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The Effects of Physical Activity Duration and Intensity on Age-Related Cognition

Christie Chung[1*], Julia A. Przemyslaw[1]

[1]*Mills College Psychology Department, 5000 MacArthur Blvd, Oakland, CA 94613, USA*

**Corresponding author: Dr. Christie Chung, Mills College Psychology Department, 5000 MacArthur Blvd, Oakland, Tel: (510) 430-2251; Email: cchung@mills.edu*

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Abstract

In the present study, we examined how intensity and duration of physical activity might differentially affect age-related cognition. We utilized clear operational definitions of physical activity intensity and duration set forth by [1], and carefully instructed 35 older adults (56-93 years old) to complete a detailed 14-day journal packet of their daily activities. Fourteen of these older adults were participants in our research lab 6 years ago, therefore, we were able to examine cross-sectional as well as longitudinal data in this study. Our longitudinal and cross-sectional results suggest that while activity duration was associated with depression status; activity intensity was important for maintenance of cognitive health and social support in old age.

Keywords: Aging; Physical Activity; Memory; Mood; Social Support

Introduction

Several studies have established a positive relationship between exercise and cognitive abilities in old age [2,3]. Cognitive decline is a particular concern in the older population [4]. As the world population becomes older, retention of cognitive abilities becomes more imperative for societies in general [4]. Not only does cognitive decline pose a threat to the mental health of individuals, it also threatens the independence of a growing part of the world's population. [5] Raised awareness about mixed findings in the area, which motivated more in depth research on factors that affect cognitive health.

Although many studies have examined the impact of physical activity on age-related cognition, the insufficiency of definitions for duration and intensity of physical activity have posed a problem in interpretation of the findings [6]. Clarifying how physical activity affects cognition is imperative if the results of studies were to be put into practice. That is, ideal duration and level of physical activity intensity have to be determined and defined. Studies have evaluated duration and intensity, but rarely have they been presented and analyzed separately in regards to the results [6]. In addition, many studies have limited physical activity to exercise. However, physical activity encompasses more than merely exercise. It is in many ways, and especially with respect to older adults, everyday choices that comprise a lifestyle. For example, [6] found a positive association between hobbies/leisurely pursuit activities and the changes in cognitive status in old age.

[7] Carefully defined leisure activity as "the voluntary use of free time for activities outside the daily routine," in their systematic review of studies on leisure activities and dementia. [7], Claim that leisure activities are crucial elements of a healthy lifestyle. The authors argue that leisure activities must be integrated into older adults' lifestyles, given how beneficial these activities can be on one's health. According to [7], physicians should be prescribing physical and leisure activities as they would prescribe medicine. [7], mentioned that leisure activities and social engagements have a protective effect against dementia. In an 18-month intervention, the experimental groups improved on cognitive tests, while the control participants' performance remained unchanged. The authors also argue that the evidence can be controversial. [7] Acknowledged the shortcomings of many studies they analyzed. The definition of leisure activity was inconsistent, and there was a disparity among types, duration, and intensity of leisure activities. The studies found a number of other leisure activity benefits, such as lowering stress, promoting overall psychological well-being, healthier lifestyle, and better diet. [8] Conducted a meta-analysis of the relationship between physical activity and cognition in older adults, comparing active to sedentary women. They

took a broader approach to the relationship between physical activity and cognition, and presented physical activity as a strategy, which is highly promising and incredibly cost effective, to prevent physical and cognitive decline. The authors also emphasized that even after adjusting for covariates, such as age, education, and ethnicity, physically active women are more likely to survive than less active women. In fact, the lack of physical activity is a strong predictor of premature death. According to [8], sedentary women have a 98 percent higher risk of earlier mortality than their active counterparts. The authors raised a few concerns that should be considered when analyzing the effects of physical activity. For example, what are the long-term effects of physical activity on cognition when participants become active later in their lives? [8] Claimed that the benefits of physical activity could yield immediate and long-term results, both in physical and emotional conditions. However, the long-term effect on cognition has not yet been determined.

Another meta-analysis of longitudinal studies conducted by [9], shows that any level of physical activity is protective against cognitive decline. However, high level physical activity was a much stronger predictor of good cognitive health than low level of physical activity. Therefore, the authors suggested that high level physical activity protected older adults from cognitive decline. [9] Claimed that there was a causal relationship between lack of physical activity and cognitive decline, they did acknowledge that physical activity could be an ill-defined term. Additionally, this ill-defined term was often administered by self-report questionnaires, which were subject to biases. Lack of properly defining physical activity and subjects' biases might lead one to question the validity of the results of experiments. [9] Mentioned that many researchers did not report much on the validity and reliability of the measures used.

