Relationship Between Physical Functioning and Physical Activity in the Lifestyle Interventions and Independence for Elders Pilot

Angela Chalé-Rush, PhD, RD,* Jack M. Guralnik, MD, PhD,† Michael P. Walkup, MS,‡
Michael E. Miller, PhD,† W. Jack Rejeski, PhD,§ Jeffrey A. Katula, PhD,§ Abby C. King, PhD,‖
Nancy W. Glynn, PhD,# Todd M. Manini,** Steven N. Blair,‡‡ and Roger A. Fielding, PhD*.

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

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

SETTING: Four academic research centers.

PARTICIPANTS: Four hundred twenty-four older adults aged 70 to 89 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 of MVPA) assessed according to the Community Healthy Activities Model Program for Seniors questionnaire, SPPB score, 400-m walk test, sex, body mass index (BMI), depressive symptoms, age, and number of medications.

RESULTS: The SPPB summary score was associated with minutes of MVPA (p = 0.16, P = .001). In multiple regression analyses, age, minutes of MVPA, number of medications, and depressive symptoms were associated with performance on the composite SPPB (P < .05). There was an association between 400-m walk time and minutes of MVPA (p = −0.18; P < .001). In multiple regression analyses, age, sex, minutes of MVPA, BMI, and number of medications were associated with performance on the 400-m walk test (P < .05).

CONCLUSION: Minutes of MVPA, sex, BMI, depressive symptoms, age, and number of medications are associated with physical function performance and should all be taken into consideration in the prevention of mobility disability. J Am Geriatr Soc 58:1918–1924, 2010.

Key words: older adults; mobility disability; physical function performance

Physical activity (PA) encompasses intentional, structured activity undertaken to improve one’s health (e.g., brisk walking or progressive weight training) and 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 in older adults with and without peripheral arterial disease (PAD) who engage in higher levels of routine PA.2 There is further indication that moderate-intensity structured exercise may be more relevant to maintaining or improving physical function performance than other levels of activity, as demonstrated in cross-sectional,3 observational,4 and intervention5 studies. These studies report that moderate-intensity structured exercise imparts greater benefits on physical function performance than 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 structured exercise, but whether this has been observed with moderate-intensity routine PA remains elusive. Because the risk of injury with aging and problems associated with adherence, more-vigorous forms...
of PA are recommended for more-experienced older adults.\textsuperscript{1}

Sex, adiposity, depressive symptoms, age, and concomitant medications may also compromise physical function in older adults. It has been reported that gardening activity was associated with performance on the 3-m walk and chair-rise tests in women but not men.\textsuperscript{6} A recent study suggested 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) than their nonobese counterparts.\textsuperscript{7} Individuals with depressive symptoms show greater decline in 6-minute walk distance, fast walking velocity, and SPPB summary score than those with no depressive symptoms.\textsuperscript{8} Nonagenarians perform worse on the Reduced Continuous Scale-Physical Function Performance Test than adults aged 60 to 74, an effect that is correlated with lower levels of PA.\textsuperscript{9} Finally, polypharmacy is common in older adults and, depending on the drug class, may be related to physical function decline.\textsuperscript{10}

The purpose of this report was to determine whether minutes of usual moderate-intensity or more-vigorous PA (MVPA), sex, 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.\textsuperscript{11,12} Data from the Lifestyle Interventions for Elders Pilot (LIFE-P), a multicenter, randomized controlled trial conducted in older adults at risk for mobility disability, were used.\textsuperscript{13}

METHODS

Overview of Study Design

The LIFE-P was a multicenter pilot study comparing the efficacy of PA with that of 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.\textsuperscript{13} Briefly, participants were randomized into a PA program that combined aerobic, strength, balance, and flexibility exercises or a SA program that consisted of non-PA-oriented educational information concerning healthy aging. Assessments of interest for the current investigation, physical functioning, and physical activity were conducted within 1 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.\textsuperscript{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.\textsuperscript{13} Eligibility criteria were\textsuperscript{13} aged 70 to 89, a score less than 10 on the SPPB,\textsuperscript{11} ability to walk 400 m unassisted within 15 minutes, and a sedentary lifestyle reported during the initial several-item screening instrument (i.e., \textless{} 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 previous 6 months or had any condition that could be treated medically (uncontrolled hypertension: systolic blood pressure \textgreater{} 200 mmHg or diastolic blood pressure \textgreater{} 110 mmHg). Participants were also temporarily excluded if they were participating in another randomized trial involving an intervention. All participants gave informed consent, and the institutional review boards of all participating sites approved the study.

