supervised training programs for peripheral artery disease improves functional capacity of patients and their comprehensive evaluation, which favors joining cardiovascular rehabilitation programs.

Key words: Ankle-brachial index, Cardiovascular risk, Peripheral artery disease, Physical training, Cardiac rehabilitation

Programa de entrenamiento físico rehabilitador para pacientes con enfermedad arterial periférica y cardiopatía isquémica

RESUMEN

Introducción: El índice tobillo-brazo ofrece un método sencillo para el diagnóstico de enfermedad arterial periférica, su uso permite identificar pacientes con claudicación intermitente de miembros inferiores que no completan satisfactoriamente una prueba ergométrica cardiovascular, lo que dificulta su inclusión en programas de rehabilitación.

Objetivo: Diseñar un programa integral de rehabilitación para pacientes con enfermedad arterial periférica y cardiopatía isquémica.

Método: Se realizó un estudio observacional, descriptivo, prospectivo, longitudinal con 28 pacientes luego de un síndrome coronario agudo y diagnóstico de enfermedad arterial periférica. Se diseñó un programa de entrenamiento y tras seguimiento durante tres meses se compararon los resultados con los del inicio de la investigación.

Resultados: Predominó el sexo masculino (67,8 %), 17 de ellos (60,7 %) tuvieron un índice tobillo-brazo menor de 0,9 ($p=0,002$). El grupo de edad más afectado fue el de 55-59 años (35,7 %). El diagnóstico principal fue el síndrome coronario agudo con elevación del segmento ST (42,85 %). El factor de riesgo más frecuentemente encontrado fue la hipertrigliceridemia (82,1 %). El hábito de fumar (75 %; $p=0,005$) y la diabetes mellitus (28,6 %; $p=0,001$) se relacionaron significativamente con un $ITB \leq 0,9$. A los tres meses de actividad física supervisada, el índice tobillo-brazo mejoró y aumentaron los tiempos de ejercicio (4:21 vs. a 10:9 minutos) y de aparición del dolor (2:31 vs. 7:6 minutos).

Conclusiones: La introducción de programas supervisados de entrenamiento para enfermedad arterial periférica mejora la capacidad funcional del paciente y su evaluación integral, lo que favorece su incorporación a programas de rehabilitación cardiovascular.

Palabras clave: Índice tobillo-brazo, Riesgo cardiovascular, Enfermedad arterial periférica, Entrenamiento físico, Rehabilitación cardiovascular

INTRODUCTION

The existence of a single vascular system shows the interrelation between organs and organ systems. Regardless of the more or less severe compromise of a particular system, searching for vascular alterations, manifested or not, can report the existence of atherosclerotic disease, morbidity and mortality from this cause in the future, not only as a result from the affected organ or system, but from other interrelated^{1,2}.

The diagnosis of lower limb peripheral artery disease (LL-PAD), alerts the prevalence of atherosclerosis in other locations: chronic renal, cerebrovascular and coronary artery diseases. Studies, mainly conducted in Europe, have demonstrated that the atherosclerotic disease is asymptomatic until the appearance of major diseases or complications (sudden death, acute myocardial infarction [AMI], ictus, claudication of the lower limbs), with an overlapping among the general population that reaches nearly 12%¹⁻³ of prevalence.

Data published from 2008 to 2014 (WHO/Rose questionnaire, NHANES, Edinburgh Claudication questionnaire, Limburg, San Diego, HOPE and the Canadian and European Societies of Cardiology) studies^{2,4-9} indicate that the prevalence of LL-PAD in Germany, Sweden and USA in adults older than 50 years is 18.2%, 18% and 14.5%, respectively; and be-

tween 10.8 - 20.5% in women. Only 4-7% of them occasionally referred symptoms of intermittent claudication.

There is few published data in Cuba; but a study carried out in Havana City between 2008-2010 placed peripheral artery disease as the seventh leading cause of death with prevalence among women, 15.6%¹⁰. It should be noted that most of the studies in the world deal with the most common complications of this disease, such as amputation of one or both limbs, the existence of treatment-resistant lower limb ulcers, critical ischemia, functional impotence or decreased physical ability of patients. The amputation incidence whether or not below the knee is 120-500 per million inhabitants among the general population¹¹. After 2 years of below-knee amputation, 30% of patients die, 15% require above-knee amputation, another 15% contralateral amputation; and only 40% keep full mobility after surgery^{11,12}.

