Examining the Relationship between Physical Activity and Cognitive Function in Older Adults

Danielle V. Rojas

B.A. Candidate, Department of Psychology, California State University Stanislaus, 1 University Circle, Turlock, CA 95382

Received 9 May, 2020; accepted 15 May, 2020

Abstract

Cognitive function is comprised of a variety of mental components, including memory, learning, reasoning, and judgement. Cognitive decline is the loss of these skills over time and is a natural result of the aging process. Prior studies have shown that physical activity, such as walking or gardening, slows this age-related cognitive decline. We aimed to explore what specific aspects of cognitive function are related to physical activity. Therefore, we examined 49 participants, from the ages of 65 to 89, from an independent living community of senior citizens who reported their typical frequency, duration, and intensity of physical activity. These responses were then weighted by metabolic equivalents, summed, and scaled to represent overall physical activity. Participants completed the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV), which is a measure of adult intelligence. We analyzed the relationship between self-reported physical activity and objective data obtained from gym facility key cards, which revealed that participants' self-reports of physical activity were accurate. Next, we examined the relationship between self-reported physical activity and cognitive function. Results indicated a significant positive correlation between physical activity and two WAIS-IV subtests, such that more frequent physical activity was associated with better working memory and better visuospatial skills. These results suggest that engaging in physical activity may be protective against age-related cognitive declines, which may have important implications for maintaining independence and the ability to execute cognitive functions as we age.

Keywords: physical activity, cognitive function, aging, exercise, WAIS-IV

Introduction

Cognitive decline is a continuous concern among the aging population (Guure, Ibrahim, Adam, & Said, 2017), and measures are being taken towards preserving brain function in older adults (Guure et al., 2017). The prevalence of diseases associated with memory impairment has more than doubled since the early 2000s and is projected to raise an additional 68% by the year 2030 (Guure et al., 2017). Researchers are exploring how much of our brain function can be preserved as we age, and how much of cognitive decline is inevitable (Guure et al., 2017). Nonmodifiable factors such as age and genetics are one reason for onset of Alzheimer's that cannot be controlled (Guure et al., 2017). However, modifiable factors such as diet and exercise can be altered to prevent deterioration of memory and brain function (Guure et al., 2017).

Previous research suggests a correlation between physical activity level and performance on tasks that measure cognitive ability (Wang et al., 2013). Studies examining the relationships between physical activity and cognition have focused mainly on older adults in an effort to prevent cognitive impairment (Wang et al., 2013). There is a decline in tasks such as memory recall and visuospatial skills as people age (Guure et al., 2017), yet results indicate positive effects of physical activity on cognitive function, dementia risk, and cognitive decline (Guure et al., 2017).

Further research supports the correlation between exercise and protein expression in the brain, which is responsible for learning and memory formation (Sleiman et al., 2016). A protein called brain derived neurotrophic factor increases in the hippocampus after exercise, which is linked to a decrease in anxiety and depression, and an increase in cognitive capabilities (Sleiman et al., 2016). One of the primary functions of the hippocampus is learning and memory formation. Therefore, the increase in neurotrophic factor helps to keep this region of the brain active (Sleiman et al., 2016). This suggests a positive correlation between physical activity and the

*corresponding author. Email: dsimpson3@csustan.edu

preservation of cognitive skills and function due to enhanced signaling pathways in the hippocampal region of the brain.

Additional research has been conducted to explore the validity and reliability of self-reported measures of physical activity in children (Verstraten et al., 2013) and the workplace (Engbers, Poppel, Mechelen, 2007), but no research has been found regarding senior citizens and self-reported physical activity. For children, self-reports of physical activity were not different from actual physical activity as measured by testing the differences in means between methods (validity) and repeated measures (reliability) (Verstraten et al., 2013). When employees in the workplace were assessed based on the use of stairs, there was no significant difference between what they reported and their actual use of the stairs (Engbers et al., 2007). The findings of this research did indicate variability in activity level influenced by an employee's work environment (Engbers et al., 2007). The concept that an individual's work environment correlates to the amount of activity they engage in can be applied outside of the workplace when examining social communities and residential living facilities. The reliability and validity of self-reported exercise in a senior citizen community can further be explored.

Significance

With the growing prevalence of dementia in geriatric patients, it is important to understand the preventative steps that can be taken to preserve cognitive function in the aging population. Physical activity is one of these modifiable lifestyle factors that can preserve cognitive capabilities. Furthermore, if self-reported measures are found to be a valid measure of physical activity, they could provide simpler methods of evaluating the impact of physical activity than objective measures.