[10] Suggested that measuring physical activity through self-administered questionnaires was not reliable. [10] Claimed that questionnaires threaten the validity of studies, because participants were often biased when reporting on their own exercise. In our present study, visits to older adults' community centers took place for a period of two months. During these visits, we had the opportunity to observe the lifestyle of older adults and to explain directly to them the importance of accurate self-report. Because unclear operational definitions for duration and intensity threatened the validity of past studies' results, the present study used clear definitions put forth by [1] to measure physical activity duration and intensity.

[1] Established four levels of duration that varied from less than 30 minutes a day to more than 120 minutes a day. An important aspect to acknowledge, when evaluating duration, is that in old age, lifestyle choices are considered to be physical activity. When considering duration, most physical efforts should be taken into account, whether they are formally considered "exercise" or not. For example, one who walks instead of using the car for errands, and makes walking part of his or her lifestyle, is in fact exercising even though it may not be a conscious effort to exercise. In this example, the time spent walking is considered physical activity. By providing four levels of duration of exercise and by stating what encompasses exercise, participants were able to identify in which of the four levels they belong. Clear descriptions were provided and guided participants towards the most accurate answer[1]. Divided intensity into the four categories that included everyday habits, various sports, hobbies, and exercise. The lowest category included slow pace walking and playing billiards, and the highest category included fast pace walking, swimming, and bicycling. These four divisions of intensity, as well as the four divisions of duration, were self-reported. As mentioned before, self-reports may pose a threat for the validity of the data. However, by clearly describing the levels of the variables to our participants, we were confident that they had chosen the most accurate answers to reflect their daily physical activities.

Based on previous findings, we hypothesized that intensity, rather than duration, of physical activity plays a major role in preventing cognitive decline [6]. We conducted a longitudinal study (Experiment 1), as well as a cross-sectional study (Experiment 1a) to address our hypothesis.

Method

Participants

Our sample consisted of 35 individuals, seven men and 28 women. Participants were screened for mental and physical illnesses, and were independent in their daily functions. Participants' ages ranged from 56 to 93 years old. They were reimbursed with $20 Trader Joe's gift cards for participation. They received one $10 gift card upon finishing the first phase of the study, and another $10 gift card upon finishing the second phase.

Experiment 1 was the longitudinal part of our study. These participants (n = 14) had participated in an age-related positivity effect study in 2008 and were contacted by their preferred method (email or phone) for this study. Experiment 1a was the cross-sectional part of our study, therefore, we recruited a new group of older adults (n = 21) from online, community centers, and word of mouth in the San Francisco Bay Area. Testing sessions took place in a quiet room in the participants' residence, residential clubhouse, or library.

Materials and Procedure

The study was conducted identically with participants in Experiments 1 and 1a. Tests were administered in the same order with all participants. All tasks are listed below, in the order they were conducted.

Prior to data collection, participants filled out an informed consent. Each participant then completed a set of self-administered demographic and general health questionnaires that addressed gender, education, ethnicity, age, marital status, and other background information.

To assess mental status, participants took the Mini Mental State Exam [11]. The MMSE consists of 11 questions that test five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The MMSE is a practical measure to assess cognition and screen for dementia, takes between five to ten minutes to administer, and is a highly reliable scale. The maximum score is 30, with scores below 27 indicating possible cognitive impairments.

To assess cognitive functioning, participants took subtests from the Wechsler Adult Intelligence Scale – Third Edition [7] as well as the Wechsler Memory Scale – Third Edition [12], which are extensive and comprehensive scales that measure intelligence and memory. The tasks selected from WAIS-III and WMS-III was Digit Span, Letter-Number sequencing, and Faces I. Participants in Experiment 1 have taken some of these cognitive tests in their previous participation; therefore, we could compare their current results to previous data.

To measure views and experiences of getting older, participants took an aging questionnaire that included the View of Aging task [13], as well as the Aging Perception Questionnaire [14].

We administered the Beck Depression Inventory [15] to screen for depression. A score of over 10 indicates possibility of depression. The BDI consists of 21 items that measure attitudes and symptoms of depression, and takes approximately 10 minutes to complete.