LL-PAD can be either symptomatic or asymptomatic, it is uncommon before age 50, and has a gradual balance in both sexes as they grow older, same as coronary artery disease. Symptoms range from intermittent claudication with pain, which increases when walking, in the calves (LL-PAD), thighs and buttocks (Aorto-iliac occlusive disease), isolated in buttocks (hypogastric arteries, bilateral, severe), or permanent coldness in feet and ulcers, to severe ischemia and gangrene¹³.

LL-PAD is closely related to cardiovascular diseases. The presence of coronary artery disease stratifies an individual as «at risk» after his diagnosis; but the risk category would also be higher if LL-PAD was associated, with possible compromise of other vascular systems (brain, kidney, mesentery, vertebral arteries)^{10,14,15}.

Ischemic heart disease is the leading cause of death in developed countries, ours is not exempt from this epidemiological evidence. It remains being the second leading cause of death, after cancer in Sancti Spiritus province¹⁶. It is also the first reason for admission to the Department of Cardiology and Cardiovascular Rehabilitation in this town, and makes a great social, psychological, familial and economic impact. The possibility to incorporate these patients to society and to their family, with full capacities after rehabilitation sessions, encourages daily work.

During cardiovascular rehabilitation sessions, during AMI convalescence, patients unable to move forward with the used technique (Modified Bruce Protocol, Naughton or heart failure on treadmill) were found as the ergometer test was performed, due to the appearance of claudication symptoms in the lower limbs, a fact that also hinders comprehensive cardiovascular stratification in order to incorporate them to physical exercise, and underestimates the evaluation or diagnosis of ischemic heart disease and the patient's functional capacity.

Therefore it was decided to design a comprehensive rehabilitation program for those patients having LL-PAD and AMI during convalescence, when they were admitted to the Cardiac Rehabilitation Department in this province; so it was necessary to determine the magnitude of the LL-PAD and design a protocol which would permit carrying out an adjusted ergometer test and incorporate them to a rehabilitation program, initially for LL-PAD and then for cardiovascular disease, in order to improve their physical abilities and social integration.

METHOD

An observational, descriptive, prospective study was conducted in the rehabilitation department from the "Hospital Provincial General Docente Camilo Cienfuegos" in Sancti Spiritus, from January 2013 to April 2014.

Out of the patients admitted to the provincial re-

habilitation department were selected those with AMI with or without ST-segment elevation in convalescence, with LL-PAD symptoms and signs during the initial ergometer test to be incorporated to physical activity and who consented to participate in the research (written informed consent); so the intentional sample was composed by 28 patients. Patients with coronary artery disease associated with another nonischemic variety of cardiovascular disease and those with limitations for physical activity were excluded from the study.

The clinical stratification and diagnosis of LL-PAD were based on the recommendations given by Guindo *et al.*¹⁷ and the Canadian Society¹⁸ regarding Fontaine and Rutherford classifications.

LL-PAD Evaluation Method¹⁹⁻²³

All of the patients entering the cardiovascular rehabilitation gym undergo an ankle-brachial index (ABI) measuring when they incorporate. It is a simple procedure, available in every Department of Angiology of the country's hospitals; it is performed through a Doppler device that measures the systolic blood pressure in the right upper limb and both lower extremities at the level of the posterior tibial and peroneal arteries. Each result is divided by the right arm measured value and ABI is determined.

It was considered the presence of severe LL-PAD with $ABI \leq 0.9$ and $ABI \geq 1.4$ (incompressible or calcified arteries), -other authors propose $ABI \geq 1.3$ ¹⁷- and normal when ABI was between 0.91-1.39. Measurement was performed at rest to gather every finding in all patients; though it can be performed immediately after exercise, when a pressure drop in any limb > 20 mmHg predicts severe LL-PAD, and tensions ≤ 50 mmHg establishes a poor healing in the patient if undergoes surgery or presents lower limb ulceration.