Assessment of Physical Function

The SPPB summary score and 400-m walk time were used to determine level of physical functioning.\textsuperscript{11,12} The SPPB summary score is predictive of future mobility disability risk\textsuperscript{14–16} and mortality;\textsuperscript{11} 400-m walk time is also predictive of mobility disability risk\textsuperscript{15} and mortality.\textsuperscript{12} Participants were included in the study if their baseline SPPB summary score was less than 10. The SPPB comprises a timed standing balance assessment, a gait speed assessment, and timed chair stands.\textsuperscript{11} The standing balance assessment is performed by asking the participant to maintain the feet in side-by-side, semi-tandem, and tandem positions for 10 seconds. 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 used. The last component of the SPPB, the chair rise assessment, requires participants to rise from a chair and sit down five times without using the 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 to 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 minutes.

Determination of PA Status

Baseline participation in PA was measured using the Community Healthy Activities Model Program for Seniors (CHAMPS) PA questionnaire.\textsuperscript{17} Preintervention participation in PA was quantified as greater and less than 150 min/wk of MVPA (activities using \geq{} 3.0 metabolic equivalents, e.g., walking, cycling, swimming, gardening and golf).\textsuperscript{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 that allowed for more accurate PA recall, was administered.\textsuperscript{17} This self-report questionnaire assesses frequency and duration of moderate-intensity and all PA from the preceding 4 weeks and is sensitive particularly to moderate-intensity PA.\textsuperscript{18} The original goal of the LIFE-P was to increase moderate-intensity PA by walking at least 150 min/wk,\textsuperscript{13} so preintervention participation in PA was quantified as greater and less than 150 min/wk of MVPA,\textsuperscript{17} and participants were dichotomized accordingly into these groups.
Baseline Assessment of BMI, Number of Medications, and Depressive Symptoms

Measured BMI was calculated at baseline weight (kg)/height (m²). Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale. Participants were also requested to bring 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 were age and sex.

Statistical Analyses

Analyses for the current investigation were conducted on baseline data only. Pearson correlation coefficients were used to determine whether the SPPB summary score and scores from performance elements that comprise the SPPB (balance, chair stand, and walk speed) and 400-m walk time were associated with minutes of MVPA. Using data from the CHAMPS, Student t-tests were conducted to test whether SPPB summary scores, elements of the SPPB, and 400-m gait time were different in participants reporting 150 min/wk or more of MVPA and those reporting less than 150 min/wk. Backward stepwise regression elimination models were used to identify variables in a final composite model predicting baseline SPPB score and 400-m walk time using MVPA and other covariates. Given their known associations with PA level, other covariates that were considered were age, sex, 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 <.05. Results are reported as means ± standard deviations unless otherwise noted.

RESULTS

Baseline characteristics of participants are presented in Table 1. Participants were separated into two groups according to greater (n = 98) and less (n = 319) than 150 min/wk of MVPA. In general, there was a larger percentage of women in the lower group (P = .04). Participants reporting 150 min/wk or more had more depressive symptoms than their less-active peers (P = .01). There were no differences between the groups in age, BMI, or number of medications.

Association Between SPPB and Minutes of MVPA

SPPB summary scores were associated with minutes of MVPA (r = 0.16, P = .001). Mean SPPB score for participants reporting 150 min/wk or more of MVPA was significantly higher (8.0 ± 1.2) than for those reporting less than 150 min/wk (7.4 ± 1.5; P < .001).

Performance was better for each of the individual components measured in the participants reporting 150 min/wk or more of moderate-intensity PA, but none of these associations were statistically significant.

Multiple regression analyses were performed to determine associations with SPPB summary score using age, sex, 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 < .05 level and constituted the final composite model of correlates of the SPPB summary score (Table 2). The coefficients of determination (R²) 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 (r = −0.18; P < .001). Mean 400-m walk time for the group performing less than 150 min/wk of MVPA was significantly higher (8.4 ± 2.1 minutes) than for those performing 150 min/wk or more (7.5 ± 1.6 minutes; P < .001).

Multiple regression analyses were performed to identify correlates of 400-m walk time using age, sex, minutes of MVPA, BMI, number of medications, and depressive symptoms as potential correlates. Age, sex, minutes of MVPA, BMI, and number of medications were significant at the P < .05 level and constituted the final composite model as correlates of 400-m walk time (Table 3). The R² 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 adults aged 70 to 89 at risk for mobility disability. The data indicate that MVPA was associated with performance on the SPPB and 400-m walk test. Participants engaging in 150 min/wk or more of MVPA, as measured according to the CHAMPS questionnaire, performed significantly better on the SPPB and 400-m walk test than those engaging in less than 150 min/wk of MVPA. These associations remained after controlling for variables that have been found to be related to physical function.

