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Activity engagement and physical function in old age sample

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ABSTRACT

Objectives: To describe the patterns of engagement in mental, physical, and social activity (MA, PA, and SA) and to examine the relationship between combined activity engagement and physical function among community-dwelling older adults.
Design: Cross-sectional correlational study.
Setting: Multiple communities.
Participants: A total of 466 individuals aged 55 years or older.
Measurements: Physical function was assessed using grip strength and gait speed. Engagement in PA, MA and SA was obtained from self-report questionnaires.
Results: We identified four classes (“Active PA and MA”, “Active MA”, “Active PA”, and “Inactive”) that significantly differed in the frequency of engagement in MA and PA using latent class analysis. SA didn’t differ across classes. Controlling for age, the “Active PA and MA”, “Active MA”, “Active PA” groups displayed similar grip strength that was superior to the “Inactive” group. “Active PA and MA” group had best gait speed relative to other groups, especially “Active MA” and “Inactive” group, while the “Active PA”, “Active MA”, and “Inactive” group were similar in gait speed.
Conclusion: Combined physical and mental activity engagement was associated with better physical function, especially in gait speed. Future interventional research should investigate the combination of both physical and cognitive training to prevent decline of physical function in older adults.
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1. Introduction

Physical function is defined as the ability to perform the basic actions (i.e., mobility, strength, and endurance) that are essential for maintaining independence and carrying out more complex activities (Painter, Stewart, & Carey, 1999). Decline in physical function is common among older adults and has been shown to increase the risk of falls, hospitalization, nursing home admissions, dependence, and poor quality of life (Brown and Flood, 2013). Hence, promoting physical function is critical for preventing its associated adverse health outcomes and constitutes one of the hallmark signs of successful aging.

One way to prevent functional decline is to engage in physical, mental, and/or social activities, although the amount and level of evidence for each activity varies. Physical activity (PA) is the most studied with accumulating evidence indicating that engaging in PA improved strength, endurance, balance and overall physical functions in older adults (Gomes-Neto, Conceicao, Oliveira Carvalho, & Brites, 2013; Gomes Neto, Ogalha, Andrade, & Brites, 2013; Taylor, 2014). The relationship between mental activities (MA) and physical function has been less studied. However, emerging interventional research suggests that engaging in MA (e.g., cognitive stimulation) can enhance physical function by improving gait and balance (Smith-Ray et al., 2015; Smith-Ray, Makowski-Woidan, & Hughes, 2014). Further, older adults who are socially active experienced less decline in physical function (e.g., as measured by their ability to perform daily tasks) compared to socially inactive counterparts (Mendes de Leon, Glass, & Berkman, 2003; Rosso, Taylor, Tabb, & Michael, 2013). Overall, more studies are needed to examine the relationship between engagement in these activities and physical function.

Moreover, it remains unclear whether combined activity engagement would be associated with better physical function. Learning from the cognition literature and the Enriched Environment Theory suggest a simultaneously effect of PA, MA, and SA on cognitive function in old age (Hertzog, Kramer, Wilson, & Lindenberger, 2008). Combined activity engagement such as PA

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and MA (Theill, Schumacher, Adelsberger, Martin, & Jancke, 2013) or MA and SA (Wang, Karp, Winblad, & Fratiglioni, 2002) indeed led to significantly greater cognitive improvement compared to engaging in a single activity. However, it is unknown whether there is any similar synergistic impact of combined activity engagement on physical function among older adults.

This study addresses the aforementioned gaps. We evaluated the relationship of engagement in individual and combined PA, MA, and SA and physical function. First, we described the patterns of engagement in PA, MA, and SA among older adults. Next, we identified the latent classes of activity engagement (clusters of participants with similar activity engagement). Last, we examined the association between activity engagement and physical function. We hypothesized that combined activity engagement would link to better physical functions than any single activity.

