Physical activity level in individuals with peripheral arterial disease: a systematic review

Nível de atividade física em indivíduos com doença arterial periférica: uma revisão sistemática

João Paulo dos Anjos Souza Barbosa[1], Patrícia Maria Henriques[1], Mauro Virgílio Gomes de Barros[1], Nelson Wolosker[2], Raphael Mendes Ritti-Dias[1]

Abstract

Background: Individuals with peripheral arterial disease (PAD) have reduced levels of physical activity. Studies on this subject have important methodological differences that vary in relation to the characteristics of the individuals, the instruments used to measure physical activity, the strategies employed to classify their level of physical activity and the outcomes measured.
Objective: To describe the physical activity level of individuals with peripheral arterial disease and to analyze the influence of physical activity level in health parameters in these individuals.
Methods: A systematic review of original studies published in English in MEDLINE, LILACS and SciELO databases, up to 2010.
Results: Of the 16 articles included in this review, 94% were published in 2000 or later. The accelerometer was the most frequent method used to quantify the levels of physical activity. Reduced levels of physical activity were observed in individuals with PAD, when compared to individuals without the disease. Among the individuals with PAD, the highest levels of physical activity were associated with better hemorheological, hemodynamic and body composition parameters.
Conclusion: Individuals with peripheral arterial disease have lower levels of physical activity than individuals without the disease. Among individuals with the disease, those who are more physically active have better health parameters.

Keywords: peripheral arterial disease; motor activity; review.

Resumo

Contexto: Indivíduos com doença arterial periférica (DAP) apresentam níveis de atividade física diminuídos. Os estudos sobre essa temática apresentam diferenças metodológicas, que variam em relação às características dos indivíduos estudados, aos instrumentos utilizados para a medida da atividade física e as estratégias empregadas para classificação do nível de atividade física e os desfechos analisados.
Objetivo: Descrever o nível de atividade física de indivíduos com DAP e analisar a relação do nível de atividade física nos indicadores de saúde desses indivíduos.
Métodos: Foi realizada uma revisão sistemática de estudos originais publicados, em periódicos indexados nas bases de dados eletrônicas MEDLINE, LILACS e SciELO, até 2010.
Resultados: Dos 16 artigos incluídos na revisão, 94% foram publicados a partir do ano 2000. O método mais utilizado para quantificação dos níveis de atividade física foi o acelerômetro. Foram verificados menores níveis de atividade física nos indivíduos com DAP em comparação a indivíduos sem a doença. Dentre os indivíduos com DAP, o maior nível de atividade física foi associado a melhores indicadores hemorreológicos, hemodinâmicos e de composição corporal.
Conclusão: Indivíduos com DAP apresentam menores níveis de atividade física que indivíduos sem a doença. Dentre os indivíduos com a doença, aqueles que são mais ativos fisicamente apresentam melhores indicadores de saúde.

Palavras-chave: doença arterial periférica; atividade motora; revisão.

Study carried out at the Physical Education School of University of Pernambuco (UPE) – Recife (PE), Brazil.
[1] Physical Education School of UPE – Recife (PE), Brazil.
[2] Hospital Israelita Albert Einstein – São Paulo (SP), Brazil.
Conflict of interest: nothing to declare.
Submitted on: 07.16.11. Accepted on: 09.13.11.
J Vasc Bras. 2011;11(1):22-28.

Introduction

Peripheral arterial disease (PAD) is a result of atherosclerotic plaques that progressively leads to partial or total obstruction of the arteries that supply the limbs. In Brazil, PAD affects around 21.6% of individuals over 60 years of age[1].

Intermittent claudication (IC) is the main symptom of PAD, characterized by pain in the limbs with the disease during walking, quickly relieved by resting[2]. This symptom results in important limitations in walking and reduced levels of patients' physical activity[3]. In addition, it has been suggested that lower levels of physical activity of individuals with PAD would be related to a worse prognosis and to increase morbidity and mortality of these patients[4].

Over the last few years, several studies have described the level of physical activity of individuals with PAD and analyzed the impact of the physical activity level on health parameters of these individuals[5-7]. However, studies on this subject show important methodological differences, which variations in the characteristics of the individuals under study, in the instruments used to measure physical activity, the strategies employed to classify the level of physical activity and the outcomes measured.