Participants also took the Geriatric Depression Scale [16], a scale designed to measure depressive symptoms specific to the older population. Participants then completed the Rasch Modeled Memory self-efficacy scale [17] to assess meta-memory functioning, i.e., how they rated their memory ability. Participants also took the Functional Social Support Questionnaire [18], which measures how people perceive the quality of their social support network.

The last two cognitive tests, Faces II and Vocabulary were subtests from the Wechsler Adult Intelligence Scale – Third Edition [7] and the Wechsler Memory Scale – Third Edition [12]. Faces II was administered approximately 30-minutes after Faces I. All cognitive and demographics information can be found in Table 1.

Participants were offered a break of at least 5 minutes during the 1-hour testing session to reduce the possibility of fatigue. Participants were told clearly before the testing session that participation was completely voluntary. If they were to experience any discomfort any time during the session, they had the right to terminate the session but still be compensated with the appropriate amount of reimbursement.

After these in-person tests, participants were asked to complete a self-report activity record for the next 2 weeks (see Appendix). We left each participant with a packet that included 14 identical questionnaires to be filled out each day. Participants recorded the types of activity that they engaged in; including the intensity (1-4 scale) and duration (1-4 scale) of each activity. Approximately one month later, we collected these packets and reimbursed participants for completing the second part of the study.

Results

Intensity of physical activity was measured in four categories (1, 2, 3, 4) including sport, hobbies, habits, and exercise. Bicycling at low pace was in the low intensity category, whereas jogging was in the high intensity category. Duration of physical activity was also measured in four categories (30 minutes or less, 31 to 60 minutes , 61 to 90 minutes, and 120 minutes or more) including sport, hobbies, habits, and exercise. All analyses reported below utilized a significance level of $p < .05$.

Bivariate Pearson correlations were conducted to examine relation among age, years of education, physical activity mean intensity, physical activity mean duration, Geriatric Depression Scale (GDS), and MMSE change scores (2008 vs. 2014). We found an overall (Experiments 1 and 1a combined) significant negative correlation between mean duration and depression (GDS), $r = -.35$, $p < .04$, and an overall significant positive correlation between mean intensity and social support (FSSQ), $r = .35$, $p < .04$.

The negative correlation between mean duration and GDS suggest that the more older adults engaged in high duration of physical activity, the less depressed they were. The positive correlation between mean intensity and FSSQ show that the more older adults engaged in high intensity physical activity, the more they perceived themselves as having a system of social support, and vice versa.

Group	Age	Years of Education	MMSE (2008)	MMSE (2014)	GDS	Mean Duration	Mean Intensity	Digit Total Score	LNS	Faces I	Faces II	BDI	FOF	FSSQ	Vocab
Exp. 1 (n = 14)	75.93 (10.02)	16.21 (2.58)	28.29 (1.81)	26.79 (2.46)	2.57 (2.47)	2.13 (1.30)	1.73 (1.35)	16.79 (3.47)	5.93 (3.95)	32.21 (6.87)	30.64 (9.14)	5.79 (4.48)	46.14 (10.83)	34.79 (6.76)	40.36 (13.67)
Exp. 1a (n = 21)	64.67** (7.11)	19.05* (3.64)	----	27.48 (2.42)	1.75 (2.71)	2.71 (1.90)	2.84 (1.96)	19.81* (2.58)	8.95 (3.15)	34.48 (5.10)	37.20** (4.55)	4.38 (4.50)	51.81 (9.47)	35.24 (5.67)	52.15** (8.50)

Table 1. Demographics and Cognitive Measures: Means and standard deviations
* $p < .05$, ** $p < .01$, for difference between Exp. 1 and 1a.

To further understand our results, we conducted two multivariate multiple linear regression analyses with GDS and MMSE change score as our dependent variables. In our first model, we included age, years of education, mean intensity, and mean duration as predictors (all in one step) of MMSE change from 2008-2014. This analysis showed that mean intensity of physical activity was the only significant predictor of cognitive difference between years 2008-2014, $b = .66$, $t = 2.41$, $p < .04$. None of the predictors achieved significance in our second model with GDS as a dependent variable. These results remained constant when age and years of education were used as covariates in subsequent analyses.