2. Methods

2.1. Design and procedure

The present study used a cross-sectional design to analyze data from the Survey of Midlife Development in the United States (MIDUS) II. MIDUS is a longitudinal study of community-dwelling adults' well-being, including two waves that were 10 years apart (MIDUS I, 1995–1996; MIDUS II, 2004–2009). Of note, a twenty-year follow-up was just completed (MIDUS III), but is not yet available publicly. MIDUS I only collected psychosocial behavioral data, which had no physical function assessments needed in the study. MIDUS II consisted of five projects covering different domains: 1) psychosocial and health, 2) daily diary, 3) cognitive assessment, 4) clinical and biomarker assessment, and 5) neuroscience. Data used in the present study were drawn from three of the projects: Project 1: participants self-administered questionnaires on socio-demographic and health information; Project 3: a series of cognitive tests were administered to participants over the telephone; and Project 4: physical function assessment obtained from a two-day visit to one of the participating General Clinical Research Centers (GCRCs). Data from individuals 55 years or older who have data from all three projects were used for the current study ($n = 466$). Of note, the sample from MIDUS I was considered a nationally representative sample, while participants who remained in MIDUS II (75% from MIDUS I) tended to have socioeconomic bias (e.g., being white, female, married, more educated), but not necessarily healthy status bias (Radler and Ryff, 2010). Institutional Review Boards from each study site approved the study. Institutional Review Boards from each study site approved the study.

2.2. Measures

Physical function was operationalized using two of the clinical assessment variables from MIDUS II Project 4: grip strength and gait speed. Grip strength was determined using a hand grip dynamometer, while subjects held the dynamometer in the hand to be tested with the elbow positioned at 90° on the side of the body. An average of three readings (in kg/force) of the dominant hand was taken. Hand grip dynamometer is a reliable instrument to measure grip strength with interclass correlation coefficient greater than 0.80 (Guerra and Amaral, 2009; Hamilton, McDonald, & Chenier, 1992).

Gait speed was assessed using the time in seconds required for an individual to walk 50 ft in their usual pace without an assistive device. An average of two readings (in feet/second) was taken. The interclass correlation coefficient was 0.97 in previous studies (Dobson et al., 2013; Unver, Kalkan, Yuksel, Kahraman, & Karatosun, 2015).

Activity engagement was measured using three distinct questionnaires: physical, mental and social. Participants were asked about frequency of engagement of these activities as part of the MIDUS II Project 1. The questionnaire of moderate PA asked about the frequency of engaging in 6 types of leisurely sports (i.e., light tennis, slow or light swimming, low impact aerobics, golfing without a power cart, brisk walking, mowing the lawn with a walking lawnmower). Participants were asked to respond to each item on a 6-point ordinal scale ranging from 1 (several times a week) to 6 (never). In the MIDUS II survey, three types of PA were available – light, moderate, and vigorous, which are highly correlated ($r = 0.34$–0.69) (Lee et al., 2015). We decided to use the moderate type PA to balance the amount of exercise and feasibility of doing the exercise in old age. MA engagement included 6 types of activities (i.e., read, do word games, play card, attend lectures, do writing, use a computer). Each participant indicated the frequency of engaging in these activities using a 6-point ordinal scale ranging from 1 (daily) to 6 (never). For PA and MA, the ratings were reversely coded and averaged with higher scores indicating more frequent engagement. SA engagement was measured with three items quantifying the frequency of attending meetings and group gatherings (i.e., union, sports, or social groups) outside the workplace in a typical month. The total number of times involved in these SA was calculated. MA engagement scale was significantly correlated to SA engagement scale ($r = 0.29$, $p < 0.001$). PA engagement scale did not correlate to MA or SA engagement scales. The three activity engagement scales were created in the MIDUS II, although formal validation evaluation has not been conducted, evidence has been accumulated to support the validity in outcomes related to the present study. For example, the three scales have been correlated to memory complaints, cognitive function and education (Lachman, Agrigoroaei, Murphy, & Tun, 2011; Lin, Heffner, Mapstone, Chen, & Porsteisson, 2014), or perceived physical health (Fujiwara and Kawachi, 2008; Lee et al., 2015) in previous studies of older adults.

Demographic and health characteristics included age, sex, education, medications, and smoking behaviors. Education was grouped into three categories: "high school graduate or less", "some college" and "college graduate or more". The use of medications such as anti-hypertension, anti-depressants and/or corticosteroids were recorded based on the original medication bottles the participants brought with them to the GCRC. Data on smoking was collected using a single question on whether the participant had ever smoked regularly. Abdominal obese was defined as waist circumference >02 cm in men and >88 cm in women.