To the authors’ knowledge, this 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. In a cross-sectional report, better summary performance scores were associated with higher levels of accelerometer-measured PA in older adults with and without PAD. Physical activity intensity was not assessed in this study, but the reported activity count is consistent with low-intensity PA as determined through similar accelerometer devices. 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 4-m walk time. 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. Investigators designated participants as inactive, lifestyle active, and exercisers. Inactive participants engaged in less than 1,000 kcal/wk of exercise activity and 2,719 kcal/wk or less of total PA, lifestyle-active participants engaged in less than 1,000 kcal/wk of exercise activity and more than 2,719 kcal/wk of total PA, and exercisers engaged in 1,000 kcal/wk or more 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). 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.

A significant association was not observed between minutes of MVPA and the individual elements that constitute 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

Table 2. Variables Used in the Full Model and Final Composite Model of the Regression Analyses for Short Physical Performance Battery

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>P-Value for the Statistic</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>P-Value for the Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.07</td>
<td>0.02</td>
<td>&lt;.001</td>
<td>0.06</td>
<td>0.016</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>0.28</td>
<td>0.15</td>
<td>.06</td>
<td>0.27</td>
<td>0.15</td>
<td>.06</td>
</tr>
<tr>
<td>Minutes of more-vigorous physical activity†</td>
<td>0.001</td>
<td>0.0003</td>
<td>.006</td>
<td>0.001</td>
<td>0.0004</td>
<td>.004</td>
</tr>
<tr>
<td>Number of medications</td>
<td>0.05</td>
<td>0.02</td>
<td>.02</td>
<td>0.02</td>
<td>0.02</td>
<td>.01</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.01</td>
<td>0.01</td>
<td>.28</td>
<td>0.01</td>
<td>0.01</td>
<td>.28</td>
</tr>
<tr>
<td>Center for Epidemiologic Studies Depression Scale score</td>
<td>0.03</td>
<td>0.01</td>
<td>.007</td>
<td>0.03</td>
<td>0.01</td>
<td>.008</td>
</tr>
</tbody>
</table>

*P < .05, coefficient of determination = 0.10.
†Measured as a continuous variable.
individual components that constitute the SPPB.\textsuperscript{2,21,22} Quantification of PA obtained from these investigations was directly assessed using accelerometry, in contrast to the current investigation, which used self-report information to quantify PA. 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, although self-report measurements of PA cannot readily be compared with one another because of inherent variations in capturing the myriad dimensions of PA, they are often modestly correlated with data obtained from accelerometry.\textsuperscript{18} Consideration must also be given to the different PA intensities used in this study than in others. The scope of the analyses was limited to an examination of self-reported levels of MVPA that constitute the current national PA recommendations for obtaining optimal health outcomes,\textsuperscript{23} and it is difficult to make comparisons between the current study and others that failed to report PA intensity or used light-intensity PA. Another explanation for the underlying discrepancies may be because of the different populations under investigation. The target population of the current study consisted only of individuals considered to be mobility limited. To meet this criterion, a participant had to score less than 10 on the SPPB.\textsuperscript{3,6,7} This may be because of the truncated sample, in terms of mobility impairment level, which would make it more difficult to discern such relationships.

Another focus of this 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\textsuperscript{15} and mortality,\textsuperscript{12} the 400-m walk test captures a distinct domain of physical function performance with respect to its ability to predict other health-related outcomes such as cardiovascular disease.\textsuperscript{12}

It was found that minutes of MVPA was significantly associated with 400-m walk time. Relevant studies examining the association between MVPA and 400-m walk performance are limited, although in addition to indicating the association between lifestyle PA and SPPB performance described previously, data from the Health ABC Study indicate a linear trend in 400-m walk times in older adults defined as 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.\textsuperscript{3}

Several possible covariates of 400-m walk performance (age, sex, BMI, number of medications, and depressive symptoms) were also evaluated. Investigators have previously examined and substantiated the relationships between age, sex, BMI, and number of medications and performance on the 400-m walk test.\textsuperscript{10,26–29} Of the variables considered, only depressive symptoms did not predict 400-m walk time, which may be the result of the truncated sample, which included adults with a specific level of mobility impairment.