In the face of such variety of information, it is necessary to synthesize the results of the studies that have analyzed the level of physical activity of individuals with PAD in order to properly present the current knowledge of this subject. Thus, the objectives of this study were to describe, through a systematic review, the level of physical activity of individuals with PAD and analyze the influence of physical activity level in health parameters of these individuals.

Methods

To carry out the present study, a systematic review was performed of original studies that analyzed the level of physical activity in individuals with PAD, published in English in MEDLINE, LILACS and SciELO databases. Each stage of the review process (from the electronic database search to the selection and evaluation of potential articles and the extraction of data from eligible studies) was performed by pairs of investigators in an independent manner. The results of each stage were compared by a third investigator, to check for any disagreement between investigators. In case of any divergence, the third investigator performed the final analysis.

The electronic database search (stage 1) was performed using advanced search tools on databases, that enable the combination of descriptors and terms and the application of search limits. The search using the descriptors and terms was made in the *Medical Subject Headings* (MeSH), on the website of *U.S. National Library of Medicine* (NLM), and in the Descritores em Ciências da Saúde (DeCS), on the Biblioteca Virtual em Saúde (BVS). The following descriptors were used: "motor activity", "exercise", "walking", peripheral arterial diseases", intermittent claudication" and "arterial occlusive diseases", as well as their corresponding terms in Portuguese: "atividade motora", "exercício", "caminhada", "claudicação intermitente", "doença vascular periférica" and "arteriopatias oclusivas". The search was limited to the studies conducted with human beings published up to 2010 in English. Figure 1 shows the procedures used in the review.

Stage 2 consisted in the analysis of the publications titles, followed by the analysis of abstracts of the publications identified through the electronic search strategy and judgement of publications which pertained to this review. In addition, the bibliographical references of the articles included in the review were analyzed to identify other studies related to the physical activity level of individuals with PAD that had not been identified through the electronic search. The exclusion criteria adopted were: review studies, case studies or comments, studies without any method to quantify the physical activity level, studies of instrument validation, studies involving other diseases and risk factors.

In stage 3, the investigators read the full texts of all eligible articles and a judicious analysis was performed of the information content of each article. The following aspects were observed in the analysis of each article included in the study: (a) publication year, (b) sample size, (c) characteristics of individuals (age, ankle-brachial index, presence of symptoms of the disease), (d) physical activity measurement instrument, (e) variables analyzed and (f) main results.

The analysis identified six studies that compared the physical activity level of individuals with and without PAD. Five other studies compared the physical activity level of individuals with PAD with different characteristics, such as history of falls and no history of falls, deceased and surviving individuals, individuals with different severities of the disease according to the ankle-brachial index (ABI) and individuals engaged and not engaged in systematic programs of physical activity. Five other studies were analyzed, which stratified patients with PAD according to the physical activity level and correlated them to hemodynamic, metabolic, hemorheological and body composition characteristics. Data from these studies were grouped into three tables.

Results

Sixteen original articles were identified, which investigated the physical activity level of individuals with PAD, published until 2010; 94% of them were published in 2000 or later, the number of individuals in the studies ranged from 22 to 540 and the most frequent method to quantify the physical activity levels was the accelerometer, used in 11 studies. All articles included in the review were registered in the MEDLINE database. No additional article was identified from the analysis of bibliographical references of these studies. Figure 2 shows the flow diagram of the selection of studies included in the review.

DeCS/MeSH – Termos/Terms
Atividade motora/Motor activity or Exercício/Exercise or Caminhada/Walking
AND
Doença vascular periférica/Peripheral arterial diseases or Claudicação intermitente/Intermittent claudication or Arteriopatias oclusivas/Arterial occlusive diseases
Limites/Limits
Humanos/Humans Data de Publicação: 0 até 2010/Publication date: 0 to 2010

Figure 1. Descriptors and terms used in the electronic search MeSH – *Medical Subject Headings*; DeCS – Descritores em Ciências da Saúde.

