

Assessment of Central Blood Pressure and Arterial Stiffness in Practicing Long-Distance Walking Race

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Abstract

Background: An ecological hiking occurs yearly in Brazil. It is a unique event because of its distance (310 km) and dynamics (mean of 62 km/day for 5 days with mean pace of 7.6 km/h). Although beneficial effects of moderate-intensity exercises are well-known, the effects of intense and long-duration exercise still require study.

Objective: To evaluate the effects of mixed walking/running race on various blood pressure (BP) parameters 30 days before (A0), on the 2nd (A2), 3rd (A3), and 4th (A4) days after completing the day's stage.

Methods: Central systolic (cSBP) and diastolic BP (cDBP), peripheral systolic (pSBP) and diastolic BP (pDBP), central pulse pressure (cPP), peripheral pulse pressure (pPP), amplified pulse pressure (aPP), corrected augmentation index (AIx75%) and pulse wave velocity (PWV) were measured using an oscillometric Mobil-O-Graph® (IEM, Stolberg, Germany) in 25 male athletes (mean age of 45.3 ± 9.1 years). A p value < 0.05 was considered a statistically-significant difference.

Results: cSBP decreased from A0 to A2 (109.5 to 118.1 mmHg) and from A0 to A3 (109.5 to 102.5 mmHg); pPP decrease from A0 to A2 (49.2 to 38.2 mmHg) and from A0 to A4 (49.2 to 41.2 mmHg); aPP decrease from A0 to A1 (15.6 to 9.5 mmHg), from A0 to A2 (15.6 to 8.0 mmHg) and from A0 to A3 (15.6 to 11.2 mmHg). PWV correlated with age.

Conclusions: Blood pressure dropped on the first days of the race and returned to close to baseline values at the end. PWV correlates strongly with age. This type of exercise promotes effects on BP and PWV similar to those seen in long-duration, high-intensity sports. These changes in trained healthy individuals do not seem to increase cardiovascular risks. This was the first study to assess the effects of this type of exercise on the cardiovascular system. (Int J Cardiovasc Sci. 2017;30(6)510-516)

Keywords: Hypertension; Blood Pressure; Vascular Stiffness; Exercise; Walking; Pulse Wave Analysis.

Introduction

Regular moderate exercise can reduce the risk of coronary heart disease through various mechanisms, including changes in cardiovascular risk factors,¹ such as glucose, lipid metabolism and blood pressure (BP) values and weight control. The protective effects of moderate exercise on the cardiovascular system are well-established.² The same is not true for long-distance

walking and vigorous exercise, whose effects on the cardiovascular system remain unclear.³

A mixed walking/running race takes place every July in Goiás state, in central western Brazil. Athletes cover 310 km in 5 days (62 km/day, on average), with stops for lunch and sleep. Women and men participate in the event and enrol voluntarily. Those selected undergo physical fitness tests and a cardiorespiratory evaluation. Men complete the

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entire course and women approximately 50%. The race ranges between fast walking and running, the average speed being 7.6km/h. No study has evaluated the effects of this type of exercise on the cardiovascular system.

The evaluation of parameters of central BP measurement and arterial stiffness, which assess aortic and peripheral pressure, vascular resistance and pressure variations throughout the arterial tree, may help improve understanding of changes in the cardiovascular system due to exercise.⁴ One parameter that should be emphasized is pulse wave velocity (PWV), which measures arterial stiffness, a factor highly predictive of cardiovascular events. In addition, arterial stiffness is associated with systolic BP (SBP) and pulse pressure (PP).⁵ The lower the PWV, the more elastic and compliant the arteries. Therefore, high PWV values reflect greater arterial stiffness.⁶ Age and physical activity can change the PWV.^{7,8}

This study studied the effects of prolonged exercise on central BP measurement in athletes during this race in Goiás.

Methods

This longitudinal study evaluated men who participated in the race in Goiás, Brazil in July 2014. The race covered 310 km and lasted 5 days. The average distance covered was 62 km/day, and the average speed was 7.6 km/h. The mean temperature of the course was 30°C (range 18-42).

