Published in final edited form as:

J Am Geriatr Soc. 2010 October ; 58(10): 1918–1924. doi:10.1111/j.1532-5415.2010.03008.x.

Relationship Between Physical Functioning and Physical Activity in the Lifestyle Interventions and Independence for Elders Pilot (LIFE-P)

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Abstract

OBJECTIVES—To determine if participation in usual moderate-intensity or more vigorous physical activity (MVPA) is associated with physical function performance and to identify socio-demographic, psychosocial and disease-related covariates that may also compromise physical function performance.

DESIGN—Cross-sectional analysis of baseline variables of randomized controlled intervention trial.

SETTING—Four separate academic research centers.

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PARTICIPANTS—Four hundred twenty-four older adults aged 70–89 years at risk for mobility-disability (scoring <10 on the Short Physical Performance Battery, SPPB) and able to complete the 400 m walk test within 15 minutes.

MEASUREMENTS—Minutes of MVPA (dichotomized according to above or below 150 min•wk⁻¹ of MVPA) assessed by the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire, SPPB score, 400 M walk test, gender, body mass index (BMI), depressive symptoms, age and number of medications.

RESULTS—The SPPB summary score was associated with minutes of MVPA ($\rho = 0.16$, $P = 0.001$). In multiple regression analyses, age, minutes of MVPA, number of medications and depressive symptoms were associated with performance on the composite SPPB ($P < 0.05$). There was an association between 400 m walk time and minutes of MVPA ($\rho = -0.18$; $P = 0.0002$). In multiple regression analyses, age, gender, minutes of MVPA, BMI and number of medications were associated with performance on the 400 m walk test ($P < 0.05$).

CONCLUSION—Minutes of MVPA, gender, BMI, depressive symptoms, age, and number of medications are associated with physical function performance and all should be taken into consideration in the prevention of mobility-disability.

Keywords

older adults; mobility-disability; physical function performance; older adults; mobility-disability; physical function performance

INTRODUCTION

Physical activity (PA) encompasses both intentional, structured activity undertaken to improve one's health (e.g., brisk walking or progressive-weight training) as well as routine activity (e.g., shopping or walking from the parking lot) (1). There is indication that routine PA may be a determinant of physical function performance in older adults. Cross-sectional studies report better summary performance scores among older adults engaging in higher levels of routine PA both with and without peripheral arterial disease (PAD)(2). There is further indication that moderate-intensity forms of structured exercise may be more relevant to maintaining or improving physical function performance as demonstrated in cross-sectional (3), observational (4) and intervention (5) studies. These studies report that moderate-intensity structured exercise imparts greater benefits on physical function performance compared to inactivity, activity performed throughout the day (3), short-term PA (4) and health-related education on successful aging (5). The data are robust for moderate-intensity forms of structured exercise but whether or not this has been observed following moderate-intensity forms of routine PA, remains elusive. Due to the higher risk of injury with aging and problems associated with adherence, more vigorous forms of PA are recommended for more experienced older adults (1).

Additionally, gender, adiposity, depressive symptoms, age and concomitant medications may compromise physical function in older adults. Martin et al. reported that increased gardening activity was associated with better performance on the 3 m walk and chair rise tests in women but not men (6). A recent study suggests that body mass index (BMI) influences functional performance in older adults such that obese older adults perform worse on the Short Performance Physical Battery (SPPB) as compared to their non-obese counterparts (7). Individuals with depressive symptoms show greater decline in 6-minute walk distance, fast walking velocity and the SPPB summary score in comparison to those with no depressive symptoms (8). Nonagenarians perform poorly on the Reduced Continuous Scale-Physical Function Performance Test compared to more active older adults

between the ages of 60–74 years, an effect that is correlated with lower levels of PA (9). Finally, polypharmacy is common in older adults and, depending on the drug class, may be related to physical function decline (10).

