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Abstract

Work-related physical activity (PA; WRPA), household PA (HPA), and leisure-time PA (LTPA) are the 3 important PA domains for most people, but their relationships with cognition functions have not been thoroughly examined, especially the subjective memory complaints (SMCs). We used a data set from the 2005 midlife development in the United States (MIDUS) survey for community-dwelling adults aged 35 to 64 years (mean age = 51.01) to examine the relationship between these 3 PA domains (and 3 levels under the domains) with SMCs (N = 1044). The moderate levels of HPA and LTPA are significantly but oppositely linked to SMCs, with the adjusted odds ratios and 95% confidence intervals of .864 and .764-.978 for HPA and 1.130 and 1.010-1.264 for LTPA, respectively. Neither vigorous or low PA level nor domains of WRPA link to SMCs. The interaction terms were not found to be associated with sex and age. Future works and limitations were also discussed.

Keywords

work-related physical activity, household physical activity, leisure-time physical activity, physical activity, subjective memory complaints, dementia

Many elderly people complain of impaired memory.¹ In diagnostic definitions addressing mild cognitive impairment (MCI), this is termed age-associated memory impairment² or age-associated cognitive decline.³ Emerging data in clinical cohort studies suggest that there may be very subtle cognitive alterations that are detectable years before meeting the criteria for MCI and that predict progression to Alzheimer's disease (AD) dementia.⁴ For example, it is suggested that the cognitive alterations in subjective memory complaints (SMCs) in the elderly people may hold value as a predictor of dementia.⁵⁻⁷ Amieva et al suggested a progressive prodromal phase of AD that, decline in cognitive performances appeared as early as 12 years before dementia in measures of semantic memory and conceptual formation,⁸ then followed by memory complaints, cognitive dysfunction, and, finally, cognitive function significantly deteriorating in the last 3 years until the participants reached the dementia phase. Jessen et al, claimed that SMCs are receiving increased attention as a possible pre-MCI condition in the course of the clinical manifestation of AD.⁹ Both the studies suggest memory complaints might be a good predictor of memory loss, which could link to dementia. Those with memory complaints seem to have 2.7 times higher risk to develop dementia than those without such complaints.¹⁰ The terms forgetfulness, memory problems, and SMCs are used interchangeably in this article.

Diagnosis of AD is not merely the clinical stages of the disease. The National Institute on Aging-Alzheimer's Association

workgroups on diagnostic guidelines for AD suggests that there may be a lag of a decade or more between the beginning of the pathological cascade of AD and the onset of clinically evident impairment.¹¹⁻¹⁵ Diagnosis of AD is not merely the clinical stages of the disease. The workgroups also suggested that individuals with biomarker evidence of early AD with pathophysiology are at greater risk of developing cognitive and behavioral impairment and progression to clinical stages of dementia. Similarly, a study also found that 97% of AD, 61% of MCI, and 22% of healthy elderly individuals had the presence of β -amyloid plaques that are strongly associated with episodic memory impairment in healthy individuals.¹¹ Studies also found that the amyloid deposition and cognitive memory markers change relatively early in the course of AD

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disease.^{12,13} Accordingly, it was suggested to adopt healthy lifestyle to reduce the risk of dementia preferably in middle age.¹⁴ In addition, women have been found more memory complaints than men (35.2% compared to 28%).¹⁵

Epidemiological studies reveal physical inactivity related to many psychological and physical health problems including (but not limited to) depression, diabetes, cardiovascular disease, hypertension, colon cancer, osteoarthritis, and osteoporosis which lead to mortality.¹⁶⁻²¹ However, the role of physical activity (PA) on cognitive function is conflicting. Researchers suggest that PA may serve as protection against memory loss, dementia, and cognitive impairment.^{22,23} Ghosh suggested that cognitive processing and memory retrieval speeds decline by as much as 20% by 40 years of age, and PA may be protective and prevent cognitive decline.²⁴ In addition, assessment using modern magnetic resonance voxel-based morphometry, Flöel et al, suggested that higher levels of PA were associated with higher levels of neurotrophin and increased cerebral gray matter volume in the human prefrontal and cingulate cortex²⁵; both studies assumed the possible mediators of the PA effects on cognitive function. Further, Vaienzuela and Sachdev claimed that dementia was diagnosed at a significantly lower rate in patients with a higher level of memory-based leisure activities and social interactions than those with less rigorous ones (relative risk = 0.54; 95% confidence interval [CI], 0.49-0.59).²⁶ Similarly, more physically active elderly individuals had better memory performance on the Word List Memory task ($r = .45$, $P < .04$).²⁷ Yet, others claim that the protective effects of PA on dementia and cognitive impairment may be overly optimistic.^{28,29} For example, Morgan et al compared leisure-time PA (LTPA) and work-related PA (WRPA) from the Caerphilly Prospective study (CaPS) with dementia and cognitive impairment not dementia (CIND) after around 16 years of follow-up. In their study, age-adjusted models found no real association with dementia, and increased risk of CIND was attenuated after adjustment for other confounders.