2.3. Data analysis

Across the entire sample, descriptive data on all main and background variables were analyzed, and the correlations between activity engagement and physical function was analyzed with Pearson's correlation in IBM SPSS 22.0.

Latent class analysis (LCA), a form of mixture modeling, was performed using Mplus version 7.0 to find the smallest number of classes (participants with similar activity engagement). LCA is a method of identifying unique classes within a set of heterogeneous individuals by examining the mean of individual cases. In the present study, we determined the number of classes controlling for the influence of age on each activity engagements. A series of models were evaluated beginning with a 1-class solution and ending with a 5-class solution. The optimal number of classes was decided based on Bayesian, Akaike, and Adjusted Bayesian Information Criteria in which lower values indicate a more parsimonious model; entropy in which higher values indicate a better model, and the Lo-Mendell-Rubin (LMR) adjusted likelihood ratio test which compares the current class solution with the class – 1 solution to determine whether the two solutions are similar ($p > 0.05$) or different ($p \leq 0.05$) (Ram and Grimm, 2009). Each class should have more than 1% of the total sample (Jung and Wickrama, 2008). Each class was described by the mean and standard deviation (SD) of relevant variables and the number of participants belonging to the class.

After deciding the number of latent classes (n = 4 in the present study), remaining analyses were performed in IBM SPSS 22.0. Analysis of variance controlling for covariates (ANCOVA) was used to assess differences across latent classes on continuous variables, and Chi-square tests were applied to compare categorical variables. Post-hoc analysis was based on the Fisher's lease significant difference adjustment for multiple comparisons with equal variance. Of note, for the ANCOVA, estimating a small to moderate effect size (f = 0.25), alpha at 0.01 (considering multiple outcomes), power at 0.90, 4 groups/latent class, and 1 covariate (age), the total sample size should be 444, which is similar to our sample size at 466.

3. Results

3.1. Activity engagement across the entire sample

Across the entire sample, participants engaged in MA (M = 2.27, SD = 0.85) and PA (M = 2.42, SD = 1.37) once to several times a month; and attended SA an average of 1.15 times a month (SD = 1.02). PA was related to both grip strength ($r = 0.14$, $p = 0.003$) and gait speed ($r = 0.22$, $p = < 0.001$), while MA was associated with grip strength ($r = 0.12$, $p = 0.009$). SA was not related to either physical function measure.

3.2. Latent class of activity engagement

Table 1 summarizes the series of model fit statistics for LCA. Synthesizing the model fit indices and the number of participants in each class, the four-class model was considered the best solution. Fig. 1A and Table 2 present the data from the four classes. Class I (n = 50, 12.7%) was characterized by relatively frequent engagement in PA and MA, labeled as *"Active PA and MA"*. Class II (n = 151, 32.4%) was characterized by relatively frequent engagement in MA but not PA, labeled as *"Active MA"*. Class III (n = 172, 36.9%) was characterized by relatively frequent engagement in PA but not MA, labeled as *"Active PA"*. Class IV (n = 93, 20.0%) was inactive in both MA and PA, labeled as *"Inactive"*. Of note, variation in SA contributed little to class designation. That is, the four classes were significantly different in MA ($F = 2.99$, $p = 0.031$) and PA ($F = 2014.01$, $p < 0.001$) but not SA ($F = 1.99$, $p = 0.12$), controlling for age.

3.3. Physical functions by latent class of activity engagement

Table 2 displays descriptive data for all variables by latent class. We found class differences in age and level of education but not in health history. Grip strength ($F = 2.86$, $p = 0.036$, $\eta_p^2 = 0.018$) and gait speed ($F = 3.57$, $p = 0.014$, η_p^2) differed significantly by latent class controlling for age. For post-hoc analysis, in "Active PA and MA", "Active PA", and "Active MA" classes all had significantly better grip strength than "Inactive" class, while the three classes were similarly in grip strength. "Active PA and MA" class had significantly better gait speed than "Active MA" or "Inactive" class, while there was no evidence of a difference between "Active PA and MA" and "Active PA" classes, or between "Active PA", "Active MA", and "Inactive" class (also see Fig. 1B).

