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BRIEF COMMUNICATION

Physical Activity is Inversely Associated With Arterial Stiffness in Adult Males: A Brief Communication

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of death worldwide [1]. Arterial stiffness (AS) is an independent risk factor for CVDs' development [2], acting secondarily in the atherosclerotic process, chronic low-grade inflammation and endothelial dysfunction [3]. The increased AS results in systemic pressure overload, reduced coronary perfusion and higher risk of myocardial ischaemia; interventions decreasing AS reduce cardiovascular morbidity and mortality [3].

Although AS primarily increases with age, it might be also be influenced by lifestyle factors, such as physical activity (PA) and smoking [4]. Literature highlights that increased PA levels play an important role in primary/secondary prevention of CVDs [5]. Despite being a potential factor influencing AS, previous studies [6–8] have failed to show an association between PA levels and AS possibly due to methodological limitations. One of which is the use self-reported questionnaires to assess PA [9–11], which are known to overestimate the PA levels, particularly moderate to vigorous PA (MVPA) [12] which is considered the most related to health benefits [13,14]. Objective evaluation may, at least partially, overcome this methodological limitation. In addition, despite knowledge that gender influences variables related to AS [15], there are few studies focussed only on men. Therefore, we aim to assess the association between PA and AS in adult men.

Material and Methods

Participants

One-hundred and ten (110) apparently healthy men between 40 and 65 years old were randomly selected from the database of the primary health care centre of Aldoar (Porto, Portugal). Exclusion criteria were: established CVD; previous cerebrovascular or cardiovascular event; pulmonary and renal disorders; acute inflammatory, infectious or immunological disorders. Those participants on medication must have had stable medication for at least the 6 months preceding the study. Participants provided written informed consent, the procedures observed the Declaration of Helsinki and the ARS Norte Ethics Committee approved the study.

Procedures and Assessments

Participants were invited by phone and those eligible were asked to perform the assessments at the health care centre during the morning period. A detailed description of the procedures can be found elsewhere [16]. In brief, participants were instructed to refrain from strenuous exercise and to avoid consuming caffeine/alcohol for 24 hours before the evaluations. First, sociodemographic, clinical and medication data were recorded. Then, weight and height were evaluated and waist circumference was measured at the midpoint between the lowest rib and iliac crest. Then, participants rested for 20 minutes in a semi-dark room (21 °C) before the assessment of blood pressure and AS. Arterial stiffness was evaluated,

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Table 1 Characteristics of the participants.

Variable	Values
Age (years)	55.3 ± 7.31
Weight (kg)	81.5 ± 11.23
Height (m)	1.68 ± 0.06
Waist circumference (cm)	99.2 ± 9.83
Body mass index (kg/m^2)	28.5 ± 3.29
Normoponderal	12 (12.2%)
Overweight	56 (57.1%)
Obesity Class I	25 (25.50%)
Obesity Class II	5 (5.10%)
Smokers	29 (29.6%)
Hypertensive	74 (75.5%)
Diabetics	26 (26.5%)
Diabetes mellitus type I	1 (3.8%)
Diabetes mellitus type II	25 (96.2%)
Dyslipidaemia	85 (86.7%)
Medication	
Antihypertensive (%)	60.2%
Antihyperglycaemic (%)	23.5%
Antidyslipidaemic (%)	43.9%
Physical Activity	
Steps/day	8367.2 ± 3568.08
Physical activity index (counts/min)	368.7 ± 173.08
Sedentary time (min/day)	484.8 ± 88.12
Light physical activity (min/day)	282.7 ± 86.81
Moderate to vigorous physical activity (min/day)	39.7 ± 29.14
≥30 min/day of moderate to vigorous physical activity	55 (56.10%)
Peripheral Blood Pressure	
Systolic blood pressure (mmHg)	132.5 ± 14.82
Diastolic blood pressure (mmHg)	80.0 ± 9.31
Mean peripheral blood pressure (mmHg)	99.8 ± 10.99
Arterial Stiffness:	
cfPWV (m/s)	10.1 ± 1.68
cfPWV (m/s) ≤ 10 m/s	51 (52%)
cfPWV (m/s) > 10 m/s	47 (48%)

Values are mean ± SD or absolute frequency (%).
Abbreviation: cfPWV, carotid-femoral pulse wave velocity; BMI, body mass index.
Criteria for diabetes are based on fasting blood glucose level >125 mg/dL or current treatment with insulin or oral antidiabetic agents; hypertension, based on seated blood pressure ≥ 140 and/or 90 mm Hg or antihypertensive treatment; overweight, based on BMI ≥25 <30 kg/m^2; obesity, based on BMI ≥30 kg/m^2; and hyperlipidaemia, based on fasting total cholesterol ≥190 mg/dL or use of antidyslipidaemic medication.

according to the guidelines, using the gold standard carotid-femoral pulse wave velocity (cfPWV) [17,18] by the SphygmoCor (AtCor Medical, West Ryde, NSW, Australia) [19]. A cfPWV >10 m/s was considered as a cut-off value for the risk of CVDs development [2]. Finally, participants received an accelerometer (ActiGraph GT1 M, Florida, USA) and were asked to use it over the right hip, for 7 consecutive days, during the waking hours. The average minutes/day spent at different PA intensities (min/day) was determined according to cut points relating counts/min to PA [20].

Statistical Analysis

The statistical analysis was performed with the software PASW Statistics 20 (SPSS IBM Corporation, Armonk, NY, USA), with a significance level of 0.05. Data normality was tested using Kolmogorov-Smirnov test. Pearson's correlation was used to analyse the relationship between cfPWV and the other variables; then, partial correlation was used controlling for age. Multivariate linear regression (Stepwise) was used to determine the cfPWV predictors. Comparisons between compliers and not compliers with the WHO recommendations for daily MVPA (30 min/day) [21] and between those with a cfPWV >10 m/s and ≤10 m/s were performed with independent t-test.

