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Meeting physical activity recommendations may be protective against temporal lobe atrophy in older adults at risk for Alzheimer's disease

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Abstract

Introduction: Physical activity (PA) is associated with brain health in older adults. However, it is unknown whether the current physical activity recommendations (PAR) impart substantive benefit. The objective of this study was to compare temporal lobe volumes between older adults who met PAR and those who did not.

Methods: Ninety-one enrollees from the Wisconsin Registry for Alzheimer's Prevention wore an accelerometer for seven consecutive days to quantify their PA behaviors and underwent a T-1 anatomic magnetic resonance imaging scan. Participants were categorized as either having met PAR or not based on the US Department of Health and Human Services recommendations of 150 minutes of moderate-to-vigorous physical activity per week.

Results: Participants who met PAR possessed significantly greater inferior ($\eta^2_P = .050$) and anterior ($\eta^2_P = .055$) temporal lobe volumes compared with those who did not ($P < .05$).

Discussion: Individuals at-risk for AD experience accelerated rates of brain atrophy. These results suggest that regular engagement in PA at or above PAR could attenuate this decline.

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1. Introduction

Alzheimer's disease (AD) affects more than 5 million Americans and that number is projected to nearly triple by 2050 [1]. A hallmark feature of AD is brain atrophy, which typically precedes the onset of symptoms [2,3] and is a predictor of future cognitive impairment [4,5]. Physical activity (PA) and fitness may mitigate brain atrophy as both have been positively associated with gray matter volume in older adults [6,7] and older adults at-risk for AD [8]. However, the influence of meeting physical activity recommendations (PAR) via accelerometry on brain volume

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in older adults is currently unknown. The Department of Health and Human Services along with the American College of Sports Medicine and the American Heart Association recommends accumulating 150 minutes of moderate intensity, or 75 minutes of vigorous intensity, or an equivalent combination of moderate and vigorous physical activity (MVPA) per week to promote health in all adults [9,10]. The temporal lobes atrophy with age, and this atrophy can predict cognitive decline to AD [11]. Thus, the present study investigated temporal lobe volumetric differences between older adults strictly categorized as having met PAR and those who were insufficiently active.

2. Methods

2.1. Participants

Ninety-one older adults (ages 50–74 years) from the Wisconsin Registry for Alzheimer's Prevention (WRAP) cohort volunteered to participate. The WRAP is a longitudinal registry composed of more than 1500 cognitively healthy adults [12]. The sample for this study included a large proportion of participants at-risk for AD (78%); defined as possessing either a parental family history (FH) of AD (70%), and/or the apolipoprotein epsilon 4 allele (*APOE* ε4) (46%), which closely reflects the makeup of the WRAP cohort. Participants were determined to be cognitively healthy using the mini-mental state examination (MMSE $\geq$ 24), did not have any major medical conditions (e.g. neurological diseases, psychiatric disorders), and were deemed safe for neuroimaging procedures. The University of Wisconsin Institutional Review Board approved all study procedures, and informed consent was obtained from all participants.

2.2. Physical activity assessment

All participants wore a triaxial GT3X+ accelerometer (Actigraph, Pensacola, FL) on their hip for seven consecutive days. Participants were instructed to wear the device during all waking hours, with the exception of when showering, swimming, or bathing. Standard accelerometry inclusion criteria consisted of at least 10 hours of valid wear time per day for a minimum of three weekdays and one weekend day [13]. Accelerometer data (in 1-second epochs) were processed using the validated Sojourn-3 axis method which uses an artificial neural net to identify boundaries between activities of different intensities and to estimate metabolic equivalents (METs) for each bout [14]. To calculate minutes spent in different intensity categories of PA, estimated METs were determined for each bout interval and were then separated into PA categories accordingly: <1.5 METs = sedentary, 1.5–2.99 METs = light, 3–5.99 METs = moderate and >6 METs = vigorous. Consistent with current public health PAR, total minutes spent in MVPA in bouts of 10 minutes or greater were used to determine whether the participant met the 150 minutes of MVPA recommendation [9,10].

2.3. Neuroimaging protocol

Magnetic resonance images (MRIs) were acquired on a GE X750 Discovery 3.0-T scanner with an eight-channel phased array head coil (General Electric, Waukesha, WI). Three-dimensional T1-weighted inversion recovery prepared spoiled gradient echo (SPGR) anatomic sequences were collected using the following parameters: TI/TE/TR = 450 ms/3.2 ms/8.2 ms, flip angle = 12°, slice thickness = 1 mm no gap, field of view (FOV) = 256, matrix size = 256 × 256, yielding a voxel resolution of 1 mm × 1 mm × 1 mm. Temporal lobe regions of interest (ROIs) included superior, middle, inferior, temporal pole, hippocampus, parahippocampal, and entorhinal. These were derived from the T1 images using the Freesurfer image analysis suite, version 5.1.0 (http://surfer.nmr.mgh.harvard.edu/), with automated volumetric segmentation. Further technical processing details are described in previous publications [15,16]. All images were visually inspected and edited (if necessary) by trained personnel to ensure that they were accurately reconstructed and without topologic defects. A summary measure for each region of interest was derived by averaging the values from the right and left hemispheres and then expressed as a percentage of intracranial volume (ICV) to account for differences in overall head size.

2.4. Statistical analyses

Independent samples *t* tests compared demographic information between those who met PAR and those who did not. Bivariate correlations explored the associations between age and temporal lobe volume ROIs. A single multivariate analysis of covariance was conducted to determine differences in brain volume between groups, controlling for age and gender with the significance level (α) set at 0.05. Because there is evidence showing that PA may have a more robust effect on brain volume in those at-risk for AD [17], secondary analyses limited to at-risk participants were conducted. All analyses were conducted using IBM SPSS, version 22.0.

3. Results

3.1. Sample

Ninety-one cognitively healthy (MMSE = 29.3 ± 1.1) participants (mean age = 64 ± 5.8) completed the study (see Table 1 for participant characteristics). Twenty-nine participants met the PAR of 150 minutes of MVPA and sixty-two did not. Groups did not differ on any measured demographic characteristics ($P > .05$). The volumes of all ROIs included in the analyses were significantly and negatively correlated with age ($P < .05$; $r_{range} = -.173$ to $-.352$).

3.2. Physical activity and temporal lobe volume

After controlling for the effects of gender and age, there were significant group effects for the inferior temporal

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