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Objectively measured physical activity and sedentary-time are associated with arterial stiffness in Brazilian young adults

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A B S T R A C T

Objective: To examine the associations between objectively measured physical activity and sedentary time with pulse wave velocity (PWV) in Brazilian young adults.
Methods: Cross-sectional analysis with participants of the 1982 Pelotas (Brazil) Birth Cohort who were followed-up from birth to 30 years of age. Overall physical activity (PA) assessed as the average acceleration (mg), time spent in moderate-to-vigorous physical activity (MVPA – min/day) and sedentary time (min/day) were calculated from acceleration data. Carotid-femoral PWV (m/s) was assessed using a portable ultrasound. Systolic and diastolic blood pressure (SBP/DBP), waist circumference (WC) and body mass index (BMI) were analyzed as possible mediators. Multiple linear regression and g-computation formula were used in the analyses.
Results: Complete data were available for 1241 individuals. PWV was significantly lower in the two highest quartiles of overall PA (0.26 m/s) compared with the lowest quartile. Participants in the highest quartile of sedentary time had 0.39 m/s higher PWV (95%CI: 0.20; 0.57) than those in the lowest quartile. Individuals achieving ≥30 min/day in MVPA had lower PWV ($\beta = -0.35$; 95%CI: −0.56; −0.14). Mutually adjusted analyses between MVPA and sedentary time and PWV changed the coefficients, although results from sedentary time remained more consistent. WC captured 44% of the association between MVPA and PWV. DBP explained 46% of the association between acceleration and PWV.
Conclusions: Physical activity was inversely related to PWV in young adults, whereas sedentary time was positively associated.
Such associations were only partially mediated by WC and DBP.

1. Introduction

Physical inactivity is a well-established risk factor for non-communicable diseases and premature mortality [1]. It influences cardiovascular risk factors, such as blood pressure, lipid profile and adiposity, and consequently, increases the risk of coronary heart diseases [1–3]. In addition, new evidence suggests that the time spent in sedentary activities might be a risk factor for non-communicable diseases, independent of physical activity [4,5].

Non-communicable diseases, particularly cardiovascular diseases are the main causes of death in high- [6] and middle-income countries [7]. The prevalence of cardiovascular risk factors such as diabetes, hypertension and obesity has increased worldwide, and these risk factors are associated with unfavorable changes in lifestyle behaviors such as an unhealthy diet and low levels of physical activity [6,7]. Prevention of adult cardiovascular diseases implies detection and intervention in early life. Atherosclerosis is a chronic

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inflammatory disease that has a long asymptomatic phase [8] beginning in childhood and adolescence, and track into adulthood [9,10].

Early detection of subclinical atherosclerosis and arteriosclerosis is possible through the evaluation of arterial stiffness, intima-media thickness and endothelial dysfunction, which can be measured by noninvasive, reproducible, and inexpensive techniques [11]. Arterial stiffness is associated with traditional cardiovascular risk factors, such as diabetes and hypertension [12,13], and predicts increased risk of cardiovascular events and mortality [14]. Further, increased arterial stiffness in children and adolescents is associated with obesity and dyslipidemia [15–17].

Arterial stiffness is lower among individuals who regularly perform aerobic exercise [18,19], and short-term aerobic exercise training reduces the stiffness in central arteries [19–21], however this effect cannot be maintained without continued exercise [22]. The association between exercise training and aortic stiffness observed in clinical studies are reinforced by observations in murine models suggesting that several genes identified involved in vasodilation and arterial elasticity are overexpressed by exercise [23].

Although an association between physical activity and arterial stiffness has been observed, few studies [24,25] have measured physical activity using objective methods and it is unknown whether sedentary time is associated with arterial stiffness independent of moderate-to-vigorous physical activity (MVPA) and other potential confounding factors. We therefore examined the independent associations between objectively measured physical activity and sedentary time with pulse wave velocity (PWV) in Brazilian young adults who have been prospectively followed up since birth.

2. Methods

2.1. Subjects

In 1982, all hospital deliveries in Pelotas, a southern Brazilian city, were identified and those live borns ($n = 5914$) whose families lived in the urban area of the city were examined, and their mothers interviewed. These individuals have thereafter been followed on several occasions throughout their life-course (at the mean ages of 1, 2, 4, 13, 15, 18, 19 and 23 years). Further details about the methods of the cohort are available elsewhere [26–28]. The study was approved by the School of Medicine Ethics Committee of the Federal University of Pelotas. All participants signed the informed consent form.