Hypotheses

I hypothesized that individuals who engage in more physical activity will have overall higher cognitive function. I also expected to find a correlation in the amount of physical activity a participant subjectively reports in comparison to the objective amount of exercise recorded by their residential key cards, such that self-reported data is a valid measure of physical activity.

Method

Participants

The study was conducted at a retirement community for independently living older adults. Forty-nine participants were recruited, from the ages of 67 to 89 (M_{age} = 79.66 years, SD = 6.30; 67% female). Sixteen of the participants were male, and 33 were female. Of the participants, 32.7% earned a Master's degree or higher, 30.6% earned a Bachelor's degree, 4.1% earned an Associate degree, and 8.2% earned a high school education. The ethnicity of participants was fairly homogenous, as 97.9% of participants identified as Caucasian and the other 2.1% identified as Asian. Participants over the age of 90 were excluded from data collection based on exclusion criteria for cognitive assessments. The group of participants were all members of the same continuing care retirement community, had access to resources that are available to individuals with high socioeconomic status, and affiliated with a religious group.

Design

This is a cross-sectional study derived from a larger longitudinal study that focuses on the correlation between the amount of physical activity (predictor variable) and cognitive functioning (outcome variable) in older adult participants.

Measures

Self-Reported Physical Activity

Participants were given a demographics questionnaire that asked questions about their engagement in physical activity. They reported a typical week of physical activities that they participate in, in addition to the intensity of the activities, and the duration of the activity in minutes and days per week. This was then converted to a scale for metabolic equivalence based on intensity and the amount of time engaged in physical activity per week: Level of intensity was given a score (vigorous = 8.0, moderate = 4.0, light = 3.3) and multiplied by minutes per day. The total minutes were summed to create a total physical activity metabolic equivalent, and then divided by 100 to standardize scores, Which ranged from .46 to 58.24 (M = 11.71, SD = 10.82).

Objective Exercise

Residents have access to gym facilities where they can record the amount of exercise they engage in. Among the resources available to them is cybercycling, which is a type of exergame which combines a traditional stationary bike with virtual reality tours, competitive avatars, and video game features. In addition to cybercycling, residents can partake in group fitness classes or independent activities such as swimming and walking. Residents also have access to weight machines, and the sets, repetitions, and weights of their resistance exercises are recorded. Raw exercise data collected from participant electronic recordings were converted to a scale for metabolic equivalence based on the total amount of exercise engaged in per week by calculating the minutes of physical activity per day. Total minutes were summed to create an average weekly total of physical activity, which was then rescaled by dividing by 100.

Cognitive Function

The WAIS-IV consists of a series of 10 subtests which measure crystallized ability, fluid reasoning, visual processing, short-term memory, quantitative reasoning, and processing speed (Benson, Hulac & Kranzler, 2010). The WAIS-IV is an interactive, face-to-face assessment where the administrator sits with the participant as if conducting an interview. The process takes about 45 minutes to an hour to administer.

Procedure

Participants were split into two sessions. During the first session, participants were given an informed consent to complete and demographic questions to answer that asked detailed questions about their demographics, health history, and physical activity. The second session consisted of administration of the WAIS-IV and a debriefing form. Analysis was conducted based on FSIQ scores and a comparison of objective data with subjective reports.

Results

The relationship between physical activity and cognitive ability was analyzed using Pearson correlations. Results indicated a strong significant positive correlation between subjective self-reports of physical activity and objective exercise (r = .96, p < .01), (*Figure 1*). Results also indicated a significant positive correlation between exercise and two WAIS-IV subtests, such that more frequent exercise was associated with better visuospatial skills (r = .32, p = .03), (*Figure 2*), and better working memory skills (r = .35, p = .02), (*Figure 3*). Pearson correlations were conducted for the remaining composite scores of the WAIS-IV and physical activity, but there were no significant correlations (*Figure 4*). Further analysis was conducted to examine the data in quantiles. Results show a comparison of overall composite scores based on physical activity examining the top 25% of participants and the bottom 25% of participants (*Figure 5*).

Discussion

These results indicate the positive relationship between physical activity and cognitive ability as we age. They also indicate the validity of self-reported data from the participants. Implications of this research indicate that self-reported physical activity is valid at measuring a participants' level of objective exercise. Additional implications show the correlation between physical activity and working memory, which shows that as we age, our ability to use short-term memory that is concerned with immediate conscious perceptual and linguistic processing can be positively associated with physical activity. The same is true for our ability to interpret spatial relations as we age.