The six studies that compared the physical activity level of individuals with PAD to individuals without PAD (Table 1) observed lower levels of physical activity in individuals with PAD. The difference between the groups ranged from 13 to 205%. One of these studies compared the physical activity level of individuals with PAD to the level of individuals with no disease, using different methods to measure the physical activity and the results indicated differences between the groups from 72% (accelerometer) to 107% (LTPA questionnaire), depending on the method employed[5]. Another study compared the number of steps at

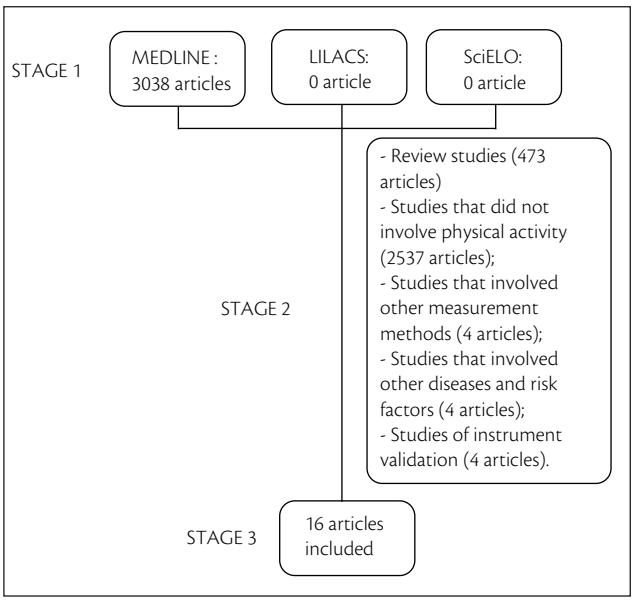

Figure 2. Flow diagram of the selection of studies included in the review.

Table 1. Summary of the studies that compared the physical activity levels of patients with peripheral arterial disease to control individuals.

Author	Groups	Measurement instrument	Variables analyzed	Main results
Sieminski and Gardner[5]	PAD (n=85) CG (n=59)	LTPA JSC PAS Accelerometer Pedometer	LTPA (Kcal/day) JSC PAS Accelerometer (Kcal/day) Pedometer (steps/day)	PAD < CG (123±164 *vs.* 251±254) (p<0.001) PAD < CG (1.4±1.0 *vs.* 2.8±1.9) (p<0.001) PAD < CG (357±238 *vs.* 616±363) (p<0.001) PAD < CG (4,737±2,712 *vs.* 8,672±4,235) (p<0.001)
McDermott et al.[7]	PAD (n=225) CG (n=121)	Accelerometer	Number of activity units (Kcal)	PAD < CG (784±426 *vs.* 1,109±640) (p<0.001)
McDermott et al.[13]	PAD (n=460) CG (n=280)	Accelerometer	Number of activity units (Kcal)	PAD < CG (600 kcal *vs.* 1,200 kcal)
Crowther et al.[27]	CG (n=25) PAD (n=28)	Pedometer	Number of steps Distance covered (Km) Energy spent (Kcal)	PAD < CG (29,093±4,008 *vs.* 47,038±3,524) (p<0.02) PAD < CG (17±2 *vs.* 30±2) (p=0.001) PAD < CG (1,149±170 *vs.* 1,847±154) (p<0.02)
Gardner et al.[3]	CG (n=129) PAD (n=98)	StepWatch3	number of steps/min. at low pace number of steps/min. at medium pace number of steps/min. at high pace	PAD = CG (1,155±460 *vs.* 1,308±430) (p=0.257) PAD < CG (1,228±660 *vs.* 1,638±724) (p=0.001) PAD < CG (766±753 *vs.* 1,285±1,029) (p<0.001)
Crowther et al.[28]	CG (n=11) PAD (n=11)	Pedometer	Number of steps Distance covered (Km) Energy spent (Kcal)	PAD < CG (18,554±17,519 *vs.* 45,603±13,157) (p<0.01) PAD < CG (9.9±10.4 *vs.* 30.2±9.3) (p<0.01) PAD < CG (653±576 *vs.* 1,954±694) (p<0.01)

DAP – peripheral arterial disease; GC – control group; LTPA – Leisure Time Physical Activity; JSC PAS – Johnson Space Center Physical Activity Scale.