The initial assessment (A0) was carried out at a specialized medical centre, and other evaluations (A2, A3 and A4) were conducted at the end of each race day in the cities where the athletes slept. Assessments included measurements of central systolic and diastolic BP (cSBP and cDBP), peripheral systolic and diastolic BP (pSBP and pDBP), central PP (cPP), peripheral PP (pPP), amplified PP (aPP), corrected augmentation index (AIx75%), PWV and total vascular resistance (TVR) using a Mobil-OGraph® oscillometric device (IEM, Stolberg, Germany). Measurements were obtained from the right upper limb with the participant seated, arms at heart level, after resting for ≥ 5 minutes.

Measurements were carried out before dinner at the end of each day. For the initial assessment, a complete medical history was taken. Due to technical problems, no assessment was made at the end of the first day of walking. Women were excluded from the study because

they had a significant difference in all BP measurements and did not cover the entire course.

The medical history included the following variables: age (in years), body mass index (kg/m²), smoking (yes/no), physical activity (sufficiently active/insufficiently active), diabetes mellitus (yes/no), dyslipidemia (yes/no) and hypertension (yes/no). Sufficiently active was defined as self-reported exercise of any type for ≥ 150 minutes weekly.⁹

This study was approved by the Ethics and Research Committee of Pontifícia Universidade Católica de Goiás (number 612.800, April 09, 2014). All participants gave written informed consent.

Statistical analysis

All participants in the ecological hiking were evaluated. Descriptive statistics are presented as means, standard deviation, confidence intervals (quantitative variables with normal distribution) and absolute and relative frequencies (qualitative variables). The statistical analysis was carried out using the Statistical Package for the Social Sciences® (SPSS), version 20.0. Shapiro-Wilk test was used to determine the distributions of the quantitative variables data. Variables related to BP measurement were compared using repeated-measures analysis of variance (ANOVA), followed by a Bonferroni post hoc test. For correlations between BP variables and age, Pearson's correlation coefficient was used. A p value <0.05 was considered a statistically significant difference.

Results

We included 25 men with a mean age of 45.3 ± 9.1 years (range 27.8-60.8). All participants engaged in physical exercise regularly, and the mean body mass index was 23.1 ± 2.6 kg/m². No participant was a smoker, and three had risk for cardiovascular disease (Table 1).

All parameters of central BP measurement and arterial stiffness were within normal levels in all assessments. cSBP decreased from A0 (113.8 ± 2.1 mmHg) to A2 (107.3 ± 1.7 mmHg) and to A3 (105.7 ± 1.6 mmHg). pPP decreased from A0 (49.2 ± 1.7 mmHg) to A2 (38.2 ± 1.8 mmHg) and to A4 (41.2 ± 1.2 mmHg). aPP increased from A0 (15.6 ± 1.3 mmHg) to A2 (9.5 ± 0.7 mmHg) to A3 (11.2 ± 0.8 mmHg) and to A4 (8.2 ± 0.3 mmHg). There was no difference between the means of other variables (Table 2).

In all evaluations, PWV was strongly correlated with age (Figure 1).

Table 1 – General health characteristics of participants in the race in Goiás, Brazil, 2014 (n = 25)

Sample characterization	n (%)
Age	
< 40	7 (2)
≥ 40	18 (72)
Exercise	
Sufficiently active	23 (92)
Insufficiently active	2 (8)
Diabetes mellitus	
Yes	1 (4)
No	24 (96)
Dyslipidemia	
Yes	1 (4)
No	24 (96)
Systemic arterial hypertension	
Yes	1 (4)
No	24 (96)

Discussion

This is the first study to evaluate effects of a mixed walking/running race on parameters of central BP measurement and arterial stiffness. Values of peripheral and aortic BP in the initial assessment were within the normal range. BP decreased at the beginning of walking and returned to initial values on the last days of the race. Therefore, between the start and finish of the event, it seems that no significant changes occurred in these parameters. These findings support the vasodilation potency of this type of moderate-intensity and long-duration exercise.