Further research should explore different types of physical activity, including cardiovascular activity and resistance training, and the impact they have on cognitive ability. Individual exercise programs, group activity exercise, and physical activity combined with mental challenge should also be examined to show the relationship between the various types of physical activity we can engage in, and how this impacts us as we age. The relationship between physical activity and other areas of psychological health such as depression, positive affect, and anxiety should also be explored.

It is important to understand the benefit of physical activity on all age categories, from adolescent to adult and through old age. Further research should be conducted to examine the physiological and psychological effects of physical activity across all age groups to incorporate an active approach to promoting overall health and wellness while preventing disease.

Limitations of the study include a small homogeneous sample of predominantly Christian participants, all residing in the same community with access to gym facilities (M_{age} = 79.66 years, SD = 6.30; 67% female). Nevertheless, engaging in physical activity may be protective against working memory decline.

References

Benson, N., Hulac, D. M., & Kranzler, J. H. (2010). Independent examination of the Wechsler Adult Intelligence Scale—Fourth Edition (WAIS-IV): What does the WAIS-IV measure? *Psychological Assessment, 22*(1), 121-130. doi:10.1037/a0017767

Engbers, L. H., Poppel, N., & Mechelen, W. (2007). Measuring stair use in two office buildings: a comparison between an objective and a self-reported method. *Scandinavian Journal of Medicine, 17*(2), 165-71.

Guure, C., Ibrahim, N., Adam, M., & Said, S. (2017). Impact of physical activity on cognitive decline, dementia, and its subtypes: meta-analysis of prospective studies. *Hindawi BioMed Research International 2017*, 1-13. https://doi.org/10.1155/2017/9016924

Sleiman, S. F., Henry, J., Al-Haddad, R., El Hayek, L., Abou Haidar, E., Stringer, T., Chao, M. V. (2016). Exercise promotes the expression of brain derived neurotrophic factor (BDNF) through the action of the ketone body β-hydroxybutyrate. *eLife*, *5*, e15092. doi:10.7554/eLife.15092

Verstraeten, R., Lachat, C., Ochoa-Avilés, A., Hagstromer, M., Huybregts, L., Andrade, S., Donoso, S., Van Camp, J., Maes, L., Kolsteren, P. (2013). Predictors of validity and reliability of a physical activity record in adolescents. *BMC Public Health*, *13*, 1109. https://doi-org.libproxy.csustan.edu/10.1186/1471-2458-13-1109

Wang, Hui-Xin., Jin, Yinlong., Hendrie, H., Liang, C., Yang, L., Cheng, Y., Unverzagt, F., Ma, F., Hall, K., Murrell, J. (2013). Late Life Leisure Activities and Risk of Cognitive Decline. *The Journals of Gerontology: Series A*, *68*(2), 205–213, https://doi.org/10.1093/gerona/gls153

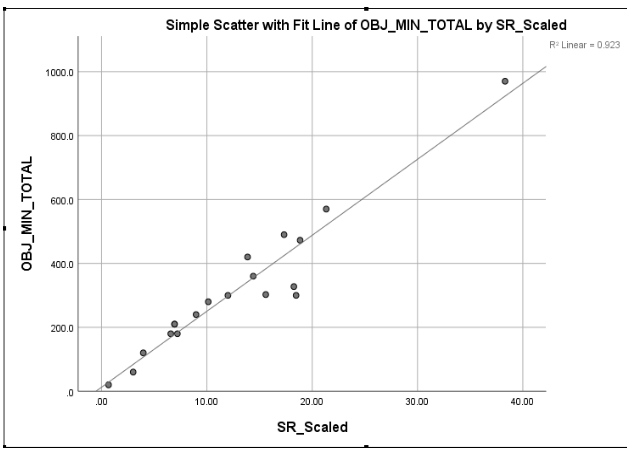

Figure 1: The relationships between self-reported physical activity and objective reports of exercise shows a strong significant positive correlation (r = .96, p < .001). Results indicate that subjective self-reports of physical activity are valid at estimating objective exercise.