Table 2. Summary of the studies that compared the physical activity levels of individuals with peripheral arterial disease to different characteristics.

Author	Groups	Measurement instrument	Variables analyzed	Main results
Gardner and Montgomery[29]	WOHF (n=346) WHF (n=120)	Accelerometer	Units of PA	WOHF > WHF (p<0.001)
Garg et al.[4]	Surviving (n=326) Deceased (n=134)	Accelerometer	Units of PA	Surviving > deceased (p=0.02)
Gardner and Clancy[6]	High ABI (n=94) Medium ABI (n=164) Low ABI (n=84)	LTPA	LTPA	High ABI > Medium ABI > Low ABI (p=0.03)
			LTPA - low intensity	High ABI = Medium ABI = Low ABI (p=0.54)
			LTPA - moderate intensity	High ABI > Medium ABI > Low ABI (p<0.02)
			LTPA - high intensity	High ABI > Medium ABI > Low ABI (p<0.01)
McDermott et al.[30]	3-7 times/without (n=143) 1-2 times/without (n=83) Not active (n=191)	Accelerometer	Units of PA	3-7 times/without > 1-2 times/without> Not active (p<0.01)
Gardner et al.[11]	Sedentary (n=299) Active (n=135)	JSC	PA Scale	Active >sedentary (p<0.001)

PA – Physical Activity; ABI – arm-brachial index; W – walking; LTPA – Leisure Time Physical Activity, JSC PAS – Johnson Space Center Physical Activity Scale; WOHF – without history of falls; WHF – with history of falls.

Table 3. Summary of the studies that analyzed hemodynamic, hemorheological and body composition variables of individuals with peripheral arterial disease to different levels of physical activity.

Author	n	Instrument	PA categorization	Variables analyzed	Main results
McDermott et al.[26]	188	Accelerometer	Quintiles (Units of PA)	Dimers-D (μg/mL)	Q1>Q2<Q3>Q4>Q5 (p=0.002)
				Prothrombin F1+2 (nmol/L)	Q1<Q2>Q3<Q4>Q5 (p<0.001)
				C-reactive protein (mg/dL)	Q1<Q2>Q3<Q4>Q5 (p=0.014)
				Tissue plasminogen activator (t-PA)	Q1=Q2=Q3=Q4=Q5 (p=0.164)
				Plasminogen activator inhibitor (PAI-1)	Q1=Q2=Q3=Q4=Q5 (p=0.109)
				t-PA/PAI-1 ratio	Q1=Q2=Q3=Q4=Q5 (p=0.506)
Craft et al.[22]	403	Accelerometer	Quartiles (Units of PA)	C-reactive protein (mg/mL)	Q1>Q2>Q3<Q4 (p=0.00)
				Isoleucine-6 (pg/mL)	Q1>Q2>Q3=Q4 (p<0.001)
				Homocysteine (μmol/L)	Q1>Q2=Q3=Q4 (p=0.00)
				Intercellular adhesion molecule (ICAM) (ng/mL)	Q1>Q2<Q3>Q4 (p=0.02)
				Vascular cell adhesion molecule (VCAM) (ng/mL)	Q1>Q2>Q3>Q4 (p<0.001)
Gardner and Killewich[21]	106	Accelerometer	Tertiles (Energy spent – Kcal)	Dimers-D (μg/mL)	Q1>Q2>Q3<Q4 (p=0.00)
				t-PA	T1<T2<T3(p<0.05)
				PAI-1	T1 >T2 >T3 (p<0.05)
Payvandi et al.[9]	111	Accelerometer	Tertiles (Units of PA)	Initial diameter of brachial artery (mm)	T1>T2>T3 (p=0.042)
				Flow (mm^3/s)	T1=T2=T3 (p=0.446)
				Heart rate	T1=T2=T3 (p=0.184)
				Brachial artery diameter 60 sec after reactive hyperemia (mm)	T1=T2=T3 (p=0.188)
				Δ Brachial artery diameter with reactive hyperemia (mm)	T1>T2<T3 (p=0.0008)
				Δ Brachial flow diameter (%)	T1 >T2<T3 (p=0.0003)
McDermott et al.[8]	439	Accelerometer	Tertiles (Units of PA)	Calf muscle area (mm^2)	T1<T2<T3(p<0.01)
				Calf muscle density (mg/cm^3)	T1<T2<T3(p<0.01)

PA – physical activity

different paces and observed that individuals with PAD are less active at medium and high walking paces[3].