Endurance athletes may present arterial remodelling, which causes an accommodation of pressure during and after exercise. The ability of the arteries of the skeletal muscle to vasodilate, promoted by training, increases the cardiac deficit without relevant repercussions in BP. This elasticity of the arterial vessels in response to physical activity suggests arterial adaptation, which is indispensable to the performance of endurance athletes.¹⁰ Runners participating in marathons in Seoul¹¹ and Athens¹² showed a reduction in both DBP

and SBP at the event's beginning and end. In our study, this behaviour was also identified regarding central BP measurement.

The PWV values of participants in our study were within the reference ranges for healthy individuals: 7.0 m/s for this age range.¹³ We found high values compared to controls performing moderate physical exercise.¹² Therefore, because of the small amount of specific training, consisting of a few hours of training weekly, and the fact that the participants' cardiovascular parameters matched reference values, we believe that the group assessed in our study was composed of active individuals, but not professional athletes.

There was no significant change in PWV in different measurements throughout the walking event, but we observed a trend towards a reduction in the first 3 days. A study that analysed PWV in male athletes participating in a 75-km race found a reduction in PWV after 45 km; beyond that point, there was an increase until 75 km, after which values nearly returned to baseline. We found similar results.¹⁴ Other studies have found no change in PWV before and after exercise in marathon runners,^{11,12} walkers,¹⁵ and runners with high BP.¹⁶ In the latter two studies, the heart rate corresponded to that seen with moderate exercise.

Other studies found a significant reduction in PWV in hypertensive individuals who did running and/or walking¹⁷ and in normotensive individuals who engaged in various types of aerobic exercise (moderate to vigorous).¹⁸⁻²⁰

A systematic review and meta-analysis that evaluated the effects of aerobic exercise on PWV found a reduction in PWV promoted by aerobic exercise. This reduction increased with long-duration exercises, which promote a higher oxygen consumption.²¹ However, reductions in cSBP and PWV have the potential to reduce the risk of additional cardiovascular events, then reinforcing the potential benefit of regular physical activity.⁵

Our study identified a strong positive correlation between PWV and age, as did studies that determined reference values,^{13,22} evaluated and compared competitive athletes and active individuals,²³ and a study in men engaging in moderate exercise using a cycle ergometer.²⁴ Other factors may be associated with PWV, such as BP and the intensity of exercise¹² and body weight.²⁵

Age influences both BP and PWV – the older the age, the higher the BP and PWV. This occurs, amongst other reasons, due to changes in arterial structure. This difference in values found between central BP

Table 2 – Mean, standard deviation and confidence interval (95%) of central blood pressure measurements in participants in the race in Goiás, Brazil, 2014 (n = 25)

