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Relationship between objectively measured physical activity and vascular structure and function in adults

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ABSTRACT

Objectives: To analyze the relationship between regular physical activity, as assessed by accelerometer and 7-day physical activity recall (PAR) with vascular structure and function based on carotid intima-media thickness, pulse wave velocity, central and peripheral augmentation index and the ambulatory arterial stiffness index in adults.

Methods: This study analyzed 263 subjects who were included in the EVIDENT study (mean age 55.85 ± 12.21 years; 59.30% female). Physical activity was assessed during 7 days using the Actigraph GT3X accelerometer (counts/minute) and 7-day PAR (metabolic equivalents (METs)/hour/week). Carotid ultrasound was used to measure carotid intima media thickness (IMT). The SphygmoCor System was used to measure pulse wave velocity (PWV), and central and peripheral augmentation index (CAIx and PAIx). The B-pro device was used to measure ambulatory arterial stiffness index (AASI).

Results: Median counts/minute was 244.37 and mean METs/hour/week was 11.49. Physical activity showed an inverse correlation with PAIx ($r = -0.179$; $p < 0.01$) and vigorous activity day time with IMT ($r = -0.174$), CAIx ($r = -0.217$) and PAIx ($r = -0.324$) ($p < 0.01$, all). Sedentary activity day time was correlated positively with CAIx ($r = 0.103$; $p < 0.05$). In multiple regression analysis, after adjusting for confounding factors, the inverse association of CAIx with counts/minute and the time spent in moderate and vigorous activity were maintained as well as the positive association with sedentary activity day time ($p < 0.05$).

Conclusion: Physical activity, assessed by counts/minute, and the amount of time spent in moderate, vigorous/very vigorous physical activity, showed an inverse association with CAIx. Likewise, the time spent in sedentary activity was positively associated with the CAIx.

Trial registration: Clinical Trials.gov Identifier: NCT01083082.

1. Introduction

Participation in regular physical activity and/or aerobic exercise is associated with a decrease in all-cause, cardiovascular and cancer mortality [1–3], and a reduced risk of fatal and non-fatal coronary events in healthy individuals over a wide age range [4]. A sedentary lifestyle is one of the major risk factors for cardiovascular disease [5].

Physical inactivity is associated to an increased carotid intima media thickness (IMT) [6]. The RISC study [7] concluded that the

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proportion of time dedicated to sedentary activities was directly associated to baseline common carotid artery IMT, independently of age and established atherosclerotic risk factors. In the DNASCO study [8], aerobic physical exercise did not attenuate the progression of atherosclerosis.

The studies that have analyzed the relationship between arterial stiffness and physical activity conclude that moderate physical activity in elderly people reduces the pulse wave velocity (PWV), particularly in hypertensive subjects [9]. Edwards et al. [10] found physical activity to be associated to PWV and to the central augmentation index (CAIx) in adolescents and young adults. Recio-Rodriguez et al. [11] published the time spent watching television to be directly correlated to the peripheral augmentation index (PAIx) in adults. On the other hand, Madura et al. [12] showed that the changes in arterial stiffness parameters due to aerobic exercise are reversible.

Despite the predominant involvement of physical activity in cardiovascular prevention and rehabilitation strategies, the role of vascular structure and function has been less investigated. We therefore aimed to analyze the relationship between regular physical activity, as assessed by accelerometer and 7 physical activity recall (PAR)-day, with vascular structure and function based on carotid IMT, PWV, CAIx and peripheral augmentation index (PAIx), and the ambulatory arterial stiffness index (AASI) in adults.

2. Methods

2.1. Study design

This study analyzed 263 subjects who were included in the EVIDENT study (NCT01083082) [13].