Discussion

The primary goal of this study was to examine how intensity and duration of physical activity affect cognitive health of older adults. Previous studies did not always clearly define intensity and duration of physical activity. This study used clear operational definitions for intensity and duration, and found a distinction between how each of these variables (intensity and duration) influenced older participants' well-being and cognition, both longitudinally and cross-sectionally.

Our results suggest that mean intensity of physical activity was a significant predictor of cognitive change from 2008 to 2014; while duration of physical activity correlated with depression status. Previous research studies have established a relationship between intensity of physical activity and cognitive health [6]. Other studies claimed that any exercise benefits cognition [8]. However, intensity and duration of physical activity were often not clearly defined.

As predicted, mean intensity of physical activity played a significant role in older adults' cognitive change (between 2008 and 2014), as well as their perceived quality of social support; while duration of physical activity correlated with their mood. Therefore, it is essential that older adults engage in high intensity physical activity, e.g., jogging, playing tennis in order to maintain their cognitive health.

The significant correlation between duration and depression indicates that duration of physical activity may be related to older adults' emotional health, although the direction of this effect is not specific. Also, group activity – which we assume increases social support level – might not only increase the amount of time spent being active, but might indeed be beneficial to older adults' cognitive health if intensity of such activity is increased. The relationship among these factors should be explored in a future study.

Our results suggest that physical exercise intensity is important for the maintenance of cognitive performance, emotional health, and social support. Our findings corroborate with [19] claim that physical exercise is a strong aid in keeping the structure of brain health and improving cognitive functioning. Physical activity could bring about changes on people's bodies in very short periods of time. A recent study by [20], examined identical twins, where one twin had become sedentary and the other twin was active, over the period of three years. Many physical and mental differences were found in the twins. Researchers concluded that physical exercise can "rapidly and substantially improve the condition of our bodies and brains" [20]. Studies such as [20] reinforce the importance of physical activity at all ages, and how it may determine cognitive, emotional, and physical health that may influence many other aspects of people's lives.

There are limitations to this study that should be considered in future research. Due to the nature of studying older adults, we had a high attrition rate from the original 2008 database. Our small sample sizes could also have affected the power of our analyses, therefore, in future studies, we hope to be able to have a larger number of participants to further examine our research questions. Future studies could also benefit from analyzing other variables such as eating habits, sleeping cycles, and alcohol/tobacco consumption in relation to physical activity and cognition.

This study consisted of two groups of participants, longitudinal and cross-sectional groups. Adding a third group (control group) consisting of sedentary participants would be of theoretical interest. Most of our participants were highly educated and of high socioeconomic status. We aim to have a more diverse sample for future studies. For example, people with physical jobs with high means in physical activity duration may not necessarily experience less depression symptoms.

In future studies, we would also like to explore some benchmarks in order to be able to suggest practical guidelines. For example, how much duration is needed to have an impact in mood? What level of intensity is needed to have an effect in cognitive health? Thirty minutes of low-intensity exercise, merely to check it off the list, may not be enough to impact on one's cognition.

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Appendix

MILLS COLLEGE

Department of Psychology

Daily Activities Self-Report

Date: ____/____/____

How many hours of sleep did you get last night? _____
What time did you get up? _____
What time did you go to bed? _____
Did you have any alcoholic drinks today? If yes, what kind and how many? _____
If you smoke, how many cigarettes did you smoke today? _____
How many meals did you eat today? _____

How did you get to your daily commitments today? Please check all that apply.

	Public transportation	Cab	Car	Walk	Other
< 1 mile					
1 to 5 miles					
> 5 miles					

Please check all that apply:

	< 30 minutes	31 to 60 minutes	61 to 120 minutes	> 120 minutes
Cook				
Climb stairs				
Clean the house				
Launder or iron				
Garden or mow the lawn				
Walk for pleasure				
Maintenance work at home				
Aerobics work				
Exercise with weights				
Conditioning exercise				
Other				

Please check all that apply:

	< 30 minutes	**31 to 60 minutes**	**61 to 120 minutes**	**> 120 minutes**
Floor exercising (yoga, stretching)				
Dancing				
Running				
Jogging				
Walking				
Swimming				
Cycling				
Bowling				
Tennis				
Squash				
Table tennis				
Golf				
Football, rugby, hockey				
Cricket				
Rowing				
Volleyball, basketball				
Fishing				
Horse-riding				
Snooker, billiards, darts				
Musical instrument playing or singing				
Sailing, wind-surfing				