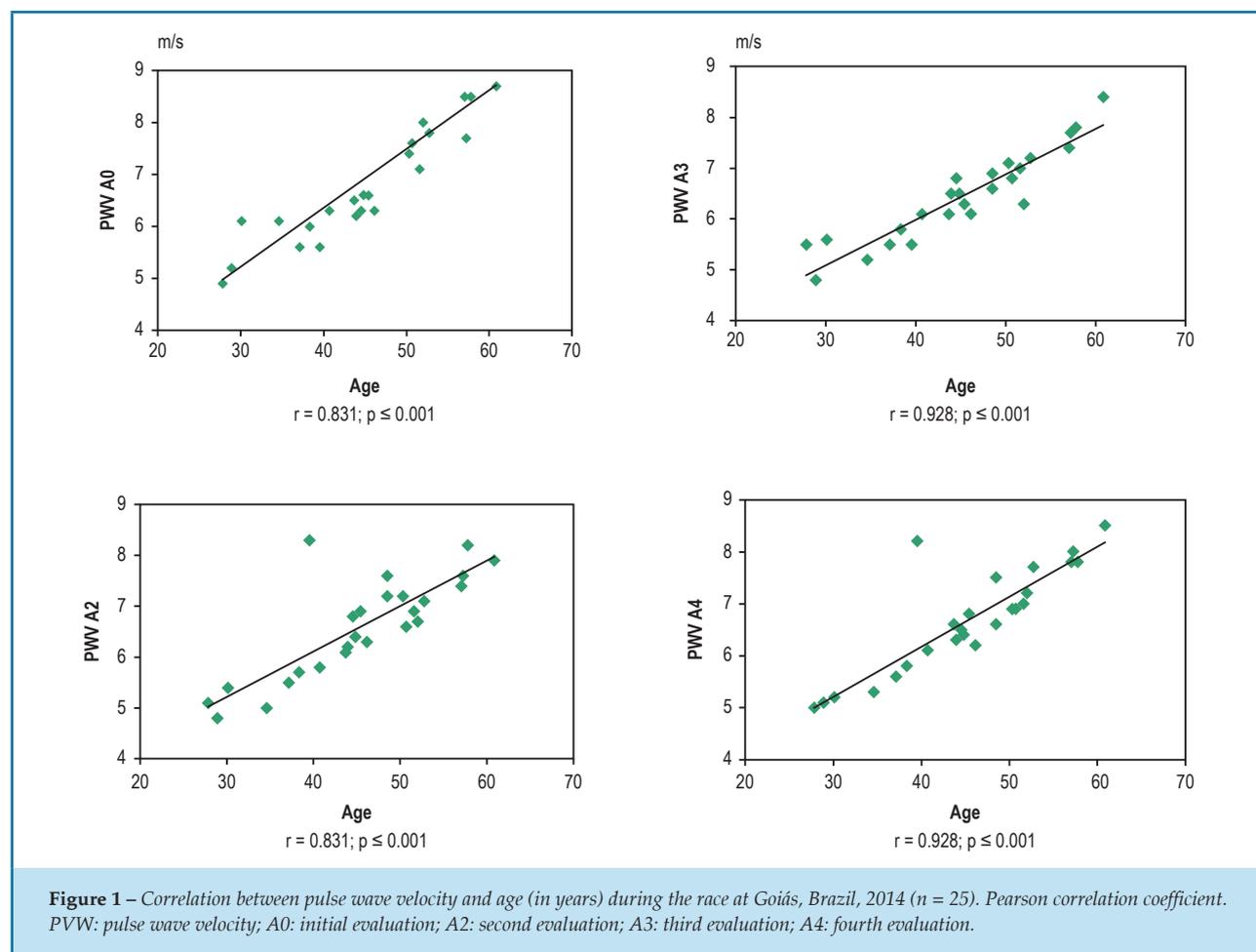
Parameter	Mean ± SD	95% CI	F p	Post hoc	Parameter	Mean ± SD	95% CI	F p	Post hoc
Central systolic blood pressure (mmHg)					Central diastolic blood pressure (mmHg)				
A0	113.8 ± 2.8	109.55-118.13			A0	80.2 ± 1.9	76.28-84.28		
A2	107.3 ± 1.7	103.74-110.97	4.42	A0-A2*	A2	78.6 ± 1.0	76.48-80.80	2.68	
A3	105.7 ± 1.6	102.46-109.06	0.006	A0-A3*	A3	74.2 ± 1.5	71.27-77.29	0.051	-
A4	111.5 ± 1.6	108.22-114.89			A4	78.6 ± 1.7	75.13-82.15		
Peripheral systolic blood pressure (mmHg)					Peripheral diastolic blood pressure (mmHg)				
A0	127.9 ± 1.3	123.07-132.85			A0	78.7 ± 1.8	74.90-82.62		
A2	115.6 ± 1.9	111.70-119.58	0.98	-	A2	77.4 ± 1.1	75.17-79.63	2.65	-
A3	115.6 ± 1.7	112.04-119.32	0.38		A3	73.0 ± 1.4	70.04-75.95	0.053	
A4	118.6 ± 1.5	115.47-121.81			A4	77.4 ± 1.6	73.98-80.90		
Central pulse pressure (mmHg)					Peripheral pulse pressure (mmHg)				
A0	33.5 ± 1.3	30.87-36.25			A0	49.2 ± 1.7	45.62-52.78		
A2	28.7 ± 1.5	25.54-31.90	2.30	-	A2	38.2 ± 1.8	34.33-42.15	7.52	A0-A2*
A3	31.4 ± 1.5	28.27-34.69	0.082		A3	42.6 ± 1.8	38.91-46.45	< 0.001	A0-A4*
A4	32.9 ± 1.2	30.36-35.48			A4	41.2 ± 1.2	38.70-43.70		
Amplified pulse pressure (mmHg)					Corrected augmentation index (%)				
A0	15.6 ± 1.3	1.95-18.33		A0-A1*	A0	13.6 ± 2.0	9.35-17.93		
A2	9.5 ± 0.7	7.99-11.05	13.04	A0-A2*	A2	17.0 ± 2.6	11.60-22.47	0.66	-
A3	11.2 ± 0.8	9.37-13.03	p < 0.001	A0-A3*	A3	13.1 ± 2.1	8.69-17.55	0.580	
A4	8.2 ± 0.3	7.48-9.07			A4	13.4 ± 2.0	9.26-17.70		
Pulse wave velocity (m/s)					Total vascular resistance				
A0	6.9 ± 0.2	6.19-7.01			A0	1.0 ± 0.0	1.00-1.00		
A2	6.6 ± 0.2	6.19-7.01	1.06	-	A2	1.0 ± 0.0	1.00-1.00	0.77	-
A3	6.4 ± 0.1	6.14-6.82	0.369		A3	1.0 ± 0.0	1.00-1.00	0.515	
A4	6.6 ± 0.2	6.24-7.12			A4	1.0 ± 0.0	1.00-1.00		