Results

Of the 110 participants, 12 did not have valid AS measures. Consequently, the final sample encompasses 98 male subjects (Table 1). Overall, the MVPA was 39.7 ± 29.1 min/day and the cfPWV was 10.1 ± 1.68 m/s. The number of participants (56.1%) meeting the MVPA recommendations was slightly higher than those not meeting (43.9%) (56.76 ± 28.53 min/day vs. 17.9 ± 6.69 min/day of MVPA, $p < 0.05$). Just over half (52%) of the participants presented a cfPWV ≤ 10 m/s (8.89 ± 0.80 vs. 11.41 ± 1.36 m/s, $p < 0.05$). Those meeting the MVPA recommendations showed lower cfPWV (9.76 ± 1.52 m/s vs. 10.53 ± 1.79 m/s, $p < 0.05$).

The cfPWV was associated with age ($r = 0.43$, $p < 0.001$), light physical activity (LPA) ($r = -0.24$, $p < 0.05$), MVPA ($r = -0.20$, $p < 0.05$), PA index ($r = -0.25$, $p < 0.05$) and systolic blood pressure (SBP) ($r = 0.22$, $p < 0.05$). Body mass index was correlated with SBP ($r = 0.24$, $p < 0.05$). When adjusted for age, only LPA ($r = -0.25$, $p = 0.01$) and SBP ($r = 0.23$, $p = 0.02$) were correlated with cfPWV.

The cfPWV predictive variables are presented in Table 2. In the first model, age explained 18% of the cfPWV variation. Age and antihyperglycaemic medication explained 29%; when adding, LPA the model explained 34% of the variation of cfPWV. In the fourth model, age, antihyperglycaemic medication, LPA and MVPA explained 37%.

Discussion

The main results indicate that both higher LPA and MVPA are associated with lower cfPWV and those meeting MVPA recommendations showed lower cfPWV.

Although the evaluation of the ageing effects on AS was not the aim of this study, ageing seems to be a determinant for PWV

Table 2 Multiple Linear Regression Analysis (Stepwise) for the predictors age, waist circumference, systolic blood pressure, body mass index, light physical activity, moderate to vigorous physical activity, antihyperglycaemic, antihypertensive and antidyslipidaemic medicaments in carotid-femoral pulse wave velocity.

Carotid-Femoral Pulse Wave Velocity (dependent variable)			
	R Square	β	p
Model (r = 0.43)	0.18		
Age		0.43	<0.001
	Adjusted R Square	β	p
Model (r = 0.55)	0.29		
Age		0.39	<0.001
Antihyperglycaemic		0.35	<0.001
	Adjusted R Square	β	p
Model (r = 0.60)	0.34		
Age		0.38	<0.001
Antihyperglycaemic		0.36	<0.001
Light Physical Activity		-0.23	0.005
	Adjusted R Square	β	p
Model (r = 0.63)	0.37		
Age		0.35	<0.001
Antihyperglycaemic		0.39	<0.001
Light Physical Activity		-0.23	0.004
Moderate to Vigorous Physical Activity		-0.20	0.015

[18]. Therefore, our sample was composed of middle-aged men, who have possibly suffered the effects of ageing on vascular structure and AS, and in whom the adoption of a healthy lifestyle could mitigate the effects of age on vascular health [4]. In line with our findings, other studies also showed similar results in middle-age adults, even after adjustments [22,23]. Ageing leads to structural/functional vessels alterations which may be amplified by the presence of CVD risk factors [4]. In this sense, the adoption of a healthy lifestyle could mitigate the ageing effects on vascular health [4].

Previous studies reporting the association between PA and cfPWV have shown results similar to ours; they reported a negative correlation between LPA and cfPWV [25]; and also showed that those with higher MVPA showed lower cfPWV [13]. However, another study showed no correlation [14], while another investigation displayed a positive correlation between LPA and cfPWV [26]; and that MVPA was not related to, or a predictor of, cfPWV [26–28]. Several reasons could explain these contrasting results; the methods used to assess physical activity (e.g. objective measures, different types of questionnaires), the characteristics of the sample, namely age and sex, and the time of the year (e.g. winter or summer season) in which the PA data was collected. In this study, PA was measurement by accelerometry, instead of questionnaires since such a method has been associated with lower validity and reliability [12]. We included only males, because there were reported gender-related differences in AS [24]; in this sense, we aimed to increase the sample homogeneity and prevent methodological bias related to gender.

Some limitations should be acknowledged. This brief report is a cross-sectional investigation, which limits the establishment of causal inferences regarding PA influence on AS. It is possible that the presence in our sample of different risk factors and their severity could have influenced cfPWV in different magnitudes. Also, we acknowledge that the use of medication may have beneficial effects on AS [29], although there were no significant differences between the cfPWV of those taking antihypertensive medication (n = 59) and those classified as hypertensive but not taking (n = 15) antihypertensive medication (10.39 ± 1.88 vs. 9.82 ± 1.06 m/s, p = 0.13). Thus, we cannot completely exclude that the positive impact of PA could have been underestimated due to the inclusion of patients under antihypertensive medicaments. Finally, although we adjusted all models for multiple variables, the influence of residual confounders cannot be excluded.

Conclusion

Greater daily time spent in LPA and MVPA time are associated with lower cfPWV in middle-aged adults. Additionally, higher LPA is correlated with lower cfPWV, even after adjusting for age.

Disclosure Statement

The authors declare no conflict of interest.

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