The purpose of this report is to determine if minutes of usual moderate-intensity or more vigorous PA (MVPA), gender, BMI, depressive symptoms, age and number of medications, would be associated with performance on the SPPB and 400 m walk test, two commonly used measurements of physical functioning (11,12). We used data from the Lifestyle Interventions for Elders Pilot (LIFE-P), a multicenter, randomized controlled trial conducted in older adults at risk for mobility disability (13).

METHODS

Overview of Study Design

The LIFE-P was a multi-center pilot study examining the efficacy of a PA versus a successful aging (SA) educational intervention on the incidence of major mobility disability or death in at-risk older adults. A full description of the LIFE-P study design has been reported elsewhere (13). Briefly, participants were randomized into either a PA program that combined aerobic, strength, balance and flexibility exercises or a SA program that consisted of non-physical activity oriented educational information concerning healthy aging. Assessments of interest for the current investigation, physical functioning and physical activity, were conducted within one month of each other. Participants were followed for 12 to 18 months, depending on the month of randomization.

Participant Eligibility and Recruitment

Determinants of eligibility have been described previously (13). Briefly, 424 participants were recruited through public advertisements and related community strategies from the Cooper Institute, Dallas, Texas; Stanford University, Palo Alto, California; University of Pittsburgh, Pittsburgh, Pennsylvania; and Wake Forest University, Winston-Salem, North Carolina (13). Eligibility criteria included (13): between the ages of 70 and 89 years, a score of < 10 on the Short Physical Performance Battery (SPPB) (11), able to walk 400 m unassisted within 15 min and a sedentary lifestyle reported during the initial several-item screening instrument (i.e., less than 20 min/wk of regular PA in the preceding month). Participants were excluded if they had a diagnosed psychiatric or cognitive disorder or a severe chronic disease for which moderate-intensity PA would be contraindicated (e.g., New York Heart Association Class III or IV congestive heart failure). Temporary exclusions were given to participants who had undergone surgery in the past 6 months, or had any condition that could be treated medically (uncontrolled hypertension: systolic blood pressure > 200 mm Hg and/or diastolic blood pressure > 110 mm Hg). Participants were also temporarily excluded if they were participating in another randomized trial involving an intervention. All participants gave informed consent and the study was approved by the institutional review boards of all participating sites.

Assessment of Physical Function

The SPPB summary score and the 400 m walk time were used to determine level of physical functioning (11,12). The SPPB summary score is predictive of future mobility disability risk (14–16) and mortality (11). The 400 m walk time is also predictive of mobility disability risk (15) and mortality (12). Participants were included in the study if their baseline SPPB summary score was less than 10. The SPPB is comprised of a timed standing balance assessment, a gait speed assessment and timed chair stands (11). The standing balance is performed by asking the participants to maintain the feet in side-by-side, semi-tandem and tandem positions for 10 s. The gait assessment is a 4 m self-paced walk at usual speed.

Participants are given two attempts and the better of the two is their designated time. The last component of the SPPB, the chair rise assessment, requires participants to rise from a chair and sit down five times, without using their arms, as quickly as possible. Performance on each of the three elements is scored between 0 and 4 with a summary score computed for the three elements ranging from 0–12. Summary scores approaching 12 reflect a higher level of physical functioning.

The 400 m walk, as administered in the LIFE-P, was a timed self-paced walk that must be performed unassisted and without the use of a walking device. Participants were required to complete 400 m in less than 15 min.