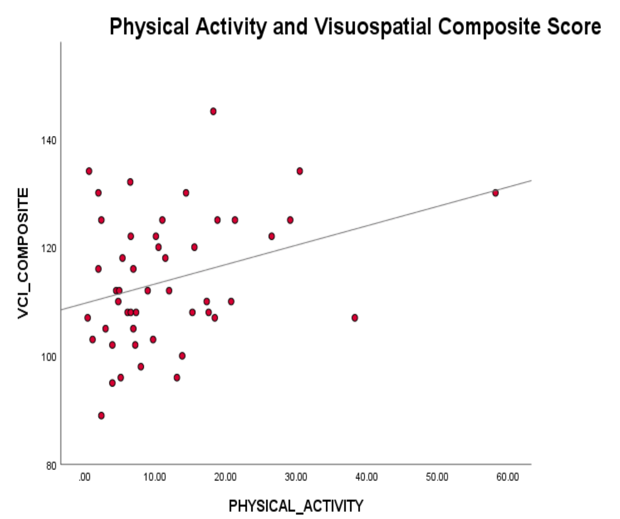

Figure 2: The relationship between physical activity and visuospatial skills shows a significant strong positive correlation (r = .32, p = .03). Results indicate that individuals who engage in more physical activity will score higher on assessments that measure visuospatial skills. This refers to our ability to perceive space and perform tasks such as drive a car.

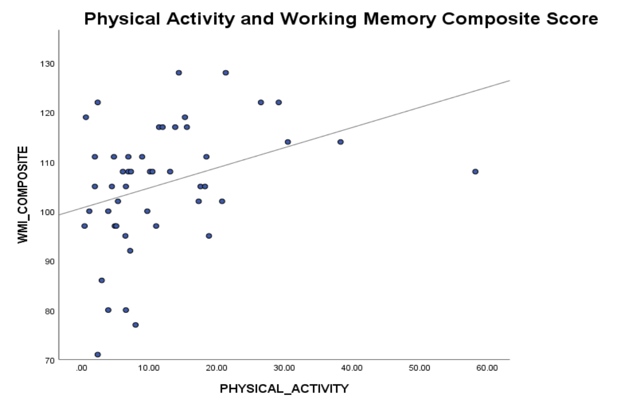

Figure 3: The relationships between physical activity and working memory shows a strong significant positive correlation (r = .35, p = .02). Results indicate that individuals who engage in more physical activity will perform better on tasks that measure working memory. This relates to our ability to use memory-related skills such as recall and decision making.

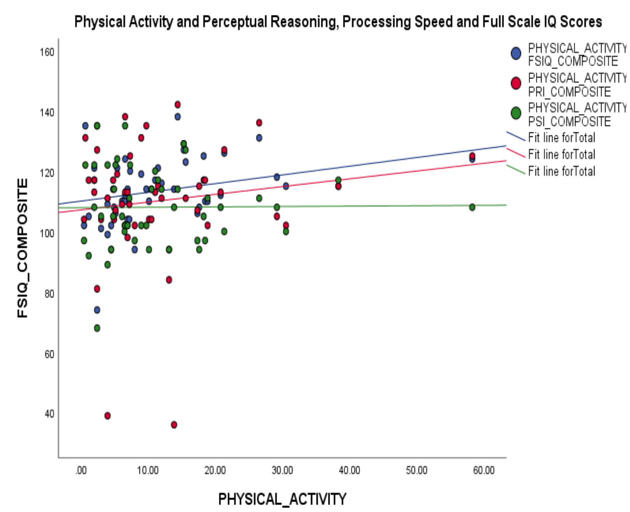

Figure 4: The relationship between physical activity and all composite scores of perceptual reasoning, processing speed, and FSIQ. Perceptual reasoning refers to our ability to think and reason using visual cues and organize our thoughts. Processing speed is how quickly we can accurately solve a problem or answer a question, and FSIQ is the sum of all the composite scores to measure a participant's full-scale IQ.

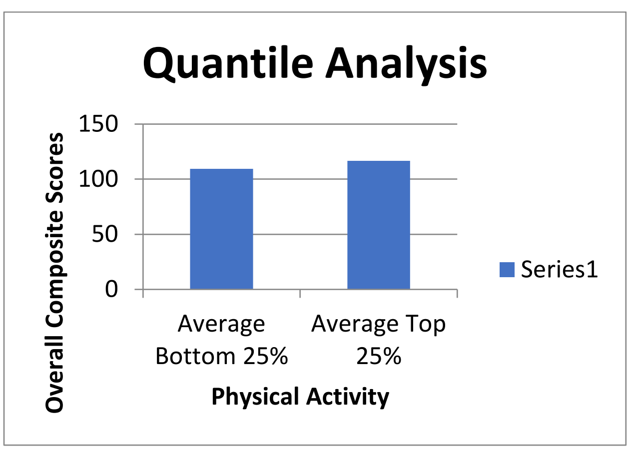

Figure 5: A quantile analysis of overall composite scores based on the top 25% of participants and the bottom 25% of participants categorized by physical activity. Analyzing the data using this graph helps to visualize the difference in overall scores of the participants between the top and bottom quantiles.