Five studies compared the physical activity level of individuals with PAD who had different characteristics. (Table 2). The results indicated that the individuals without history of falls, surviving, with lower disease severity and engaged in systematic programs of physical activity presented higher physical activity levels.

Table 3 shows the studies that analyzed hemorheological, hemodynamic and body composition variables in individuals with PAD and different levels of physical activity. The results of the studies that analyzed hemorheological

variables found a negative association of physical activity level with levels of inflammatory and platelet aggregation markers. However, for coagulation markers, the results were controversial, as one study observed a negative association of physical activity levels with levels of coagulation markers and another study did not observe any significant association. Only one study analyzed the hemodynamic variables, with the results indicating a positive association of the physical activity level with the initial diameter of brachial artery, the size of brachial artery diameter with reactive hyperemia and the size of the brachial flow diameter with reactive hyperemia.

Only one study analyzed the body composition variables, with the results indicating a positive association of physical activity levels with calf muscle area and calf muscle density.

Discussion

The main findings of this study were: (i) the physical activity level of individuals with PAD is lower than the level of those with no disease; (ii) among the individuals with PAD, lower levels of physical activity are observed in those with higher severity of the disease, with history of falls and in those not engaged in systematic physical activity programs; and (iii) individuals with PAD with higher levels of physical activity showed better health parameters.

Most studies used direct methods, with the accelerometer as the most frequently used method[3,4,8,9]. This is an interesting aspect, as the accelerometer is considered an instrument sensitive to movement intensity and quantity and it is more reliable and durable than the spring mechanisms, such as the pedometer[10]. The accelerometer is more precise when the prevailing activity is walking, and, since this is the main type of physical activity of individuals with PAD, the utilization of accelerometers seems more adequate to this population. However, some studies also used indirect methods, such as *The Minnesota Leisure Time Physical Activity questionnaire* (LTPA) and the *The Johnson Space Center Physical Activity Scale* (JSC PAS) to quantify the physical activity level of individuals with PAD. Although the validation of these methods is questionable in this population[3,5,6,11,12], the results of one of the studies included in this review showed that these methods allow the comparison of individuals with and without PAD, providing similar results to those that used direct methods[5].

All studies included in the review showed that individuals with PAD are less physically active than individuals with no disease. In addition, the analysis showed that individuals with PAD perform from 13 to 205% less physical activity than individuals with no disease, depending on the analyzed instrument and variable. The lower level of physical activity of individuals with PAD was already expected and can be explained by the symptoms of IC, which make patients perform less physical activity to avoid the occurrence of these symptoms. Indeed, one of the studies observed that the individuals with PAD are less active particularly in activities of moderate and high intensity[3]. As IC symptoms in these patients occur earlier when they practice more intense physical activities, the patients probably avoid physical activities of moderate and high intensity to prevent the occurrence of IC symptoms.

Among the factors that seem to be related to the physical activity level of individuals with PAD, the disease severity seems to be one of the most important. One study showed that individuals with lower ABI, the main indicator of disease severity, were those with lowest levels of physical activity[6]. Studies have indicated that the severity of PAD limits the individual's participation in physical activities due to a number of reasons[6,7,13]. First, the ABI is an indication of low blood flow to peripheral muscles[14]. Second, the individuals with higher disease severity present lower walking efficiency, which can also cause IC symptoms[15]. Lastly, studies have shown that the higher disease severity is related to impaired metabolic capacity to produce energy through the aerobic pathways[16,17]. All these factors make individuals with higher PAD severity to present IC symptoms earlier, resulting in greater functional limitation.

Another interesting result was observed in a follow-up study included in this review. The study showed that physical activity level of individuals with PAD that died was significantly lower than in surviving individuals[4]. These results show that reduced physical activity in daily life predicts a higher index of cardiovascular morbidity and mortality in individuals with PAD[4,11]. These results are similar to those from studies performed in other populations showing that more physically active individuals present lower cardiovascular morbidity and mortality[18-20].