Determination of Physical Activity Status

Baseline participation in PA was measured by the Community Healthy Activities Model Program for Seniors (CHAMPS) PA questionnaire (17). Pre-intervention participation in PA was quantified as above and below 150 min•wk⁻¹ of MVPA, i.e. those activities ≥ 3.0 METs (i.e. frequency of participation and energy expenditure for activities such as walking, cycling, swimming, gardening and golf) (17). Although a sedentary lifestyle, assessed through a brief screening interview, was an eligibility criterion in the LIFE-P, there was a subset of individuals who subsequently reported engaging in MVPA at baseline when the CHAMPS PA questionnaire, a more quantitative self-report measure of PA, which allowed for more accurate PA recall (17). This self-report questionnaire assesses frequency and duration of moderate-intensity as well as all PA from the preceding 4 weeks and is sensitive particularly to moderate-intensity PA (18). The original goal of the LIFE-P was to increase moderate-intensity PA by walking to at least 150 min•wk⁻¹(13); therefore, we quantified pre-intervention participation in PA as above and below 150 min•wk⁻¹ of MVPA (17), and participants were dichotomized accordingly into these groups.

Baseline Assessment of Body Mass Index, Number of Medications and Depressive Symptoms

Measured BMI was calculated at baseline as follows: weight (kg)/height (m²). Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D)(19). Participants were also requested to bring both prescription and nonprescription medications they had taken in the preceding 2 weeks to the baseline visit. These were documented in their charts. Other variables of interest included age and gender.

Statistical Analyses

Analyses for the current investigation were conducted on baseline data only. Pearson correlation coefficients were used to determine if the SPPB summary score and scores from performance elements that comprise the SPPB (balance, chair stand and walk speed) as well as 400 m walk time were associated with minutes of MVPA. Using data from the CHAMPS, Student's t-tests were conducted to test whether SPPB summary scores, elements of the SPPB and 400 m gait time were different among participants reporting ≥ 150 min•wk⁻¹ of MVPA in comparison to those reporting < 150 min•wk⁻¹. Backward stepwise regression elimination models were used to identify variables in a final composite model predicting baseline SPPB scores and 400 m walk time using MVPA and other covariates. Given their known associations with PA level, other covariates that were considered included age, gender, BMI, number of medications and depressive symptoms. Covariates were forced into a model along with MVPA and retained in the composite model if they had a p-value < 0.05. Results are reported as means ± SD, unless otherwise noted.

RESULTS

Baseline characteristics of participants are presented in Table 1. Participants were separated into two groups according to above ($n = 98$) and below ($n = 319$) $150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA. In general, there was a larger percentage of women in the lower group ($P = 0.04$). Participants reporting $\geq 150 \text{ min} \cdot \text{wk}^{-1}$ had more depressive symptoms than their less active peers ($P = 0.01$). There were no differences between the groups in age, BMI or number of medications.

Association between SPPB and Minutes of MVPA

Short Physical Performance Battery summary scores were associated with minutes of MVPA ($\rho = 0.16$, $P = 0.001$). The mean SPPB score for participants reporting $\geq 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA was significantly higher (7.96 ± 1.16) than for those reporting $< 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA (7.38 ± 1.47 ; $P = 0.0006$).

Performance was better for each of the individual components measured in the participants reporting $\geq 150 \text{ min} \cdot \text{wk}^{-1}$ of moderate-intensity PA but none of these associations were statistically significant.

We performed multiple regression analyses to determine associations for the SPPB summary score using age, gender, minutes of MVPA, BMI, number of medications and depressive symptoms as independent variables. Age, minutes of MVPA, number of medications and depressive symptoms were significant at the $P < 0.05$ level and comprised the final composite model of correlates of the SPPB summary score (Table 2). The R^2 values for the full and final composite models were 0.09 and 0.10, respectively.

Association between 400 m Walk Time and Minutes of MVPA

There was a significant association between 400 m walk time and minutes of MVPA ($\rho = -0.18$; $P = 0.0002$). The mean 400 m walk time for the group performing $< 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA was significantly higher ($8.37 \pm 1.96 \text{ min}$) than for those performing $\geq 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA ($7.55 \pm 1.56 \text{ min}$; $P = 0.0003$).

Multiple regression analyses were performed to identify correlates of 400 m walk time using age, gender, minutes of MVPA, BMI, number of medications and depressive symptoms as potential correlates. Age, gender, minutes of MVPA, BMI and number of medications were significant at the $P < 0.05$ level and comprised the final composite model as correlates of 400 m walk time (Table 3). The R^2 values for the full and final composite models were 0.17 and 0.16, respectively.

