Rev Port Cardiol. 2014;33(7-8):425–430

Revista Portuguesa de
Cardiologia
Portuguese Journal of Cardiology
www.revportcardiol.org

ORIGINAL ARTICLE

Treadmill walking with load carriage increases aortic pressure wave reflection

Fernando Ribeiro[a,b,*], **Nórton L. Oliveira**[b], **Joana Pires**[b], **Alberto J. Alves**[b,c], **José Oliveira**[b]

[a] *School of Health Sciences, University of Aveiro, Aveiro, Portugal*
[b] *Research Centre in Physical Activity, Health and Leisure (CIAFEL), Faculty of Sport, University of Porto, Porto, Portugal*
[c] *Higher Institute of Educational Sciences, Felgueiras, Portugal*

Received 9 September 2013; accepted 30 November 2013
Available online 21 August 2014

KEYWORDS
Augmentation index;
Arterial stiffness;
Isodynamic exercise;
Pulse wave analysis

Abstract
Introduction and objectives: The study examined the effects of treadmill walking with load carriage on derived measures of central pressure and augmentation index in young healthy subjects.
Methodology: Fourteen male subjects (age 31.0 ± 1.0 years) volunteered in this study. Subjects walked 10 minutes on a treadmill at a speed of 5 km/h carrying no load during one session and a load of 10% of their body weight on both upper limbs in two water carboys with handle during the other session. Pulse wave analysis was performed at rest and immediately after exercise in the radial artery of the right upper limb by applanation tonometry.
Results: The main result indicates that walking with load carriage sharply increased augmentation index at 75 bpm (−5.5 ± 2.2 to −1.4 ± 2.2% vs. −5.2 ± 2.8 to −5.5 ± 2.1%, $p<0.05$), and also induced twice as high increments in central pulse pressure (7.4 ± 1.5 vs. 3.1 ± 1.4 mmHg, $p<0.05$) and peripheral (20.5 ± 2.7 vs. 10.3 ± 2.5 mmHg, $p<0.05$) and central systolic pressure (14.7 ± 2.1 vs. 7.4 ± 2.0 mmHg, $p<0.05$).
Conclusions: Walking with additional load of 10% of their body weight (aerobic exercise accompanied by upper limb isometric contraction) increases derived measures of central pressure and augmentation index, an index of wave reflection and arterial stiffness.

* Corresponding author.
E-mail addresses: fernando.ribeiro@ua.pt, fernando.silva.ribeiro@gmail.com (F. Ribeiro).

http://dx.doi.org/10.1016/j.repc.2013.11.012

PALAVRAS-CHAVE
Índice de aumentação;
Rigidez arterial;
Exercício isodinâmico;
Análise da onda de pulso

Caminhar na passadeira rolante com transporte de peso aumenta a reflexão da onda de pressão aórtica

Resumo
Introdução e objetivos: O presente estudo avaliou os efeitos de caminhar na passadeira rolante transportando uma carga adicional nos membros superiores em parâmetros derivados de pressão central e índice de aumentação de jovens aparentemente saudáveis.
Metodologia: 14 sujeitos do sexo masculino (idade de 31,0 ± 1,0 anos) participaram no estudo. Os sujeitos caminharam 10 minutos na passadeira rolante a uma velocidade de 5 km/h, sendo que numa sessão não transportaram carga adicional e noutra sessão transportando 10% do seu peso corporal nos membros superiores em dois garrafões de água. A análise da onda de pulso foi efetuada em repouso e imediatamente após o exercício na artéria radial do membro superior direito por tonometria de aplanação.
Resultados: Os principais resultados indicam que caminhar transportando peso nos membros superiores aumenta marcadamente o índice de aumentação a 75 batimentos por minuto (−5,5 ± 2,2 para −1,4 ± 2, 2% *versus* −5,2 ± 2,8 para −5.5 ± 2,1%, p<0,05), a pressão de pulso central (7,4 ± 1,5 *versus* 3,1 ± 1,4 mmHg, p<0,05), a pressão de pulso periférica (20,5 ± 2,7 *versus* 10,3 ± 2,5 mmHg, p<0,05) e a pressão sistólica central (14,7 ± 2,1 *versus* 7,4 ± 2,0 mmHg, p<0,05).
Conclusões: Caminhar transportando uma carga adicional de 10% do peso corporal nos membros superiores (exercício aeróbio acompanhado de contração isométrica dos músculos dos membros superiores) aumenta medidas derivadas da pressão central e o índice de aumentação, um índice de reflexão da onda e rigidez arterial.

Table of Abbreviations

Table of Abbreviations

AIx	Augmentation index
AIx@75	AIx at a HR of 75 beats per min
cf-PWV	Carotid-femoral pulse wave velocity
DBP	Diastolic blood pressure
HR	Heart rate
PP	Pulse pressure
PWV	Pulse wave velocity
SBP	Systolic blood pressure
VO2	Oxygen uptake

Introduction

In the last decade, arterial stiffness has emerged as an important predictor of cardiovascular and all-cause mortality in the context of cardiovascular diseases.[1–3] Increased arterial stiffness induces several harmful hemodynamic consequences including increases in systolic blood pressure (SBP) and pulse pressure (PP),[4] which are related to systolic and diastolic cardiac dysfunction at a central level,[5] augmented cardiac load, and reduced coronary perfusion.[6] In fact, arterial stiffness is an important factor in the balance between the myocardial blood supply and the demand, with implications to myocardial work capacity impacting on exercise capacity and cardiovascular risk.[7]

The ''gold standard'' non-invasive measure of aortic wall stiffness is the carotid-femoral pulse wave velocity (cf-PWV), also called aortic pulse wave velocity (PWV).[8] Aortic PWV has been suggested as a strong and independent predictor of cardiovascular and all-cause mortality in subjects with coronary artery disease, renal disease, hypertension, or diabetes.[3,8] Another measure related to arterial stiffness can be derived from the analysis of pulse wave in peripheral arteries, such as the radial artery, using applanation tonometry.[3,9] This noninvasive method provides an index of pulse-wave reflection and arterial stiffness, called augmentation index (AIx), which reflects the degree of aortic pressure augmentation relative to central pulse pressure.[3,9] AIx denotes the difference in amplitude between incident and reflected pulse waves expressed as a percentage of pulse pressure.[9] Likewise aortic PWV, AIx has been shown to be an independent predictor of cardiovascular events and mortality in cardiovascular patients.[2,10–12]

Exercise training alone or incorporated in a cardiac rehabilitation program promotes positive effects on several aspects, including endothelial dysfunction, vascular wall inflammation, and arterial stiffness related indexes (e.g. aortic PWV and AIx).[13–16] In contrast to chronic exercise, an acute bout of exercise increases transiently AIx both in healthy subjects.[17,18] Also in cardiovascular disease patients,[19] a single bout of aerobic exercise of moderate intensity increased proximal arterial stiffness expressed by increases in carotid systolic blood pressure, pulse pressure (PP) and PP amplification.

If the aerobic exercise is known to acutely increase PWV, central pressures and AIx, less is know regarding isodynamic exercise. In fact, the hemodynamic parameters and energy