Between June 2012 and February 2013, when participants were on average 30 years, we tracked the entire cohort using multiple strategies to locate cohort members. All participants were invited to visit the research clinic for interviews and a clinical examination.

2.2. Physical activity

Physical activity was measured using the GENEActiv accelerometer (ActivInsights Ltd., Kimbolton, UK). The monitor was worn on the non-dominant wrist. The GENEActiv activity monitor is waterproof and measures acceleration in three axes (x, y, z) with a sample frequency of 85.7 Hz. Data are stored directly as sampled from the MEMS chip and provided in units of g ($1\ g = 9.81\ m/s^2$ = the magnitude of gravitational acceleration).

Individuals received the device during their visits to the research clinic. Participants who were disabled, living in others cities (except individuals who visited Pelotas weekly), with labor activity that did not allow the accelerometer use (i.e. baker, cook, mechanic, etc) were excluded from the measurements (825 exclusions, refusals and losses, including 72 pregnant women). Women who were pregnant during the clinical visit were not eligible and invited after delivery to wear the accelerometer. Physical activity was assessed between four and seven days, including at least one weekend day using a 24-h protocol. Participants who started their measurements on Mondays, Tuesdays or Wednesdays were monitored until the following Monday and, those who started their measurements on Thursdays, Fridays or Saturdays, were monitored until the following Wednesday. The first 10 h were excluded because this was the maximum period observed between initialization and attachment of the monitors.

The accelerometers were set up and downloaded in the GENEActiv software. The accelerometer data in binary format were analyzed with R-package GGIR (http://cran.r-project.org). The average magnitude of wrist acceleration over the measurement period normalized to a 24-h period after exclusion of invalid data segments was the main measure used. The signal processing scheme as carried out by GGIR included the following steps: verification of sensor calibration error using local gravity as a reference [29], detection of sustained abnormally high values, non-wear detection, calculation of the vector magnitude of body acceleration using the Euclidian Norm minus one (ENMO: $\sqrt{x^2 + y^2 + z^2} - 1g$) with resulting negative values rounded up to zero, and imputation of invalid data segments by the average of similar time points on different days of the measurement.

Files were considered as valid if data were present for every 15-min period in a 24-h cycle (even when scattered over multiple days) and with calibration error lower than 0.02 g (after calibration error correction). Results are presented in milli-g (1 mg = 0.001 g) for readability reasons. A time window (60-min with 15-min moving increments) was classified as non-wear time if, for at least two out of the three accelerometer's axes, the standard deviation was less than 13 mg and the value range was less than 50 mg.

The summary measure ENMO was used as an indicator of average magnitude of dynamic wrist acceleration over the measurement period. Time spent in moderate-to-vigorous physical activity (MVPA) per day was estimated using an intensity threshold of 100 mg based on 5-s epoch data and 10 min bout durations in the minimum, and <20% of the data points below this threshold. Sedentary time was defined as the time spent below an intensity threshold of 50 mg, excluding the hours between 11:00 p.m. and 7:00 a.m. – assumed as sleeping period, measured in minutes/day [30]. The percentage of individuals who achieved the recommendation of at least 30 min/day spent in MVPA was calculated.

2.3. Pulse wave velocity

The carotid-femoral PWV (meters/second) was examined twice during the clinical visit using a portable ultrasound, Sphygmocor® (Atcor Medical version 9.0, Sydney, Australia) in the supine position and measurements were taken in the right side. An electrocardiogram was registered at the same time. Duration of the examination was 10–15 min for each participant. The distance of pulse wave transit was measured by a flexible tape as the distance from suprasternal notch to femoral point of application of the tonometer and the distance from carotid point of tonometer application and the suprasternal notch. PWV was calculated by the software as the distance between the measurement sites divided by transit time delay between femoral and carotid pulse wave. The mean of measurements was used in the data analysis.

Training for PWV assessment was carried out in two days using volunteers. PWV was calculated by the software as the distance between the measurement sites divided by transit time delay between femoral and carotid pulse wave. The software evaluated the