DISCUSSION

The purpose of the current investigation was to evaluate the baseline associations between MVPA and performance on the SPPB and 400 m walk test in a sample of 70–89 year old adults at risk for mobility disability. Our data indicate that MVPA was associated with performance on both the SPPB and 400 m walk test. Participants engaging in $\geq 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA, as measured via the CHAMPS questionnaire, performed significantly better on the SPPB and 400 m walk test than those engaging in $< 150 \text{ min} \cdot \text{wk}^{-1}$ of MVPA. These associations remained after controlling for variables that have been found to be related to physical function.

To our knowledge, our study is unique in its examination of the specific relationship between MVPA and performance on the SPPB. Although information on PA intensity typically has not been available, other studies of interest have reported a positive association

between PA in general and performance on the SPPB (2,3). In a cross-sectional report by McDermott et al., better summary performance scores were associated with higher levels of accelerometer-measured PA in older adults with and without PAD (2). Physical activity intensity was not assessed in this study. However, the reported activity count is consistent with low-intensity PA as determined through similar accelerometer devices (20). In two more recent studies, investigators reported complementary results in this population and extended their findings to other functional outcomes such as 6-minute walk distance and the 4 m walk time (21,22). Other cross-sectional data, from the Health, Aging and Body Composition (Health ABC) study, support an association between lifestyle PA (defined as older adults who were physically active daily but did not participate in structured exercise) and functional performance (3). Investigators designated participants as inactive, lifestyle active and exercisers. Inactive participants engaged in < 1, 000 kcal/wk of exercise activity and ≤ 2, 719 kcal/wk of total PA; lifestyle active participants engaged in < 1, 000 kcal/wk of exercise activity and > 2, 719 kcal/wk of total PA; and exercisers engaged in ≥ 1, 000 kcal/wk of exercise activity. Information on PA intensity was gathered through self-report. Lifestyle active participants engaged in light-intensity PA (e.g., walking for exercise and aerobic dance) and exercisers in MVPA (e.g., jogging and swimming). Among participants deemed inactive, lifestyle active or as exercisers, exercisers had better summary performance scores than inactive older adults. After controlling for disease and demographic variables, there was no difference in summary performance scores between lifestyle active adults and exercisers providing further support for the importance of MVPA in physical function performance.

We did not observe a significant association between minutes of MVPA and the individual elements that comprise the SPPB, but the associations were all in the expected direction. In contrast, other cross-sectional and longitudinal observations have found that routine forms of PA, of estimated light-intensity, were associated with the individual components that comprise the SPPB (2,21,22). Quantification of PA obtained from these investigations was directly assessed using accelerometry, in contrast to our investigation, which used self-report information to quantify PA. We acknowledge that this is a limitation of the current investigation. Self-report information may be less sensitive than objective PA assessment in discerning relationships between PA and such component elements. Moreover, while self-report measurements of PA cannot readily be compared to each other because of inherent variations in capturing the myriad dimensions of PA, they also are often modestly correlated with data obtained from accelerometry (18). Consideration must also be given to the different PA intensities used in our study compared to others. The scope of our analyses was limited to an examination of self-reported levels of MVPA that constitute the current national PA recommendations for obtaining optimal health outcomes (23) and it is difficult to make comparisons between our study and others that failed to report PA intensity or used light-intensity PA. Another explanation for the underlying discrepancies may be due to the different populations under investigation. Our target population consisted only of individuals considered mobility-limited. In order to meet this criterion, a participant had to score <10 on the SPPB.

We were also interested in identifying select socio-demographic, psychosocial and health-related variables that could be associated with performance on the SPPB. In support of earlier reports, we found that age, depressive symptoms and number of medications were independent correlates of the SPPB score (8–10,24,25). Contrary to other findings, gender and BMI were not associated with the SPPB score (3,6,7). This may be due to our truncated sample, in terms of mobility impairment level, which would make it more difficult to discern such relationships.