Historically, the beneficial effects of PA on health found in the literature focus on LTPA. In general, PA is often classified into 4 domains that reflect the purpose of the activity. The present study analyzed 3 specific domains of PA, WRPA, household PA (HPA), and LTPA, which are rarely examined together to determine their relationship with health.³⁰ Specifically, the relationship of the 3 domains of PA with SMC has never been previously examined in a single study. Separately, they had been assessed with various diseases. For example, light HPA has been reported to significantly reduce the risk of diabetes.³¹ In addition, Wiles et al suggested that there was little evidence that men in the most physically demanding jobs had reduced odds of common mental disorders after 5 years.³²

The goals of the current study aimed to answer 3 research questions: (1) are the 3 levels (high, moderate, and low) of PA along with the 3 types (WRPA, HPA, and LTPA) related to SMC? (2) Are the 3 types and 3 levels of PA related to SMC in the same direction (positively or negatively)? (3) Would the association differ between PA and age or between men and women (interaction terms)?

Methods

Participants

We drew data from the Midlife Development in the United States (MIDUS) surveys of 2005. It was based on a national representative random-digit-dialRDD sample of noninstitutionalized, English-speaking adults aged 25 to 74 (wave I) years, selected from working telephone banks in the coterminous United States in 1995.

With support from the National Institute on Aging, a longitudinal follow-up (wave II, 10 years later) of the original MIDUS national probability sample ($n = 3487$) was conducted in 2005.³³ The MIDUS II respondents were aged 35 to 86 years, and the sample selected in the current study differs from the overall MIDUS in that data included only those aged 35 to 64 years who responded to SMCs' questions with either improvement or decline and only those with either current full-time or part-time jobs (mean age = 51.01, $N = 1044$). Participants who responded with "stay at the same" in the SMCs were excluded. The characteristics of included and excluded groups are shown in Table 1.

Study Design

This study was based on MIDUS II data from a cross-sectional survey, designed by the MacArthur Midlife Research Network. This questionnaire comprised questions concerning behavioral, psychological, and social factors to understand age-related differences in physical and mental health.

Measures

Dependent Variable

Subjective Memory Complaints. This is a 1-question variable that inquires participants about their current memory function compared with 5 years ago. Participants were asked: "How would you rate yourself today compared to 5 years ago on memory?" Participants rated their subjective memory performance on a 5-point scale ranging from 1 ("improved a lot") to 5 ("gotten a lot worse.") Those indicated "stayed the same" compared to 5 years ago was excluded for analysis. For analysis purposes, those indicated improvement (either a little or a lot) on their memory was recorded as 1, those who indicated decline (either a little or a lot) was coded as 2.

Independent Variable

Physical Activity. The 3 domains of PA included WRPA, HPA, and LTPA. Representing these 3 domains, various levels of PA (vigorous, moderate, and light) were ascertained during summer and winter seasons while the participants were at their job, home, or during leisure time. Based on their answers for each domain, scores of 2 (highest) to 12 (lowest) were recorded indicating highest level (several times a week) to lowest level (never) of PA, respectively. The questions for probing participant levels of PA are same for all 3 domains and also the same

Table 1. Comparison of the Included and Excluded Samples for Data Analysis.