According to the results of this review, individuals with PAD who have higher physical activity level present better levels of inflammatory, hemodynamic and body composition markers[8,9,21,22]. PAD is a marker of atherosclerotic risk, caused by different factors that include inflammation[23]. As mentioned above, the main indicator of PAD prognosis is the ABI, but some studies suggest that inflammation can independently affect the susceptibility of individuals with PAD to future cardiovascular events[24,25]. In order to possibly postpone those events, individuals with PAD have to include physical activity practices, for leading to symptomatic improvement, besides reducing inflammatory markers[23].

The association of muscle mass indicators with higher physical activity level observed in individuals with PAD seems to be related to a higher tolerance to walking in individuals with higher muscle mass in the leg[8,26]. This way, it seems that larger muscle mass may favor the walking capacity, enabling increased levels of physical activity in patients with PAD.

The current review has some limitations. Out of the studies selected for review, it can be noticed that, even though differences were detected between the groups with PAD and individuals with no disease, it is not known whether the quality of such studies may have compromised the power of recommending or not the use of the interventions under analysis. Another limitation is that those are all cross-sectional studies and it was not possible to establish a cause-effect relation in them.

Conclusion

The results of this review allow the conclusion that most studies indicate that individuals with PAD present lower levels of physical activity than the individuals with no the disease. In addition, among the individuals with PAD, those who are more physically active present better health parameters.

Acknowledgements

We would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the master's degree program scholarship.

References

1. Makdisse M, Pereira AC, Brasil DP, et al. Prevalência e fatores de risco associados à doença arterial periférica no projeto corações do Brasil. Arq Bras Cardiol. 2008;91:402-14.
2. Locatelli EC, Pelizzari S, Scapini KB. Exercícios físicos na DAOP. J Vasc Bras. 2009;8(3):247-54.
3. Gardner AW, Montgomery PS, Scott KJ, et al. Patterns of ambulatory activity in subjects with and without intermittent claudication. J Vasc Surg. 2007;46(6):1208-14.
4. Garg PK, Tian L, Criqui MH, et al. Physical activity during daily life and mortality in patients with peripheral arterial disease. Circulation. 2006;114(3):242-8.
5. Sieminski DJ, Gardner AW. The relationship between free-living daily physical activity and the severity of peripheral arterial occlusive disease. Vasc Med. 1997;2(4):286-91.
6. Gardner AW, Clancy RJ. The relationship between ankle-brachial index and leisure-time physical activity in patients with intermittent claudication. Angiology. 2006;57(5):539-45.
7. McDermott MM, Greenland P, Ferrucci L, et al. Lower extremity performance is associated with daily life physical activity in individuals with and without peripheral arterial disease. J Am Geriatr Soc. 2002;50(2):247-55.
8. McDermott MM, Guralnik JM, Ferrucci L, et al. Physical activity, walking exercise, and calf skeletal muscle characteristics in patients with peripheral arterial disease. J Vasc Surg. 2007;46(1):87-93.
9. Payvandi L, Dyer A, McPherson D, et al. Physical activity during daily life and brachial artery flow-mediated dilation in peripheral arterial disease. Vasc Med. 2009;14(3):193-201.
10. Melansson EL, Freedson PS. Physical activity assessment: A review of methods. Crit Rev Food Sci Nutr. 1996;3650:385-96.
11. Gardner AW, Montgomery PS, Parker DE. Physical activity is a predictor of all-cause mortality in patients with intermittent claudication. J Vasc Surg. 2008;47(1):117-22.
12. Sieminski DJ, Cowell LL, Montgomery PS, et al. Physical activity monitoring in patients with peripheral arterial occlusive disease. J Cardiopulm Rehabil. 1997;17(1):43-7.
13. McDermott MM, Greenland P, Liu K, et al. The ankle brachial index is associated with leg function and physical activity: the Walking and Leg Circulation Study. Ann Intern Med. 2002;136(12):873-83.
14. Hirsch AT, Haskal ZJ, Hertzer NR, et al. ACC/AHA 2005 Practice Guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease): endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. Circulation. 2006;113(11):e463-654.
15. Gardner AW, Montgomery PS, Ritti-Dias RM, et al. The effect of claudication pain on temporal and spatial gait measures during self-paced ambulation. Vasc Med. 2010;15(1):21-6.
16. Brass EP, Hiatt WR, Green S. Skeletal muscle metabolic changes in peripheral arterial disease contribute to exercise intolerance: a point-counterpoint discussion. Vasc Med. 2004;9(4):293-301.
17. Hiatt WR, Regensteiner JG, Hargarten ME, et al. Benefit of exercise conditioning for patients with peripheral arterial disease. Circulation. 1990;81(2):602-9.
18. Dorn JP, Cerny FJ, Epstein LH, et al. Work and leisure time physical activity and mortality in men and women from a general population sample. Ann Epidemiol. 1999;9(6):366-73.
19. Oguma Y, Sesso HD, Paffenbarger RS, Jr., et al. Physical activity and all cause mortality in women: a review of the evidence. Br J Sports Med. 2002;36(3):162-72.
20. Haapanen N, Miilunpalo S, Vuori I, et al. Characteristics of leisure time physical activity associated with decreased risk of premature all-cause and cardiovascular disease mortality in middle-aged men. Am J Epidemiol. 1996;143(9):870-80.

