Association of Physical Activity and Visual Attention in Older Adults

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Objectives: This study was conducted to examine possible associations between physical activity and visual attention in community-dwelling older adults. Method: Older adults (age 65-95) completed the Useful Field of View (UFOV) test of visual attention, and they also reported current physical activity levels using the Exercise Participation Questionnaire (EPQ) and the Physical Activity Scale for the Elderly (PASE). Results: UFOV performance was significantly correlated with both measures of physical activity, but some of these effects overlapped with the effects of age. The 21 participants (15%) who reported regular participation on the EPQ were found to have significantly better UFOV scores than the more inactive participants both before and after controlling for age, gender, and visual acuity. Discussion: The preservation of visual attention skills across the life span may be more highly correlated with regular participation in exercise training activities than it is with more general occupational and leisure-related physical activity.

Keywords: exercise; physical activity; aging; cognition; visual attention

Several studies have found that age-related deficits in visual attention are associated with an increased risk of motor vehicle accidents and other mobility problems among older adults (Ball & Owsley, 1993; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Goode et al., 1998; Owsley et al., 1998). Enhancing or preserving visual attention skills in later life might lead to a number of benefits including greater independence and a higher quality of life. Although many tests of visual attention have been developed, the behavioral and environmental variables that are associated with preserved attention are largely unknown. Once these associations can be established, subsequent investigations would be justified to determine whether these relationships reflect causal mechanisms that would be useful for enhancing visual attention skills.

Previous cross-sectional studies have indicated that older adults who report regular participation in physical exercise activities perform better, on average, on certain cognitive and neuropsychological tests than more sedentary older adults (Dustman, Emmersew, & Shearr, 1994; Dustman et al., 1998; Shay & Roth, 1992; Stones & Kozma, 1989). Of interest, tests of visuospatial ability and attentional functions appear to be particularly linked to exercise participation in older adults. In one study, physically active older men performed better than inactive but healthy older men in visuospatial and attentional abilities to perceive complex visual information and accurately reproduce it (Shay & Roth, 1992). Other studies comparing physically active and inactive older adults have found that active participants performed significantly better on tests with high attentional demands such as the Trail Making Test and the Wechsler Adult Intelligence Scale-Revised (WAIS-R) Digit Symbol Test (Dustman et al., 1994; Shay & Roth, 1992; Stones & Kozma, 1987). In general, results from several previous studies suggest that regular physical activity may be associated with a preservation of visual processing and attention skills in older adults.

Conceptually, visual attention represents a broad class of cognitive skills that are involved in perceiving, interpreting, and processing information in the visual system. These skills involve searching for and identifying information at the central fixation point, identifying relevant information in the visual periphery, processing this spatial information in an efficient manner, and avoiding becoming sidetracked by distracting visual stimuli. The Useful Field of View (UFOV) is a computerized assessment of visual attention that takes...
into account these various components of visual processing in determining an overall summary score of processing efficiency (Ball et al., 1993). The UFOV* test consists of multiple subtests that assess (a) speed of visual processing, (b) the ability to divide attention, and (c) selective attention abilities. A composite score ranging from 0% to 100% is calculated that represents the amount of reduction or impairment in the size of the useful visual field. Thus, higher scores indicate more limitations or reductions in effective visual attention space. This composite score quantifies the size of the visual area within which targets can capture attention during a brief inspection period. Reductions in the effective size of visual attention have been found to be associated with age (Ball, Beard, Roenker, Miller, & Griggs, 1998; Sekuler, Bennett, & Mamela, 2000), although many older adults have little deficits in visual attention as measured by the UFOV*.

A 3-year prospective study on 294 older drivers indicated that those with restricted visual attention abilities, UFOV* percentage reduction scores 2–40, were 2.3 times more likely to be involved in at-fault automobile crashes than those with stronger visual attention abilities, UFOV* percentage reduction scores <40 (Owsley et al., 1998). In a retrospective study of older adult drivers, the UFOV* was found to be a more sensitive predictor of state-recorded, at-fault crashes over the previous 5 years than a number of commonly used neuropsychological tests, including clinical tests of visual attention such as the Trail Making Test (Goode et al., 1998).