* p < 0.05 (Repeated-measures ANOVA). SD: standard deviation; CI: confidence interval; A0: initial evaluation; A2: second evaluation; A3: third evaluation; A4: fourth evaluation.

and peripheral BP results from the reduction in arterial gauge and compliance as central arteries become peripheral.⁴ Elasticity depends especially on the composition of the vascular media layer. In young and healthy individuals, there is a predominance of elastin over collagen in the central portion of the arterial bed. However, an inversion of collagen proportion exists

in relation to elastin in muscle peripheral arteries. Therefore, the aorta presents greater elasticity compared with the arteries of the limbs, which are more rigid.²⁶

Although this study did not evaluate the effects of inflammatory substances and endothelium adhesion, these factors must be also considered. Variations in PWV



may be related to many adaptations due to moderate aerobic activity that involve increased production of a number of substances with vasodilating and anti-inflammatory properties.^{27,28}

A study that evaluated hypertensive and non-hypertensive ultra-marathon runners, collecting samples after 100 km, 200 km and 308 km (end of the race), identified an increase in vascular cell adhesion molecule 1 (at 100 and 200 km), E-selectin (at 100 km), and leukocytes (at 208 km), which were higher in hypertensive individuals than in normotensive individuals. In both groups, there was a gradual increase in creatine kinase and C-reactive protein. Therefore, vigorous exercise can stimulate more intense endothelial responses in hypertensive individuals, regardless of inflammatory markers.²⁹

Likewise, PWV depends on the arterial structure and the relationship between resistance and elasticity, properties directly related to the amount of collagen and elastin. Therefore, PWV changes are identified over

time; to verify the effects of exercise on this parameter, further long-term, longitudinal studies would be needed to analyse the chronic effects of exercise.²⁶

Our study also did not evaluate variations in mean central BP after the end of the event. However, the acute effect was well analysed and showed that this activity is fairly safe for well-evaluated participants, even without specific training.

Conclusion

Blood pressure dropped in the first days of the race and returned to close to baseline values at the end. PWV correlates strongly with age. Ecological hiking seems to promote effects on arterial pressure and PWV similar to those seen in marathons and other long-duration and high-intensity sports. Changes promoted by this type of exercise in active and healthy individuals do not seem to pose high risks for cardiovascular health.

Author contributions

Conception and design of the research: Pereira EM, Vitorino PVO, Souza WKS, Pinheiro MC, Sousa ALL, Jardim PCB, Rezende JM. Acquisition of data: Pereira EM, Vitorino PVO, Souza WKS, Pinheiro MC, Rezende JM. Analysis and interpretation of the data: Pereira EM, Vitorino PVO, Souza WKS, Pinheiro MC, Rezende JM. Statistical analysis: Pereira EM, Vitorino PVO, Pinheiro MC, Rezende JM. Writing of the manuscript: Pereira EM, Vitorino PVO, Souza WKS, Jardim PCB, Rezende JM. Critical revision of the manuscript for intellectual content: Vitorino PVO, Souza WKS, Sousa ALL, Jardim PCB, Coca A.