Variable	Included sample (N = 1044)	Excluded sample (N = 1199)	P value
Memory ^a score	3.81	3.00	<.05
PAphysical activity (PA) ^b			
Job (low)	5.24	5.16	.571
Home (low)	3.49	3.58	.37
Leisure (low)	3.67	3.68	.988
Job (moderate)	8.08	7.96	.487
Home (moderate)	5.94	6.11	.188
Leisure (moderate)	5.48	5.46	.921
Job (high)	9.26	9.98	.063
Home (high)	7.50	7.40	.428
Leisure (high)	6.70	3.68	.567
Age, Mean in years	51.01	50.58	.197
Male,%	44.00	53.13	<.05
Education	7.70	7.63	.502
Smoker,%	53.47	59.26	.436
Frequent alcohol use,%	3.55	3.60	.372
Financial situation ^d	6.33	6.48	.078
Heart issues,%	16.35	16.33	.995

^a Memory refers to self-report subjective memory complaints compared to 5 years ago.

^b PA scale: 2 = highest level (several times a week), 12 = lowest level (never). Under the PA scale, low = light PA that requires little physical effort; moderate = moderate PA that is not physically exhausting; high = vigorous PA that causes heart to beat rapidly.

^c Education level range: 1 (no school) to 12 (PhD, MD, or other professional degrees).

^d The financial situation ranges from 0 (worst) to 10 (best).

for both the seasons. That is, 2 questions (one for summer and the other for winter) total for each level under each domain.

The sample question for probing high PA was how often do you engage in vigorous PA that causes your heart to beat so rapidly that you can feel it in your chest and you perform the activity long enough to workup a good sweat and to breath heavily? This question is asked twice (1 for summer and 1 for winter) and asked for each domain.

The question asked for probing moderate PA was: how often do you engage in moderate PA, that is not physically exhausting, but it causes your heart rate to increase slightly and you typically workup a sweat? The question for probing low PA was: how often do you engage in light PA that requires little physical effort? In addition, an example was given for each question to illustrate the meaning. For example, for light level of PA light housekeeping activities like dusting or laundry; bowling, archery, easy walking, and golfing with a powered cart or fishing.

Statistical Methods

Logistic regression analysis was performed to evaluate the risk of any SMC, in conjunction with the 3 domains of PA (WRPA, HPA, and LTPA). The low level of the 3 PA domains was analyzed first to examine the relationship with SMC, followed by moderate and high levels, respectively.

Covariates (see Confounders section) were included to adjust the PA–SMC relationship. The odds ratios (ORs) and 95% CIs were calculated. To further probe PA interaction with age and sex, the interaction terms of the 3 PA domains with age and PA with sex were included in the analysis. The participants in the secondary analysis are the same as the primary analysis. The association between PA and SMC was expected to differ between men and women and between the age groups. The participants' ages were divided into 2 groups (group 1: 35-50 years, and group 2: 51-65 years) for assessing their interaction effects. Missing data were handled as system-missing values for all the variables.

Confounders

Potential confounders that were taken into account included sex, age (35-65 years), educational level (no school to PhD: 1-12), cigarette smoking regularly (yes/no), heart trouble suspected/confirmed by a doctor (yes/no), alcohol intake (at least 1 drink during the past month: yes/no), and financial situation (from worst to best: 0-10).

Results

Descriptive characteristics of the participants are shown in Table 1. Most (87.53%) people mentioned their memory got worse, and only a small portion of those surveyed stated that they improved (12.47%). For patients participating in PA, WRPA (vigorous level) has the highest mean (9.116) followed by WRPA (moderate level). The lowest mean is HPA (low level), indicating most people participated in a low level of PA for 3 domains, followed by moderate level, and few people at the high level of PA. Please note that a high mean stands for low frequency of PA.

Logistic regression analysis was performed for the 3 domains of PA to better understand the OR of risk in terms of the relationship between PA and SMC scores. Only moderate level of HPA and LTPA was significantly associated with SMC with the adjusted OR (OR_{adj}) = .864 (95% CI = .764-.978, P = .021), and OR_{adj} = 1.130 (CI = 1.010-1.264, P = .033), respectively, as in Table 2. Please note that the β -weight difference for HPA and LTPA (1 positive and 1 negative), indicating those who self-reported (1 unit) less engagement in household chores increased the chance by 13.6% of memory improvement. Those who reported (1 unit) less of PA during their leisure time increased the risk by 13% of having worse memory than 5 years ago. The WRPA was not significantly related to SMC.