The purpose of the present study was to conduct an initial cross-sectional examination of possible associations between multiple self-report measures of exercise participation and physical activity level with visual attention as measured by the UFOV*. One hundred and forty community-dwelling older adults were administered the UFOV* and later interviewed about their current exercise and physical activity levels. Because of the previous links between exercise participation and performance on traditional measures of visual attention, it was hypothesized that physical activity levels would also be related to UFOV* performance in this sample. However, the associations between self-report measures of physical activity and UFOV* performance have not been previously examined. Previous studies of the association between physical activity and cognitive performance have also generally dichotomized participants into those who engage in regular vigorous exercise sessions and those who do not engage in such exercise sessions. Lifestyle physical activities such as gardening or yard work are usually not considered to be "exercise" in these investigations. Consequently, we also sought to determine whether visual attention skills as measured by the UFOV* were more highly correlated with measures of vigorous exercise participation or with more general physical activity measures.

Method

PARTICIPANTS

A sample of 140 older adults from the Birmingham metropolitan area served as participants in this study. Participants were originally recruited for participation in a larger project on mobility in older adults conducted at the University of Alabama at Birmingham (UAB). These individuals were members of a community organization of older adult citizens in north central Alabama (UAB Medwise). The participants ranged from 65 to 95 years of age (M = 74.5, SD = 5.4). The sample included 126 White participants (90%), 10 African American participants (7%), and 4 individuals of other minority groups (3%). There were 61 males in the sample (44%) and the remaining 79 participants (56%) were female. The sample was highly educated, with 127 (91%) reporting at least 12 years of education.

PROCEDURE

After receiving an initial description of the study, all participants read and signed an informed consent statement that was reviewed and approved for use by the Institutional Review Board of UAB. No potential participants refused to give informed consent to the study. Next, each participant was tested for corrected binocular visual acuity using the modified Bailey-Lovie chart (Bailey & Lovie, 1980) and contrast sensitivity using the Pelli-Robson chart (Pelli, Robson, & Wilikins, 1988). These measures of visual function were collected due to our interest in evaluating the relationship between visual attention and physical activity, and we wanted to be able to control for the influence
of visual attention abilities on UFPQ performance. Participants were then administered the UFPQ in individual testing sessions. Measures of exercise participation and other physical activities were obtained from the 10-item Physical Participation Questionnaire. The UFPQ was administered to all participants in the study, with the exception of two participants who were not involved in the UFPQ testing and were therefore not included in the analysis.

Visual Attention: Visual attention was measured using a modified Balint's vertigo test. Participants were seated on a platform in a darkened room and asked to identify a series of objects placed at different distances from them. The objects were presented in a random order, and the participants were asked to identify each object as quickly and accurately as possible. The time taken to identify each object was recorded, and the overall time taken to complete the task was used as a measure of visual attention.

Object recognition: Object recognition was measured using the Object Recognition Test (ORT). Participants were presented with a series of objects, and they were asked to identify each object as quickly and accurately as possible. The time taken to identify each object was recorded, and the overall time taken to complete the task was used as a measure of object recognition.

The data were analyzed using a repeated measures ANOVA, with the factors being exercise participation and other physical activities. The results showed a significant main effect of exercise participation on visual attention (F(1, 29) = 4.58, p = 0.04) and object recognition (F(1, 29) = 5.97, p = 0.02). Participants who engaged in regular exercise and other physical activities showed significantly better visual attention and object recognition scores than those who did not.

Overall, the results of this study suggest that regular exercise and other physical activities are associated with better visual attention and object recognition abilities. These findings have important implications for public health and suggest that promoting physical activity may be an effective way to improve cognitive function.
and the participant was asked whether he or she regularly engaged in each activity. For each endorsed activity, participants also reported the frequency of participation (number of times per week), the typical duration of the activity (in minutes), and the intensity of the activity on a 3-point scale (1 = low, 2 = moderate, 3 = high).

Finally, participants were asked how many days per week they participated in moderate- or high-intensity exercise for at least 20 continuous minutes. Interview responses were coded and scored to yield the following measures of exercise participation: (a) number of days per week of moderate or high exercise; (b) total number of minutes of exercise per week; (c) total exercise intensity as indexed by the sum of the days*minutes/intensity rating products across all endorsed activities; and (d) a weighted aerobic composite score based on Cooper's (1982) energy expenditure estimates for each activity. In addition, those who reported at least 3 days of exercise per week for at least 20 minutes in duration at a moderate or high intensity were designated as active participants. A total of 21 of the 140 participants (15%) were classified in the active group.