2.2. Study population

Subjects for the study were selected by stratified random sampling, including individuals ranging from 20 to 80 years of age who agreed to participate. The exclusion criteria for the study were: known coronary or cerebrovascular atherosclerotic disease, heart failure, moderate or severe chronic obstructive pulmonary disease, musculoskeletal disease that limited walking, advanced respiratory, renal, or hepatic disease, severe mental disease, treated oncological disease diagnosed in the 5 years before the start of the study, terminal disease, and pregnancy. Recruitment and data collection for the study were carried out from January 2011 to December 2011. The 263 participants with measures of vascular structure and function were sufficient to detect a difference of 0.05 mm in IMT between two of the three tertiles of physical activity evaluated as counts/minute in a two-sided test, assuming a common standard deviation (SD) of 0.10 mm with a significance level of 95% and a power of 80%. The study was approved by an independent ethics committee of Salamanca University Hospital, and all participants gave written informed consent according to the general recommendations of the Declaration of Helsinki [14].

2.3. Measurements

A detailed description has been published elsewhere regarding how the clinical data were collected, the anthropometric measurements were made and the analytical parameters were obtained [13].

2.3.1. Physical activity

Physical activity was estimated by accelerometer and the 7-day physical activity recall (PAR).

The ActiGraph GT3X accelerometers (ActiGraph, Shalimar, FL, USA), which have been previously validated [15–17]. ActiGraph is a monitor that uses a piezoelectric acceleration sensor to filter and convert the signals produced from the sensor in samples collected at a preset frequency in hertz. The samples are summed over a user-specified time sampling interval, called an “epoch”. Activity “counts” are recorded to the internal memory of accelerometers by converting acceleration units over a given epoch [18]. Subjects wore the accelerometer fastened with an elastic strap to the right side of the waist for 7 consecutive days involving regular physical activity, except for bathing and performing activities in the water. All subjects were verbally instructed on how to use the accelerometer. The accelerometer was set to record physical activity data every minute. The MAHUFFE software, available from: http://www.mrc-epid.cam.ac.uk/research/resources/materials-transfer-disclaimer/physical-activity-downloads/(accessed: 30/12/2013), will be used to analyze the data. Sequences of 10 or more consecutive zero counts were considered non-wearing time and were excluded from the analyses. Inclusion criteria were a minimum of four days of recording, including at least one weekend day, and at least 600 registered minutes per day. The main outcome variable from the activity monitor was the average intensity of physical activity (counts/minute), calculated with equal weighting given to each day (regardless of registered time per day). The intensity of physical activity was determined according to the cut-off points proposed by Freedson [19], sedentary (<100 counts/minute), light (100–1952 counts/minute), moderate (1952–5724 counts/minute), vigorous (>5724 counts/minute), and very vigorous (>9498 counts/minute). Moderate-vigorous activity was considered as activity accumulated from all bouts lasting at least 1 min.

The 7-day PAR is a general measure of physical activity, which has been recognized as a valid and reliable tool in recent years and is widely used in epidemiological, clinical and behavioral change studies [20]. It consists of a semi-structured interview (10–15 min) in which participants provide an estimate of the number of hours dedicated to physical or occupational activities that required at least a moderate effort over the previous 7 days. The dose of physical activity was estimated in mean metabolic equivalents (METs)/hour/week, and active persons were considered as those doing at least 30 min of moderate activity for five days a week or at least 20 min of hard activity for 3 days a week. Persons not reaching this level of physical activity were considered sedentary [21]. Reliability between 7-day PAR and accelerometer data was evaluated by correlation coefficient (CC) between METs/hour/week and counts/minute ($r = 0.397$; $p < 0.001$).

2.3.2. Anthropometric measurements

Body weight was determined on two occasions using a homologated electronic scale (Seca 770) following calibration (precision ± 0.1 kg), with the patient wearing light clothing and no shoes. Height in turn was measured with a portable system (Seca 222), recording the average of two readings. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). A value of >30 kg/m^2 was taken to define obesity. Finally, waist circumference was measured using a flexible graduated measuring tape with the patient in the standing position without clothing.

2.3.3. Office blood pressure

Office blood pressure (BP) was calculated as the average of the last two of three measurements of sistolic blood pressure (SBP) and diastolic blood pressure (DBP) made with a validated sphygmomanometer (OMRON Model M10-IT). Measurements were made on the right upper arm of participants in the seated position after at least 5 min of rest, with a cuff of appropriate size as determined by