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Objectively measured physical activity and sedentary behaviour and ankle brachial index: Cross-sectional and longitudinal associations in older men

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ABSTRACT

Background: Associations between bouts of physical activity (PA), sedentary behaviour (SB) and cardiovascular disease, and their mutual independence are not well defined. A low ankle brachial index (ABI $\leq$0.9) indicates peripheral arterial disease (PAD) and is predictive of cardiovascular events and functional impairment. We investigated the independence of PA and SB and the importance of bout duration in relation to ABI using objective measures.
Methods: 945 men from the British Regional Heart Study, mean age 78.4 y, had concurrent measurements of ABI (Vicorder) and physical activity (Actigraph GT3X accelerometer); 427 men also had accelerometer measurements one year previously and contributed data to longitudinal analyses.
Results and conclusion: In cross-sectional analyses, after adjusting for covariates each extra 10 min of moderate and vigorous PA per day was associated with an OR of 0.81 (95% CI 0.72, 0.91) for a low ABI, a stronger association than for light PA (OR 0.85, 95% CI 0.75, 0.98). Each extra 30 min of SB was associated with an OR of 1.19 (95% CI 1.07, 1.33) for a low ABI. Associations between moderate and vigorous PA and ABI persisted after adjustment for light PA or SB. Bout lengths for PA and SB were not associated with a low ABI. One year changes in PA or SB were not associated with low ABI.
All physical activity and lower levels of SB, regardless of bout duration were inversely associated with ABI; more intense PA showed a stronger association. No associations between changes in PA and ABI were observed, but power may have been limited.

1. Introduction

Whilst there is good evidence for higher moderate to vigorous physical activity (MVPA) levels and lower levels of sedentary behaviour (SB) reducing the risk of cardiovascular disease [1], little is known about the importance of activity bout length, how often sedentary behaviour should be interrupted, and whether light activity has health benefits in older age groups. There are few studies with objective measures of physical activity which allow more detailed investigation of these patterns. Peripheral arterial disease (PAD) is under-recognised compared with other cardiovascular diseases, and yet is the most common cause of major amputation [2] and is associated with functional impairment [3] and functional decline even among asymptomatic individuals [4]. Patients with PAD have high rates of fatal and non-fatal cardiovascular events, comparable to rates for patients suffering acute stroke or myocardial infarction [2,5], and up to a third experience pain on walking (intermittent claudication) [6] and about half report atypical leg symptoms that interfere with mobility [7].

The ankle brachial index (ABI) is the ratio of ankle:arm systolic

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pressure and a non-invasive vascular measure that is predictive of cardiovascular events, independent of existing risk factors [8]. ABI is generally 1.0–1.4 in healthy individuals; values lower than 1, and particularly under 0.9, indicate progressively worse levels of peripheral arterial disease (PAD) [9]. A low ABI (≤0.9) has been associated with an approximately two-fold increase in 10 year total mortality, cardiovascular mortality and major coronary event rates, across all categories of baseline risk [8]. Two large recent studies, one cross-sectional [10], one longitudinal [11], both in middle aged adults (mean age 63y and 61y respectively) demonstrated associations between higher or increased self-reported physical activity levels and lower risk of PAD (as indicated by ABI<0.9). However some studies with self-reported physical activity have found associations only in women [12] or men [13] or no association [14]. Self reports of physical activity are limited in some respects, and tend to be less reliable in older adults [15]. Objective measures of physical activity allow more detailed investigation of patterns of physical activity and sedentary behaviour (SB, also a risk factor for CVD) so that different intensities of activity (light, moderate, vigorous) and SB can be quantified not only in terms of total amounts, but also time spent in bouts of different durations. Very few studies have examined objectively measured physical activity (PA) and SB in relation to ABI [16–18], one in a general population [16], and to our knowledge, questions around bout length and PA intensity have not yet been addressed.

Using a large sample of community-dwelling older men, we investigated associations between objectively measured physical activity of different intensities, moderate and vigorous activity (MVPA), light activity (LPA) and sedentary behaviour (SB), and PAD, as indicated by a low ABI (≤0.9). We also investigated whether the duration of bouts of activity (as indicated by current physical activity guidelines) was important, and whether the associations of PA or SB with ABI were independent. In addition, we examined longitudinal relationships between changes in MVPA, LPA and SB over 1 year and ABI.