4. Discussion

In the present study we have identified four groups of individuals that were characterized by distinctly different patterns of activity engagement in PA and MA. SA didn't differ among groups. The first group included individuals who were active in both PA and MA ("Active PA and MA"). The second and third groups included individuals who were active in either activity ("Active PA" or "Active MA"). The fourth group included individuals who were active in neither activity ("Inactive"). Controlling for age, the first three groups displayed similar grip strength that was superior to the "Inactive" group. "Active PA and MA" group had the better gait speed than other groups, especially "Active MA" and "Inactive" group, while the "Active PA", "Active MA", and "Inactive" groups were similar in their gait speed. Noticeably, the four groups were similar in their health status. To our best knowledge this is one of the first studies to assess the relationship between combined activity engagement and physical function.

Previous studies that have evaluated combined activity engagement in the aging literature have focused on the cognitive

Table 1
Latent Class Analysis Fit Statistics for Different Class Solutions of Activity Engagement.

Model	Latent Class	N (%)	AIC	BIC	Adjusted BIC	Entropy	LMR adjusted Likelihood ratio test, χ^2 test (p)
One-class	1	466 (100)					
Two-class	1	466 (100)	4079.39	4149.84	4095.89	1.00	0 (0.50)
	2	0 (0)					
Three-class	1	59 (12.7)	4022.46	4113.63	4043.81	0.846	55.50 (0.001)
	2	302 (64.8)					
	3	105 (22.5)					
Four-class	1	50 (10.7)	3963.30	4075.20	3989.51	0.880	66.98 (<0.001)
	2	151 (32.4)					
	3	172 (36.9)					
	4	93 (20.0)					
Five-class	1	8 (1.7)	3887.56	4020.18	3918.62	0.768	2.81 (0.57)
	2	148 (31.8)					
	3	143 (30.7)					
	4	45 (9.7)					
	5	122 (2.6)					

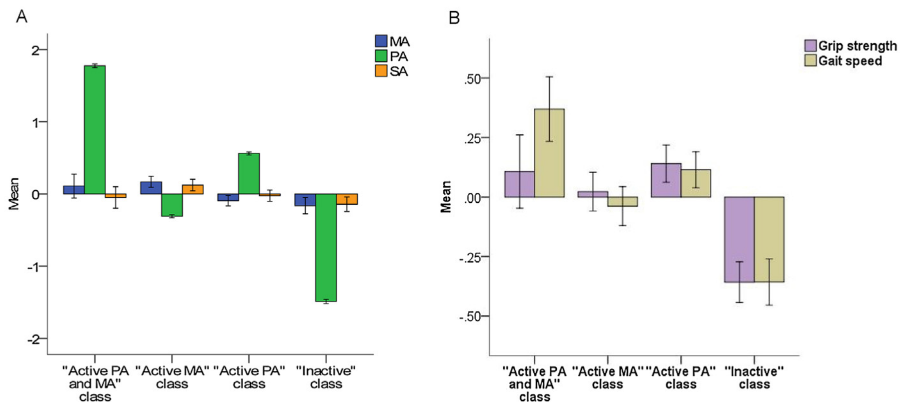

Fig. 1. Class Difference in Activity Engagement (A) and Physical Function (B). Note. All data were Z-transformed. Higher value in activity engagement indicates more engagement; higher value in mobility outcome indicates better function.

Table 2
Background Characteristics, Activity Engagement, Mobility Outcomes, and Cognitive Function as Total Sample and by Activity Engagement Class.