LL-PAD Ergometer test

When LL-PAD was already diagnosed, every patient with $ABI \leq 0.9$ and $ABI \geq 1.4$ underwent a treadmill test with an adjusted protocol for the disease (Naughton: speed of 3.2 km/h slope 10°)^{24,25}, where the start and relief time of symptoms were set, whether or not stopping the test, accompanying symptoms and the rest of the usual ergometer test variables: exercise time, percentage of the maximum heart rate, maxi-

imum myocardial oxygen consumption (MVO_2) and metabolic equivalents or energy output (MET), where 1 MET = 3.5 ml of oxygen per kg weight per minute.

LL-PAD Training program^{8,25}

Physical exercise from the designed training program was conducted on treadmill for more than 3 months. A speed of 3.2 km/h with a 10° slope, and a minimum exercise time of 30 minutes per session were originally scheduled with 3 to 5 minutes intervals and periods of active or passive rest of 5 minutes. The load was gradually increased according to the patient's tolerance.

As training finished an ergometer test was performed to reevaluate the LL-PAD and, a week later, another test (modified Bruce or Naughton protocol), limited by symptoms, was applied in order to assess the cardiovascular disease, according to the diagnosis so the patient was referred to rehabilitation sessions.

Follow up loss

Three patients left the physical training program, one of them requiring an abdominal surgery and the rest for an early reincorporation to work.

Ethics

This work was approved by the Hospital Research Ethics Committee and patients showed compliance by signing the written informed consent.

RESULTS

It was observed a male predominance (67.8%) and the age groups between 55-59 (35.7%) and 60-64 (28.6%) years in patients with LL-PAD and AMI convalescence phase (Table 1). Both of them accounted for more than half of the sample. Although the number of patients is equal between 60-64 years in both sexes, women were much better represented; a relatively younger age was found in men. It is evident the increasing prevalence of this disease from 50 years on, 89.3% of patients being this age.

Table 1. Patients with peripheral and coronary artery disease in rehabilitation program. January 2013 – April 2014.

Age groups	Female	Male	Total
40 – 44	0 (0,0)	1 (5,26)	1 (3,6)
45 – 49	0 (0,0)	2 (10,52)	2 (7,1)
50 – 54	2 (22,22)	5 (26,31)	7 (25,0)
55 – 59	3 (33,33)	7 (36,84)	10 (35,7)
60 – 64	4 (44,44)	4 (21,05)	8 (28,6)
Total	9 (100)	19 (100)	28 (100)

Values express n (%).

Table 2. Diagnosis of coronary artery disease at admission in cardiovascular rehabilitation (n=28).

Enfermedad coronaria	Nº	%
NSTACS	12	42,86
STACS	9	32,14
PCI	5	17,86
CABG	5	17,86

CABG: coronary artery bypass graft surgery; PCI, percutaneous coronary intervention; NSTACS, non-ST segment elevation acute coronary syndrome; STACS: ST segment elevation acute coronary syndrome.

The main diagnosis for those patients who were referred to cardiac rehabilitation (Table 2) was acute coronary syndrome: with (42.85%) or without ST-segment elevation (32.14%). Minor representation had those who underwent percutaneous coronary intervention and coronary artery bypass graft surgery.

Patients with $ABI \leq 0.9$ predominated in both sexes (Table 3), but it only achieved a statistically significant difference, compared to $ABI \geq 1.4$, in men ($p=0.002$). The most common risk factor found in the study was hypertriglyceridemia (82.1%). Smoking (75%; $p=0.005$) and diabetes mellitus (28.6%; $p=0.001$) were significantly related to the presence of $ABI \leq 0.9$.

The comparison between the mean values of ABI before and after the training program was completed for patients with LL-PAD (Table 4) shows an improvement in those with a $ABI \leq 0.9$ in both sexes (0.89 to 1.00 in women and 0.73 to 1.06 in men). Val-

Table 3. Characteristics of the patients according to the ankle-brachial index results.