A secondary 1-way ANOVA was conducted between participants for 6 conditions (several times a week, once a week . . . to never) of PA (independent variable) on the SMC (dependent variable). The analysis found a significant effect of moderate LTPA on SMCs with $F_{5, 2171} = 2.355$, P = .038.

There were no significances found for SMC on the rest of the PA domains. Post hoc multiple comparisons using the least significant difference test indicated that those more active

Table 2. Corrected Relations Between WRPA, HPA, and LTPA and Subjective Memory Complaints (Odds Ratios ; 95% Confidence Interval [CI] Corrected for Age, Sex, Education, Cigarette Smoke, Alcohol Use, Financial Situation, and Heart trouble) Included Interaction Terms of PA With Age and PA With Sex. (N = 1044).

	b	Subjective memory complaints	P Value
PA			
WRPA (M)	.071	1.073 (.989-1.165)	.091
HPA (M)	-.146	.864 (.764-.978)	.021
LTPA (M)	.122	1.130 (1.010-1.264)	.033
Interaction			
WRPA (M) × age		1.067 (.911-1.250)	.419
HPA (M) × age		1.029 (.809-1.311)	.814
LTPA (M) × age		.839 (.677-1.040)	.108
WRPA (M) × sex		1.005 (.854-1.182)	.951
HPA (M) × sex		1.145 (.888-1.478)	.297
LTPA (M) × sex		.885 (.713-1.098)	.265

Abbreviation: PA; physical activity; WRPA, work-related PA; HPA, household PA; LTPA, leisure time PA; (M), moderate level of PA.

Table 3. Post Hoc LSD Comparisons for Moderate Leisure Physical Activity on Subjective Memory Complaint.

Comparisons	Mean difference	Std error	95% CI	
			Lower bound	Upper bound
Once a week vs once a month	-0.126 ^a	0.055	-0.230	-0.020
Once a week vs less than once a month	-0.136 ^a	0.058	-0.250	-0.020
Several times a month vs once a month	-0.117 ^a	0.054	-0.220	-0.010
Several times a month vs less than once a month	-0.127 ^a	0.057	-0.240	-0.020
Once a month vs never	0.138 ^a	0.064	0.010	0.026
Less than once a month vs never	0.148 ^a	0.066	0.020	0.280

Abbreviations: CI, confidence interval; LSD, least significant difference; Std Error, standard error.

^aP < .05.

elders on LTPA tend to complain less on memory loss (see Table 3).

In the interaction analysis, there were no significant 2-way interactions between the 3 domains of PA with age and between PA and sex, indicating that the relationship between PA and SMCs was not stronger in younger people than in older people nor with men compared to women.

Discussion

Summary of the Key Study Findings

Participants who engaged in a specific level of household and leisure domains of PA are related to lower risk of SMC. Specifically, this association is only limited to the moderate level and

not the other 2 levels of PA (low or high). The PA–SMC link is opposite for HPA and LTPA. The interaction terms of PA with age and PA with sex were not found.

Contribution of this Study to the Existing Literature

Given the importance of the PA link to cognition impairment and dementia,¹³⁻¹⁶ the present study tried to probe a more specific link between PA (3 levels of PA under 3 specific domains) and SMC. By examining randomly selected national (United States) representative community-dwelling middle-age samples (aged 35-64), the current study is unique in its focus on the link between the 3 specific PA domains (WRPA, HPA, and LTPA) and SMC. To the best of our knowledge, this specific PA–SMC connection within 1 model has not been examined in the current literature. By including the covariates of gender, age, education, cigarette smoking, alcohol use, financial situation, and heart disease, this study contributes to the present literature by (1) exploring the relationship of the 3 PA domains (WRPA, HPA, and LTPA) and levels (low, moderate, vigorous) with SMC, within 1 model. In addition, (2) the current study examined the association direction (positive or negative) of the 3 PA domains with SMC. Finally, (3) this study provided the interaction term information between PA and gender along with PA and age.

Research Question 1: Are the 3 Levels (High, Moderate, and Low) of PA Under the 3 Types (WRPA, HPA, and LTPA) Related to SMC?