Another focus of our investigation was to determine whether participation in MVPA was significantly associated with performance on the 400 m walk test. In addition to being highly predictive of mobility disability risk (15) and mortality (12), the 400 m walk test also captures a distinct domain of physical function performance with respect to its ability to predict other health-related outcomes such as cardiovascular disease (12).

We found that minutes of MVPA were significantly associated with 400 m walk time. Relevant studies examining the association between MVPA and 400 m walk performance are limited. However, in addition to their observations on the association between lifestyle PA and SPPB performance described previously, data from the Health ABC study are indicative of a linear trend in 400 m walk times among older adults deemed inactive, lifestyle active (light-intensity PA) and exercisers (MVPA). Exercisers had the fastest 400 m walk times, followed by lifestyle active and then inactive participants (3).

We also evaluated several possible covariates of 400 m walk performance (age, gender, BMI, number of medications and depressive symptoms). Investigators have previously examined and substantiated the relationships of age, gender, BMI and number of medications with performance on the 400 m walk test (26–28)(10,29). Of the variables considered, only depressive symptoms did not predict 400 m walk time the result of which may be due to our truncated sample that included adults with a specific level of mobility impairment.

Clearly, further elucidation of the predictive role of MVPA in performance on the SPPB and 400 m walk test is required. Our data are limited due to the cross-sectional nature of our investigation (thus, preventing causal inferences) and the fact that the range of variables was restricted by the inclusion/exclusion criteria used for entry into the LIFE-P trial. Nevertheless, we provide evidence that there is an association between SPPB scores as well as 400 m walk time and minutes of MVPA in an older, more vulnerable population. While MVPA accounted for only a small fraction of the variance in the SPPB and 400 m walk test, it is a modifiable variable and, as such, holds great public health significance. There is a lack of Phase III trial evidence demonstrating that interventions of PA can improve physical function and prevent disability. Results from a large study like the proposed phase III LIFE trial will enable examination of different levels of dose of PA and changes in function and disability.

Acknowledgments

Drs. Chalé-Rush's and Fielding's contribution are supported by grants USDA 58-1950-7-707, NIA AG-25270 and DK007651. Any opinions, findings, conclusion or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

The Lifestyle Interventions and Independence for Elders (LIFE-P) Pilot Study is funded by a National Institutes on Health/National Institute on Aging Cooperative Agreement #U01 AG22376 and sponsored in part by the Intramural Research Program, National Institute on Aging, NIH.

Sponsor's Role: The investigators had complete control over all aspects of the conduct of the study, data analysis, and manuscript preparation.

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Dr. Fielding's contribution is partially supported by the U.S. Department of Agriculture, under agreement No. 58-1950-4-401. Any opinions, findings, conclusion, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Dept of Agriculture.

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The Pittsburgh Field Center was partially supported by the Pittsburgh Claude D. Pepper Center P30 AG024827.

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The Wake Forest University Field Center is, in part, supported by the Claude D. Older American Independence Pepper Center #1 P30 AG21332.

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Dr. Gill is the recipient of a Midcareer Investigator Award in Patient-Oriented Research (K24AG021507) from the National Institute on Aging.

Table 1

Baseline Characteristics of Participants Reporting Above or Below 150 min•wk⁻¹ of Usual Moderate-Intensity or More Vigorous PA (MVPA)