Parameters	Ankle-brachial index		p
	≤ 0.9	≥ 1.4	
Female	8 (28,6)	1 (3,6)	0,163
Male	17 (60,7)	2 (7,1)	0,002
Smoking	21 (75,0)	2 (7,1)	0,005
Diabetes mellitus	8 (28,6)	1 (3,6)	0,001
Body mass index	19 (67,9)	2 (7,1)	0,872
Hypertension	11 (39,3)	1 (3,6)	0,231
Hypertriglyceridemia*	23 (82,1)	2 (7,1)	0,230

Values express n (%), n=28.

* Triglycerides > 1,7 mmol/L

ues did not change in patients with ABI≥1.4, so it was not found improvement after the completion of the training program.

When comparing the two ergometer tests for LL-PAD at the beginning and after three months of supervised physical activity, exercise time (4:21 vs. 10: 9 minutes) and onset of pain (2:31 vs. 7:6 minutes) increased more than twofold, without stopping the march, despite the onset of pain in the lower limbs, which eased faster than the initial test (5:6 vs. 1 minute). The heart rate, MVO₂ and therefore metabolic equivalents also experienced a clear improvement (Table 5).

DISCUSSION

Atherosclerosis is a systemic disease that affects the entire vascular endothelium, so the LL-PAD and ischemic heart disease share the same risk factors^{1,2,25}.

In this research, where both diseases were present, men and age older than 50 years prevailed. It is known that women show less cardiovascular events than men in younger ages; but after menopause, their untreated risk factors, comorbidities, such as diabetes mellitus and less physical activity, favor an equal or greater chance of developing atherosclerotic disease at any level^{4,26-29}. In addition, many women in the study used to smoke until the cardiovascular ischemic event ap-

peared. Regardless of these factors, it is important to note that the fewer number of females studied could be because they incorporate less frequently into the activity of cardiovascular rehabilitation in our health area.

The fewer number of patients with percutaneous coronary intervention and coronary artery bypass graft surgery is related to the absence of this kind of health service in our province so the sick should go to Villa Clara's Cardiology Hospital.

Classic risk factors such as hypertriglyceridemia, smoking, hypertension and diabetes mellitus were the most related to the prevalence of LL-PAD. Several studies^{2,3,11,30}

have shown that hypertension has a 2.8 of relative risk for developing fatal cardiovascular events in patients with LL-PAD. Others, on the natural history of intermittent claudication, indicate that there is a low risk of losing the lower limb in patients without diabetes mellitus (≤2%); however, the risk to progress to a limb-loss-threatening is-

Table 4. Ankle-brachial index before and after rehabilitation.

Ankle-brachial index	Initial		Final	
	Female	Male	Female	Male
≤ 0,9	8 (0,89)	17 (0,73)	-	-
0,91 – 1,39	0 (0,0)	0 (0,0)	7 (1,00)	15 (1,06)
≥ 1,4	1 (1,43)	2 (1,45)	1 (1,43)	2 (1,45)

Values express n (X̄)

Table 5. Mean values on the ergometer test for patients with peripheral artery disease before and after rehabilitation.

Variables	Ergometer test (X̄)	
	Initial (n=28)	Final (n=25)
Exercise time (min:seg)	4:21	10:9
Onset of pain (min:seg)*	2:31	7:6 ^Ω
Pain relief (min:sec)**	5:6	1
Máximum reached HR(%)	65,8	87,3
MVO ₂ (ml/kg/min)	33,5	46,4
MET	5,1	6,2

* Exercise minutes ** Rest minutes

^ΩDoes not suspend the march.

HR: heart rate; MET: metabolic equivalents; min: minutes; MVO₂: myocardial oxygen consumption; sec: seconds.

chemia that is multiplied by three among patients with diabetes; and the risk increases between 20-25% for each 0.1 unit decrease in ankle-brachial index^{1,2,30}.