References

- Sesso HD, Paffenbarger RS Jr, Lee IM. Physical activity and coronary heart disease in men: The Harvard Alumni Health Study. *Circulation*. 2000;102(9):975-80. PMID: 10961960.
- Thompson PD, Buchner D, Pina IL, Balady GJ, Williams MA, Marcus BH, et al; American Heart Association Council on Clinical Cardiology Subcommittee on Exercise, Rehabilitation, and Prevention; American Heart Association Council on Nutrition, Physical Activity, and Metabolism Subcommittee on Physical Activity. 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):3109-16. doi: 10.1161/01.CIR.0000075572.40158.77.
- O'Keefe JH, Schnohr P, Lavie CJ. The dose of running that best confers longevity. *Heart*. 2013;99(8):588-90. doi: 10.1136/heartjnl-2013-303683.
- McEnery CM, Cockcroft JR, Roman MJ, Franklin SS, Wilkinson IB. Central blood pressure: current evidence and clinical importance. *Eur Heart J*. 2014;35(26):1719-25. doi: 10.1093/eurheartj/ehu565.
- Cecelja M, Chowienczyk P. Dissociation of aortic pulse wave velocity with risk factors for cardiovascular disease other than hypertension: a systematic review. *Hypertension*. 2009;54(6):1328-36. doi: 10.1161/HYPERTENSIONAHA.109.137653.
- Rocha E. [Pulse wave velocity: a marker of arterial stiffness and its applicability in clinical practice]. *Rev Port Cardiol*. 2011;30(9):699-702. doi: 10.1016/S0870-2551(11)70012-9.
- Townsend RR, Wilkinson IB, Schiffrin EL, Avolio AP, Chirinos JA, Cockcroft JR, et al; American Heart Association Council on Hypertension. Recommendations for improving and standardizing vascular research on arterial stiffness: a scientific statement from the American Heart Association. *Hypertension*. 2015;66(3):698-722. doi: 10.1161/HYP.0000000000000033.
- Vlachopoulos C, Xaplanteris P, Aboyans V, Brodmann M, Cifková R, Cosentino F, et al. The role of vascular biomarkers for primary and secondary prevention. A position paper from the European Society of Cardiology Working Group on peripheral circulation: Endorsed by the Association for Research into Arterial Structure and Physiology (ARTERY) Society. *Atherosclerosis*. 2015;241(2):507-32. doi: 10.1016/j.atherosclerosis.2015.05.007.
- World Health Organization. (WHO). The world health report 2002: reducing risks, promoting healthy life. Geneva: 2002.
- Green DJ, Spence A, Rowley N, Thijssen DH, Naylor LH. Vascular adaptation in athletes: is there an 'athlete's artery'? *Exp Physiol*. 2012;97(3):295-304. doi: 10.1113/expphysiol.2011.058826.
- Jung SJ, Park JH, Lee S. Arterial stiffness is inversely associated with a better running record in a full course marathon race. *J Exerc Nutrition Biochem*. 2014;18(4):355-9. doi: 10.5717/jenb.2014.18.4.355.
- Vlachopoulos C, Kardara D, Anastakis A, Baou K, Terentes-Printzios D, Tousoulis D, et al. Arterial stiffness and wave reflections in marathon runners. *Am J Hypertens*. 2010;23(9):974-9. doi: 10.1038/ajh.2010.99.
- Reference Values for Arterial Stiffness Collaboration. Determinants of pulse wave velocity in healthy people and in the presence of cardiovascular risk factors: 'establishing normal and reference values'. *Eur Heart J*. 2010;31(19):2338-50. doi: 10.1093/eurheartj/ehq165.
- Burr JF, Phillips AA, Drury TC, Ivey AC, Warburton DE. Temporal response of arterial stiffness to ultra-marathon. *Int J Sports Med*. 2014;35(8):658-63. doi: 10.1055/s-0033-1358478.
- Choi KM, Han KA, Ahn HJ, Hwang SY, Hong HC, Choi HY, et al. Effects of exercise on sRAGE levels and cardiometabolic risk factors in patients with type 2 diabetes: a randomized controlled trial. *J Clin Endocrinol Metab*. 2012;97(10):3751-8. doi: 10.1210/jc.2012-1951.
- Guimaraes GV, Ciolac EG, Carvalho VO, D'Avila VM, Bortolotto LA, Bocchi EA. Effects of continuous vs. interval exercise training on blood pressure and arterial stiffness in treated hypertension. *Hypertens Res*. 2010;33(6):627-32. doi: 10.1038/hr.2010.42.
- Beck DT, Martin JS, Casey DP, Braith RW. Exercise training reduces peripheral arterial stiffness and myocardial oxygen demand in young prehypertensive subjects. *Am J Hypertens*. 2013;26(9):1093-102. doi: 10.1093/ajh/hpt080.
- Rauramaa R, Halonen P, Väisänen SB, Lakka TA, Schmidt-Trucksäss A, Berg A, et al. Effects of aerobic physical exercise on inflammation and atherosclerosis in men: the DNASCO Study: a six-year randomized, controlled trial. *Ann Intern Med*. 2004;140(12):1007-14. PMID: 15197018.
- Nordstrom CK, Dwyer KM, Merz CN, Shircore A, Dwyer JH. Leisure time physical activity and early atherosclerosis: the Los Angeles Atherosclerosis Study. *Am J Med*. 2003;115(1):19-25. PMID: 12867230.
- Kozáková M, Palombo C, Morizzo C, Nolan JJ, Konrad T, Balkau B; RISC Investigators. Effect of sedentary behaviour and vigorous physical activity on segment-specific carotid wall thickness and its progression in a healthy population. *Eur Heart J*. 2010;31(12):1511-9. doi: 10.1093/eurheartj/ehq092.
- Huang C, Wang J, Deng S, She Q, Wu L. The effects of aerobic endurance exercise on pulse wave velocity and intima media thickness in adults: a systematic review and meta-analysis. *Scand J Med Sci Sports*. 2016;26(5):478-87. doi: 10.1111/sms.12495.