Variable	Total N = 466	Class "Active PA and MA" n = 50	"Active MA" n = 151	"Active PA" n = 172	"Inactive" n = 93	F or χ^2 value (p)
Age, M(SD)	67.6 (7.51)	65.80 (6.91)[a]	67.75 (7.39)[a]	66.13 (6.84)[a]	71.04 (8.12)[b]	**10.27 (<0.001)**
Male, n (%)	219 (47.0)	28 (56.0)	71 (47.0)	87 (50.6)	33 (35.5)	7.46 (0.059)
Education, n (%)						**17.80 (0.007)**
- high school or less	119 (25.6)	12 (24.0)[a, b]	28 (18.7)[b]	44 (25.7)[a, b]	35 (37.6)[a]	
- some college	137 (29.5)	18 (36.0)[a]	44 (29.3)[a]	44 (25.7)[a]	31 (33.3)[a]	
- college graduate or more	208 (44.8)	20 (40.0)[a, b]	78 (52.0)[b]	83 (48.5)[b]	27 (29.0)[a]	
Smoker, n (%)	40 (8.6)	6 (12.0)	11 (7.3)	13 (7.6)	10 (10.8)	1.86 (0.60)
Taking antidepressant, n (%)	60 (12.9)	4 (8.0)	17 (11.3)	24 (14.0)	15 (16.1)	2.47 (0.48)
Taking corticosteroid, n (%)	73 (15.7)	6 (12.0)	23 (15.2)	28 (6.0)	16 (3.4)	0.75 (0.86)
Taking hypertension medication, n (%)	222 (47.6)	17 (34.0)	70 (46.4)	83 (48.3)	52 (55.9)	6.41 (0.10)
Abdominal obese, n (%)	255 (54.7)	24 (48.0)	79 (52.3)	94 (54.7)	58 (62.4)	3.46 (0.33)
MA[#], M(SD)	2.27 (0.85)	2.36 (1.00)[a, b]	2.42 (0.80)[b]	2.18 (0.79)[a]	2.15 (0.93)[a]	**2.99 (0.031)**
PA[#], M(SD)	2.42 (1.37)	4.86 (0.25)[a]	1.99 (0.35)[b]	3.19 (0.37)[c]	0.51 (0.40)[d]	**2014.01 (<0.001)**
SA[#], M(SD)	1.15 (1.02)	1.10 (1.07)	1.29 (1.00)	1.13 (1.03)	1.01 (0.99)	1.99 (0.12)
Grip strength (kg/force)[#], M(SD)	34.04 (11.24)	35.24 (12.26)[a]	34.29 (11.24)[a]	35.62 (11.51)[a]	30.05 (9.18)[b]	**2.86 (0.036)**
Gait speed (feet/s)[#], M(SD)	3.34 (0.72)	3.61 (0.69)[a, b]	3.32 (0.72)[c]	3.43 (0.72)[b, c]	3.09 (0.67)[c]	**3.57 (0.014)**

Note. [#] controlled for age; Letters indicate significant difference at p = 0.05 level in post-hoc analysis.

outcomes. Our findings suggest that combined activity engagement is associated with better physical function, especially in the domain of gait speed. The difference in gait speed between "Active PA and MA" and other groups (e.g., "Active MA", "Inactive") is 0.30 ft/s or greater (equal to 0.09 m/s or greater), which is greater than the clinically meaningful change indicated in the literature (0.04 to 0.06 m/s) (Perera, Mody, Woodman, & Studenski, 2006). On the other hand, the difference in grip strength between the activity engagement groups and the inactive group is ~5 kg/force. This change is statistically significant but is slightly less clinically meaningful difference than what is indicated in literature (i.e., 6 kg/force) (Kim, Park, & Shin, 2014; Nitschke, McMeeken, Burry, & Matyas, 1999).

We found that maintaining or improving gait speed in old age relies on the engagement of both mental and physical activities. There has been a consistent literature supporting the positive impact of physical intervention or PA on gait speed (Nadkarni et al., 2013; Pahor et al., 2014; VanSwearingen, Perera, Brach, Wert, &