	All participants (N=417)	<150 min/week (N=319)	≥150 min/week (N=98)	P-value
Sex				0.04
Male	127 (30.5%)	89 (27.9%)	38 (38.8%)	
Female	290 (69.5%)	230 (72.1%)	60 (61.2%)	
Age (years)	76.76±4.24	76.95±4.27	76.14±4.08	0.10
# Prescription drugs	5.09±3.26	5.14±3.32	4.93±3.03	0.44
Total number of diseases	1.41±1.00	1.41±1.02	1.40±0.92	0.68
High blood pressure	287/ 416 (69.0%)	219/ 318 (68.9%)	68 (69.4%)	0.92
Heart attack	39/ 409 (9.5%)	29/ 312 (9.3%)	10/ 97 (10.3%)	0.77
Stroke	20/ 414 (4.8%)	18/ 317 (5.7%)	2/ 97 (2.1%)	0.15
Cancer	72/ 412 (17.5%)	52/ 316 (16.5%)	20/ 96 (20.8%)	0.32
Diabetes	89/ 410 (21.7%)	68/ 313 (21.7%)	21/ 97 (21.6%)	0.99
Hip fracture	13/ 414 (3.1%)	10/ 317 (3.2%)	3/ 97 (3.1%)	0.98
Liver disease	10/ 413 (2.4%)	7/ 316 (2.2%)	3/ 97 (3.1%)	0.62
Lung disease	58/ 408 (14.2%)	48/ 312 (15.4%)	10/ 96 (10.4%)	0.22
Total number of symptoms (last 6 months)*	3.10±1.91	2.99±1.83	3.47±2.09	0.01
BMI	30.23±6.07	30.32±6.35	29.91±5.04	0.57
Sleep quality (WHIIRS)	7.10±3.95 (N=104)	7.18±3.82 (N=76)	6.86±4.34 (N=28)	0.72
Pain severity score	3.89±0.56	3.88±0.58	3.90±0.49	0.92
CES-D (depression)	7.32±6.71	6.84±5.89	8.87±8.74	0.01
Minutes of moderate intensity PA**	116.5±181.9	36.63±47.33	376.5±212.7	
Minutes of all activity**	528.5±376.2	433.3±302.5	838.3±424.4	
SPPB score	7.51±1.42	7.38±1.47	7.96±1.16	0.0006
400 meter walk time	8.17±1.90	8.37±1.96	7.55±1.56	0.0003

Variables are reported as mean ± SD.

* Anxiety, fatigue, decreased appetite, insomnia, dizziness, muscle or joint stiffness, muscle strain or soreness, ankle or knee sprain and foot pain.

** P-values not shown as participants were dichotomized according to these variables.

Table 2
Variables Used in the Full Model and Final Composite Model of the Regression Analyses for SPPB

Variables in Full Model				Variables in Final Composite Model*		
Variable	Parameter Estimate	Standard Error	Pr > F	Parameter Estimate	Standard Error	Pr > F
Age	−0.07	0.02	0.0001	−0.06	0.016	<0.0001
Female	−0.28	0.15	0.06	−0.27	0.15	0.06
Minutes MVPA [†]	0.001	0.0003	0.006	0.001	0.0004	0.004
# Medications	−0.05	0.02	0.02	0.02	0.02	0.01
BMI	−0.01	0.01	0.28			
CES-D (depressive symptoms)	−0.03	0.01	0.007	−0.03	0.01	0.008

* $P < 0.05$, $R^2 = 0.10$.

[†] MVPA measured as a continuous variable.

Variables Used in the Full Model and Final Composite Model of the Regression Analyses for 400 m Gait Speed

Table 3

Variables in Full Model				Variables in Final Composite Model*		
Variable	Parameter Estimate	Standard Error	Pr > F	Parameter Estimate	Standard Error	Pr > F
Age	0.13	0.02	<0.0001	0.13	0.02	<0.0001
Female	0.43	0.19	0.02	0.43	0.19	0.02
Minutes MVPA†	-0.001	0.0005	0.006	-0.001	0.0005	0.008
# Medications	0.07	0.03	0.01	0.07	0.03	0.007
BMI	0.08	0.01	<0.0001	0.08	0.01	<0.0001
CES-D (depressive symptoms)	0.02	0.01	0.13			

* P < 0.05, R² = 0.16.

† MVPA measured as a continuous variable.