21. Gardner AW, Killewich LA, Katzel LI, et al. Relationship between free-living daily physical activity and peripheral circulation in patients with intermittent claudication. Angiology. 1999;50(4):289-97.

22. Craft LL, Guralnik JM, Ferrucci L, et al. Physical activity during daily life and circulating biomarker levels in patients with peripheral arterial disease. Am J Cardiol. 2008;102(9):1263-8.

23. Brevetti G, Giugliano G, Brevetti L, et al. Inflammation in peripheral artery disease. Circulation. 2010;122(18):1862-75.

24. Criqui MH, Langer RD, Fronek A, et al. Mortality over a period of 10 years in patients with peripheral arterial disease. N Engl J Med. 1992;326(6):381-6.

25. Newman AB, Shemanski L, Manolio TA, et al. Ankle-arm index as a predictor of cardiovascular disease and mortality in the Cardiovascular Health Study. The Cardiovascular Health Study Group. Arterioscler Thromb Vasc Biol. 1999;19(3):538-45.

26. McDermott MM, Criqui MH, Greenland P, et al. Leg strength in peripheral arterial disease: associations with disease severity and lower-extremity performance. J Vasc Surg. 2004;39(3):523-30.

27. Crowther RG, Spinks WL, Leicht AS, et al. Relationship between temporal-spatial gait parameters, gait kinematics, walking performance, exercise capacity, and physical activity level in peripheral arterial disease. J Vasc Surg. 2007;45(6):1172-8.

28. Crowther RG, Spinks WL, Leicht AS, et al. Effects of a long-term exercise program on lower limb mobility, physiological responses, walking performance, and physical activity levels in patients with peripheral arterial disease. J Vasc Surg. 2008;47(2):303-9.

29. Gardner AW, Montgomery PS. The relationship between history of falling and physical function in subjects with peripheral arterial disease. Vasc Med. 2001;6(4):223-7.

30. McDermott MM, Liu K, Ferrucci L, et al. Physical performance in peripheral arterial disease: a slower rate of decline in patients who walk more. Ann Intern Med. 2006;144(1):10-20.

Correspondence
Raphael Mendes Ritti Dias
Universidade de Pernambuco
Rua Arnóbio Marques, 310 – Santo Amaro
CEP 50100-130 – Recife (PE), Brazil
E-mail: raphaelritti@gmail.com

Author's contributions
Conception and design: JPASB, RMR, NW
Analysis and interpretation: JPASB, PMH, MVGB, RMR
Data collection: JPASB, PMH
Writing: JPASB, RMR
Critical analysis: RMR, MVGB, NW
Final approval*: JPASB, PMH, MVGB, NW, RMR
Statistical analysis: AV, MPR
Overall responsibility: BM
* All authors have read and approved the final version submitted to J Vasc Bras.