Studenski, 2011; Villareal et al., 2011). More emerging literature suggests that cognitive intervention such as MA leads to improvement in gait speed (Dodge et al., 2008; Doumas, Rapp, & Krampe, 2009; Li et al., 2010; Smith-Ray et al., 2015; Verghese, Mahoney, Ambrose, Wang, & Holtzer, 2010). Noticeably, gait is not a unitary concept, which is related to multiple cognitive capacities (e.g., executive function, attention, episodic memory and processing speed) (Bolandzadeh et al., 2014; Parihar, Mahoney, & Verghese, 2013; Yogev, Hausdorff, & Giladi, 2008). Our results differ from those of Ng et al.'s intervention study reporting that in frail Asian older adults PA alone had better effects on gait speed than combined PA and MA engagement (Ng et al., 2015). In contrast, we found similar relationship between combined PA and MA, as well as PA alone, and gait speed. Different from gait speed, grip strength seems to have a nonselective acceptability to engagement in PA or/and MA. Grip strength is known to be modifiable by increasing the level of PA (Cadore et al., 2014; Justine, Hamid, Mohan, & Jagannathan, 2012). Our previous study on a different older American cohort suggests that grip strength may be particularly sensitive to cognitive deficits (e.g., speed of processing, attention), compared to some other measures of physical function (e.g., overall physical function, activity of daily living) (Lin, Chen, Vance, & Mapstone, 2012). Also, grip strength may have a stronger relationship with cognitive function and MA than gait speed (Atkinson et al., 2010). Synthesizing the different findings and evidence on grip strength and gait speed and their relationship to activity engagement, we urge the further validation and comprehensive comparison of different activity engagement on different aspects of physical function.

In this study, we observed that the strength of correlations between physical function (muscle strength and gait) and engagement in PA and MA are statistically significant, but relatively low. Previous observational studies do not always find positive associations between PA and muscle strength (Cooper, Mishra, & Kuh, 2011; Scott, Blizzard, Fell, & Jones, 2011). Several factors besides PA engagement influence grip strength such as fatigue, time of day, nutritional status, restricted motion, and pain. Similarly in meta-analysis of PA interventions, engaging in PA has small effect on gait speed, suggesting that other factors may be involved in supporting gait speed (Chou, Hwang, & Wu, 2012; de Vries et al., 2012). Of note, we did not observe an association between the engagement in SA and physical function. The difference in the measures of functional outcome may explain the different findings. Compared to MA and PA that may directly modify basic upper or lower extremity function, SA may contribute to the self-perception of functions in more complex activities under social context (e.g., instrumental activities of daily living, disability) (Mendes de Leon et al., 2003; Rosso et al., 2013; Thomas, 2011).

We acknowledge some limitations of our study. First, the cross-sectional study design can only identify associations instead of causality. Second, the three activities (PA, MA and SA) were assessed using frequency of activity engagement based on self-report questionnaires without attention to the duration and intensity of activity engagement and did not capture other activities that were not listed in the study activity engagement questionnaires. Third, the four groups were similar in SA, which may be due to the different format the questions were asked compared to the questions for PA and MA. Fourth we did not exclude acceleration and deceleration phases in our gait speed measurement to obtain stable and comparable gait speed (Wang, Chen, Lin, Liu, & Chen, 2012). Finally, our findings may not be applicable to other groups of older adults such as older men, or older adults with lower education, racial or ethnic minorities. Regardless, the strengths of our study also should be noted. First, our study is among the first to examine relationships between different type of activity engagement, especially the combined activity, and physical function. Second, our outcome data uses objective measures of physical function rather than subjective measures; performance based measures are better suited to capture early stages of functional decline and have greater validity and reliability compared to using self-reports (Brown, Sinacore, Binder, & Kohrt, 2000; Guralnik et al., 1994).

In conclusion, our study provides evidence that engagement in a combined PA and MA compared to engagement in only one type of activity is associated with better physical function (particularly walking ability). Our study not only reinforces the importance of PA in improving physical function, but also underscores the importance of MA in improving walking ability in older adults. Lastly, the significance of increasing MA (e.g. cognitive stimulation) to prevent functional decline is potentially even more important in older adults, particularly those with underlying cognitive impairments. Future interventional research should investigate the combination of both physical and cognitive training to prevent functional decline and frailty in older adults.

Conflicts of interest

None.

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Sponsor's role

None.

Author contributions

The authors' role are as follows: study concept and design (FVL, KNS), data analysis and interpretation of data (FVL, KNS, FY, JMM), and preparation of manuscript (FVL, KNS, FY, JMM).

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