Smoking predominance in men is related to what has been published in literature where cultural and historical patterns are addressed as the main causes for this behavior. There is a high prevalence of this bad habit among Cuban population³¹, one of the main risk factors to develop peripheral artery disease. It has been observed a higher mortality risk in smokers than in those who do not smoke, and in those who smoke more than 25 cigarettes a day the LL-PAD risk is 15 times higher. Smoking cessation produces symptoms regression, and therefore a disease improvement when is not terminal. Smoking is the individual modifiable risk factor with greater impact on the development of LL-PAD, and affects the patients' quality of life with greater economic and social impact^{31,32}.

Cardiovascular diseases are the leading cause of death in patients with intermittent claudication and the annual rate of cardiovascular events for different causes is 5-7%^{25,29}; hence LL-PAD exercise therapy is also directed to reduce cardiovascular risk resulting from changes that occur in the endothelium during physical activity performance: decreased vascular inflammation, improvement in endothelial function, and arterial stiffness. In addition, it also increases insulin sensitivity, helps control both blood glucose and glycosylated hemoglobin levels, reduces low-density lipoproteins (LDL), increases high-density lipoproteins (HDL) and improves fibrinolytic activity^{25,33-36}.

Supervised exercise determined a significant difference in the patients' physical capacity with $ABI \leq 0.9$, including index improvement at the end of the scheduled training period. The answer is implicit in the benefits of physical activity on vascular changes that occur in atherosclerosis and those which overlap when risk factors are involved, such as diabetes mellitus, smoking, dyslipidemia and hypertension. Muscles blood flow recovering improves efficient energy uptaking steps by producing greater oxygen extraction from the arteries of the lower limbs and improve endothelium-dependent vasodilation, types I and II fibers are also increased, capillary density and type IIb fibers decrease, which improves the muscle resistance³⁷⁻⁴¹.

In this research, patients with $ABI \geq 1.4$ only showed relative improvement in physical capacity, which is because these injuries are more complex,

calcified, thickened and sometimes occlusive, which determines a more extensive compromise of the arterial vessels.

Exercise time increases by improving tolerance to physical activity; besides, onset of pain or claudication time prolongs, without stopping the march, and MVO_2 and the necessary heart rate to perform the cardiovascular ergometer test increase²⁵. Each MET achieved improves survival in 12-13%, less than 8 minutes duration ergometer test has a relative risk of 4.54 for cardiovascular death when compared to 11 minutes duration, and MVO_2 less than 27.6 ml/kg/min has a relative risk of 3.09 for cardiovascular death compared to $MVO_2 > 37.1$; therefore, this diagnostic test allows a comprehensive assessment of cardiovascular patients thus obtaining the necessary elements to complete their training³⁹⁻⁴¹.

Life expectancy of patients with LL-PAD, AMI or cerebrovascular disease (CVD), decreases between 14.9 and 16 years; however, if a patient with previous CVD presents a new CVD or AMI event, life expectancy would be reduced to 5 years. On the other hand, the existence of LL-PAD coupled with an AMI or a CVD, would reduce it to only 1.5 years; and the existence of a previous AMI plus reinfarction or CVD reduces this expectancy to less than 5 months (Framingham study)^{2,3,11,30}.

The LL-PAD is clinically stratified according to Fontaine and Rutherford classifications, patients in I-IIa Fontaine score or 0-I Rutherford (mild) have a mortality rate of 20-30%, 5 years after diagnosis; in both authors' major stage classifications, this increases to 75%, 5 years after the symptoms appear^{17,18}.

It is important to highlight, for the differential diagnosis with other diseases which have similar symptoms, that claudication by LL-PAD is exercise-triggered, reproducible at the same travelled distance, relieved by rest and is not produced with bipedalism. It must be differentiated from spinal stenosis, arthritis, venous congestion and compartment syndrome. There are current important treatments that attempt to return the patient's clinical stability by controlling risk factors, using drugs, angioplasty and stenting, bypass surgery, and -less used-, supervised exercise therapy^{4,11,12,42,43}.

CONCLUSIONS

Supervised physical activity improved the symp-

toms of LL-PAD patients with $ABI \leq 0.9$ and their exercise tolerance, allowing a better assessment of coronary artery disease, better risk stratification and, therefore, their incorporation to cardiovascular rehabilitation programs. Using it in daily practice ensures greater adherence to rehabilitation treatment which is effective and safe.

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