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Study Association

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22. Diaz A, Galli C, Tringler M, Ramirez A, Cabrera Fischer EI. Reference values of pulse wave velocity in healthy people from an urban and rural argentinean population. *Int J Hypertens*. 2014; 2014: 653239. doi: 10.1155/2014/653239.
23. Maldonado J, Pereira T, Polonia J, Martins L. Modulation of arterial stiffness with intensive competitive training. *Rev Port Cardiol*. 2006;25(7-8):709-14. PMID: 17069436.
24. Roberts PA, Cowan BR, Liu Y, Lin AC, Nielsen PM, Taberner AJ, et al. Real-time aortic pulse wave velocity measurement during exercise stress testing. *J Cardiovasc Magn Reson*. 2015;17:86. doi: 10.1186/s12968-015-0191-4.
25. Petersen KS, Blanch N, Keogh JB, Clifton PM. Effect of weight loss on pulse wave velocity systematic review and meta-analysis. *Arterioscler Thromb Vasc Biol*. 2015;35(1):243-52. doi: 10.1161/ATVBAHA.
26. Safar ME, Frohlich ED. *Atherosclerosis, large arteries, and cardiovascular risk*. Basel (Switzerland): Karger; 2007.
27. Barroso WK, Jardim PC, Vitorino PV, Bittencourt A, Miquetichuc F. Influência da atividade física programada na pressão arterial de idosos hipertensos sob tratamento não-farmacológico. *Rev Assoc Med Bras*. 2008;54(4):328-33.
28. Barroso WK. Benefícios da atividade física na hipertensão arterial e orientações práticas. *Rev Bras Hipertens*. 2004;11:115-6.
29. Jee H, Park J, Oh JG, Lee YH, Shin KA, Kim YJ. Effect of a prolonged endurance marathon on vascular endothelial and inflammation markers in runners with exercise-induced hypertension. *Am J Phys Med Rehabil*. 2013;92(6):513-22. doi: 10.1097/PHM.0b013e31829232db.