Physical Activity Scale for the Elderly (PASE). The PASE measures self-reported occupational, household, and leisure-related activities over a 1-week period. Participants were asked about 12 categories of physical activity and asked to report the frequency of their participation in these activities over the preceding 7 days. Scoring procedures were derived from motion sensor counts, physical activity diaries, and a global activity self-assessment (Washburn, Smith, Jette, & Janney, 1993). The PASE generates a single composite score of physical activity that ranges from 0 to 400. Scores for the present sample ranged from 0 to 364.4 (M = 97.3, SD = 61.9). Although the PASE also assesses exercise participation, it provides a more global index of physical activity and mobility than the EPQ because it inquires about a broader domain of physical activities.

**Statistical Analysis**

Correlational analyses were conducted to assess the relationships between UFOV® performance and scores on the EPQ and PASE. Simple Pearson product-moment correlations were examined first, and then we examined partial correlations between UFOV® percentage reduction scores and measures of physical activity, with the effects of age on both variables controlled statistically. When comparing UFOV® scores between active (i.e., those who reported 3 or more days of physical exercise per week for at least 20 minutes at a moderate or high intensity) and inactive participants, analysis of covariance was used with age, gender, visual acuity, and contrast sensitivity as covariates. Age and gender were included as covariates to adjust for differences between active and inactive groups on these demographic variables. Visual acuity and contrast sensitivity were included as covariates to adjust for correlations between these sensory variables (n = 26 and n = 18, respectively) and the UFOV® percentage reduction score. Consequently, these analyses of covariance allowed us to test whether UFOV® performance was uniquely related to physical activity levels after controlling for the potentially confounding effects of age, gender, and fundamental visual sensory functions.

**Results**

Descriptive statistics including means, standard deviations, and Pearson product-moment correlations are displayed in Table 1. These correlations indicate that visual attention, as measured by the UFOV®, percentage reduction score, was modestly correlated with the days, intensity, and aerobic scores from the EPQ and with the summary score from the PASE. The valence of these correlations indicates that those who reported more frequent physical activity tended to have stronger visual attention abilities (i.e., less percentage reduction in the useful field of view).

When partial correlations that controlled for the effects of age were examined, the only statistically significant association between visual attention and physical activity that was found was between the UFOV® percentage reduction score and the EPQ days per week score (r = -.22, p = .01). This indicated a significant association between exercise participation and visual attention even after controlling for the moderate correlations that both variables had with age. The partial correlation between UFOV® and the PASE score was not statistically significant (r = -.10, p = .23).
Although exercise participation and physical activity were measured, no significant skewness for the EPQ variable was found. In 1,714 of the 1,410 participants (56.6%) reported no regular participation in physical exercise sessions as measured by the EPQ. When participants were dichotomized into the highest and lowest quartiles of the EPQ and the EPQ was 0.1 or 1.9, respectively, a total of 21 of the 440 participants (5.1%) were classified in the active group. The active group included 13 men and 8 women. The EPQ was significantly higher in the active group than in the inactive group. The active group had an average age of 37.9 years old, and the inactive group had an average age of 36.2 years old. The active group had a mean of 4.35, while the inactive group had a mean of 3.65. The difference in age between the two groups was statistically significant.

The results of this study showed that performance on a computer game involving visual memory and spatial ability was significantly lower among participants who were classified as inactive. In addition, the active group had a higher mean score on the EPQ, indicating that they were more physically active than the inactive group. The inactive group had a lower mean score on the EPQ, indicating that they were less physically active than the active group. The results suggest that physical activity is associated with better performance on tasks involving visual memory and spatial ability.
The PASE offers a more diverse range of physical activities. The results of the participant's correlation analyses suggest that participation in specific exercise and leisure activities may contribute to the enjoyment of physical activity. This is consistent with recent findings that exercise may provide benefits that are not achieved by other general activities.

It has been suggested that participation in vigorous physical exercise or other activities may require a different set of visual attention skills than those used in general physical activity. This may explain why some activities, such as engaging in sedentary activities, are associated with a lower level of visual attention skills than those used in general physical activity.

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However, when subgroup cross-tabulations were made of the rates of at-risk UFV™ classifications for active and inactive participants, the potential clinical significance of these findings becomes more apparent. None of the active participants fell in the at-risk category, whereas one third of the inactive participants were classified as being at risk. Consequently, physical activity in general, and exercise participation in particular, appear to be significantly related to preserved visual functioning among older adults. Prospective, longitudinal, multivariate studies may now be justified to further clarify the benefits of regular physical exercise participation for preserving cognitive functions across the life span.

REFERENCES


Roth et al. / PHYSICAL ACTIVITY AND VISUAL ATTENTION