2. Research design and methods

2.1. Sample

The British Regional Heart Study is a prospective, population-based cohort study following up 7735 men (>99% Caucasian) recruited from primary care practices in 24 British towns in 1978–80. In 2010–2012, 3137 survivors were invited to a physical examination which included measurement of ankle brachial index (ABI). In addition, all men were asked to wear a physical activity monitor (accelerometer) at yearly intervals since 2010, one of which coincided with the 2010–2012 physical examination. The National Research Ethics Service (NRES) Committee London provided ethical approval. Participants provided informed written consent to the investigation in accordance with the Declaration of Helsinki.

2.2. Ankle brachial index (ABI)

Ankle brachial index (ABI) was assessed on the right and left sides using a Vicorder (Skidmore Medical Ltd, Bristol, UK) with the participants supine. Hokanson SC10 cuffs were positioned on the upper arm and lower leg (above the ankle). Photoplethysmography sensors were clipped to the end of the middle finger and the big toe. The cuffs were inflated to 180 mmHg simultaneously occluding the brachial and tibial arteries. Blood pressures were taken at the point of the pulse returning at both sites as the cuffs slowly deflated. Two measurements were normally made for each side and the mean taken, but if the difference in sequential brachial and ankle recordings was >5 mmHg, three measures were taken for each side and a mean taken. Measurements from men whose vessels did not occlude were excluded. ABI was categorised as; low ≤0.9, borderline >0.9 and <1, normal 1.0–1.4, high >1.4 [9]. Men with either or both left and right values ≤0.9 were classified low and men with either or both values >1.4 were classified as having a high ABI. Men with ABI >1.4 were excluded from analyses since this usually indicates arterial calcification in the leg, which artificially increases ABI. All measures were made by 2 vascular technicians, with an intra-class correlation of 0.65.

2.3. Body mass index and blood pressure

Body mass index (BMI, kg/m^2) was calculated from height (Harpenden stadiometer) and weight in light indoor clothing (Tanita body composition analyser (BC-418) or Tanita scales if the participant had a pacemaker or defibrillator). The average of two seated blood pressure readings (Omron HEM-907 recorder, mmHg) were used.

2.4. Objective physical activity assessment

Men wore the GT3X accelerometer (Actigraph, Pensacola, Florida) over the right hip for 7 days, during waking hours, removing it for swimming or bathing. Data were processed using standard methods [19]. Non-wear time was excluded using the R package “Physical Activity” [20]. Valid wear days were defined by convention as ≥600 min wear time, and participants with ≥3 valid days were included in analyses. Each minute of activity was categorised using intensity threshold values of counts per minute developed for older adults: <100 for sedentary behaviour (SB) (<1.5 MET), 100–1040 for light activity (LPA) (1.5–3 MET) and >1040 for moderate and vigorous physical activity (MVPA), (≥3 MET) [21].

2.5. Questionnaire data

Men self-completed a questionnaire including information about: current cigarette smoking, alcohol consumption, living alone, current use of antihypertensive medication, ever receiving a doctor diagnosis of heart attack, heart failure or stroke (with symptoms lasting >24 h), narrowing or hardening of the leg arteries (including claudication) (PAD) and leg pain on walking. Diabetes was defined as a doctor diagnosis, or a fasting blood glucose of ≥7 mmol/l. Social class was based on longest held occupation at study entry (1978–80) and categorised as manual and non-manual [22]. Region of residence (1978–80) was grouped into Scotland, North, Midlands and South of England.

2.6. Statistical methods

Men reporting a diagnosis of heart attack, heart failure, or stroke (with symptoms lasting >24 h) were excluded from analyses. Descriptive statistics for demographic characteristics, vascular measures, PA and SB, were calculated by category of ABI.

Associations between each of the different PA measures and ABI were investigated in a series of logistic regression models. The PA exposures investigated were: total activity counts per day, steps per day and minutes per day of SB, LPA and MVPA. For ease of interpretation the OR for a low ABI was estimated for each 10,000 counts of total activity, 1000 steps, 30 min of SB or LPA and 10 min of MVPA. In order to evaluate the independence of associations of activity intensities, models were mutually adjusted; (i) MVPA and SB and (ii) MVPA and LPA in the same model. SB and LPA were not included in the same model due to collinearity ($r = -0.62$). Associations between number of minutes accumulated in bouts of