In the present study based on the MIDUS survey data, the frequency of middle-age adults (aged 35-64) engaged in a specific level of HPA and LTPA are related to lower risk of SMC. In addition, the association was only limited to the moderate level of HPA and LTPA. This study is consistent with previous research in that a specific level of LTPA protects against memory decline, which may be a sign to predict later cognitive decline.^{13-16,25,34} The secondary analysis of the present study also supports the LTPA and SMC relationships where those adults (age: 35-64) with frequent moderate LTPA tend to have less memory complaints. The direct link between HPA and cognition was not established in the previous studies. It was sometimes included in PA as total PA (all domains).

Vigorous PA was recommended and promoted during mid-1980s. However, public health benefits of moderate PA first became prominent in the mid-1990s with the publication of PA and public health recommendations from the Center for Disease Control and Prevention, the American College of Sports Medicine in 1995, and the US Surgeon General's Report on Physical Activity and Health in 1996.³⁰ In comparison to the moderate-level PA, Huang and Chen suggested those participating in either vigorous or low PA are both susceptible to musculoskeletal injury.^{35,36} Participation in moderate PA has been suggested to gain health benefits.³⁷

Research Question 2: Are the 3 Types (WRPA, HPA, and LTPA) and 3 Levels (High, Moderate, and Low) of PA Related to SMCs in the Same Direction?

Both HPA and LTPA are significantly related to SMC but in the opposite directions. Those who reported less involvement in moderate HPA chores increase the probability that their memory subjectively improved, that is, higher moderate-level HPA linked to worsen memory (negative relationship). Those who reported less involvement in moderate PA during their leisure time increase the risk of subjective memory worsening, that is, additional moderate-level LTPA is linked to subjectively better memory (positive relationship). No relationship was found for WRPA and SMC.

The positive link between LTPA and cognitive function was well discussed in the previous studies. Although many studies discussed the PA–cognition relationship, to the best of our knowledge, no study has explored the specific link between HPA and SMC. The current study included participants with either full- or part-time jobs and may explain the results of middle-age adults (aged 35-64) who are already expending much energy during their work and are negatively inclined or even depressed about doing “extra” home chores for both the genders.³⁸ Previous studies established that depression might lead to cognitive impairment.³⁹ Besides, the characteristics of never ending home chores might discourage adults with young kids. This again may make people feel depressed or stressed, especially when their jobs are also demanding. For example, in a survey of 1316 Taiwanese working women, “having too many household chores to do” tops the list of various role stressors.⁴⁰ Accordingly, women shoulder most of the household chores while holding a job.⁴¹ In terms of healthy memory, it might be a burden for only 1 person to be responsible for all household chores.

Research Question 3. Does the Association Differ Between PA and Age and Between Men and Women (Interaction Term)?

It has been suggested that the variables associated with insufficient levels of PA in leisure were female and older age. In occupational and household settings, the variables were female, respectively.⁴² However, the present study did not find interaction of PA-age and PA-sex significantly related to SMCs. This does not contradict the previous study; it just simply indicates that the interactions related to SMCs were not obvious or strong enough in the present data.

Future Study and Limitations

Future studies might further the research by promoting LTPA, given the positive results of an activity. Moderate-intensity PA, especially, may deserve more attention. In addition, the negative results of moderate-intensity level HPA provide an opportunity for future study to further explore the types of sociodemographic groups or individuals that belong to the

HPA group. Furthermore, the memory in the study was not specifically identified regarding which type of human memory might be affected by PA (semantic, episodic, or procedural, etc). Knowing the memory type affected may be helpful to develop effective treatment plans for such patients. Both the independent and the dependent variables are subjectively perceived or frequency measures that limit precision compared to objective measures. However, the examples of PA levels given during interview make the subjective measures closer to the objective measures. Nevertheless, future studies should adopt the objective measures for more sensitive detection of correlations. Sperling et al suggested that future studies also need to develop sensitive measures in multiple cognitive or behavioral domains that will reveal evidence of early synaptic dysfunction in neural networks vulnerable to AD pathology. These measures may allow early disease detection or monitor response to potential disease-modifying therapies in these very early stages.⁴

Conclusion

Physical activity has been suggested and recommended for every group of individuals. Our study suggests that moderate-intensity HPA may negatively affect cognitive benefits (SMCs), and LTPA may positively promote cognitive benefits. In addition, the interaction terms between PA-age and PA-sex are not obviously linked to SMCs.

Declaration of Conflicting Interests

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