Further elucidation of the predictive role of MVPA in performance on the SPPB and 400-m walk test is required. These data are limited because of the cross-sectional nature of the investigation (preventing causal inferences) and the fact that the inclusion and exclusion criteria used for entry into the LIFE-P trial restricted the range of variables. Nevertheless, this study provides evidence that there is an association between SPPB scores and 400-m walk time and minutes of MVPA in an older, vulnerable population. Although 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 PA interventions can improve physical function and prevent disability. Results from a large study such as 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 U.S. Department of Agriculture Grants 58-1950-7-707 and DK007651 and the Boston Claude D. Pepper Older Americans Independence Center (IP30AG031679). Any opinions, findings, conclusions, 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 LIFE-P Study is funded by National Institutes on Health (NIH), National Institute on Aging Cooperative Agreement;UO1 AG22376 and sponsored in part by the Intramural Research Program, National Institute on Aging, NIH.

Author Contributions: ACR: analysis and interpretation of data, preparation of manuscript. JMG, ACK, and SNB: concept and design, acquisition of subjects and data, analysis and interpretation of data, review and editing of manuscript. MPW, MEM, and RAF: concept and design, analysis and interpretation of data, review and editing of manuscript. WJR, JAK, and NWW: acquisition of subjects and data, analysis and interpretation of data, review and editing of manuscript.

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

Research Investigators for Pilot Phase of LIFE
 Cooper Institute, Dallas, TX: Steven N. Blair, PED, Field Center Principal Investigator; Timothy Church, MD, PhD, MPH, Field Center Co-Principal Investigator; Jamie A. Ashmore, PhD; Judy Dubreuil, MS; Georita Frierson, PhD; Alexander N. Jordan, MS; Gina Morss, MA; Ruben Q. Rodarte, MS; Jason M. Wallace, MPH
 National Institute on Aging; Jack M. Guralnik, MD, PhD, Co-Principal Investigator of the Study; Evan C. Hadley, MD; Sergei Romashkan, MD, PhD
 Stanford University, Palo Alto, CA: Abby C. King, PhD, Field Center Principal Investigator; William L. Haskell, PhD, Field Center Co-Principal Investigator; Leslie A. Pruitt, PhD; Kari Abbott-Pilolla, MS; Karen Bolen, MS; Stephen Fortmann, MD; Ami Laws, MD; Carolyn Prosak, MS; Kristin Wallace, MPH
 Tufts University: Roger Fielding, MD; Miriam Nelson, PhD

Dr. Fielding's contribution is partially supported by the U.S. Department of Agriculture, under agreement 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. Department of Agriculture.

University of California, Los Angeles, Los Angeles, CA: Robert M. Kaplan, PhD, MA
 VA San Diego Healthcare System and University of California, San Diego, San Diego, CA: Erik J. Groessl, PhD
 University of Florida, Gainesville, FL: Marco Pahor, MD, Principal Investigator of the Study; Michael Perri, PhD; Connie Caudle; Lauren Crump, MPH; Sarah Hayden; Longania Holmes; Cinzia Maraldi, MD; Crystal Quirin
 University of Pittsburgh, Pittsburgh, PA: Anne B. Newman, MD, MPH, Field Center Principal Investigator; Stephanie Studenski, MD, MPH, Field Center Co-Principal Investigator; Bret H. Goodpaster, PhD, MS; Nancy W. Lynn, PhD; Erin K. Aiken, BS; Steve Anthony, MS; Sarah Beck (for recruitment papers only); Judith Kadosh, BSN, RN; Piera Kost, BA; Mark Newman, MS; Jennifer Rush, MPH (for recruitment papers only); Roberta Spanos (for recruitment papers only); Christopher A. Taylor, BS; Pam Vincent, CMA

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

Wake Forest University, Winston-Salem, NC: Stephen B. Kritchevsky, PhD, Field Center Principal Investigator; Peter; Brubaker, PhD; Jameel Demons, MD; Curt Furburg, MD, PhD; Jeffrey A. Katula, PhD, MA; Anthony Marsh, PhD; Barbara J. Nicklas, PhD; Jeff D. Williamson, MD, MPH
 Rose Fries, LPM; Kimberly Kennedy; Karin M. Murphy, BS, MT (ASCP); Shruti Nagaria, MS; Katie Wickley-Krupel, MS

Data Management, Analysis and Quality Control Center: Michael E. Miller, PhD, Field Principal Investigator; Mark Espeland, PhD, Co-Principal Investigator; Fang-Chi Hsu, PhD; Walter J. Rejeski, PhD; Don P. Babcock, Jr., PE; Lorraine Costanza; Lea N. Harvin; Lisa Kaltenbach, MS; Wei Lang, PhD; Wesley A. Roberson; Julia Rushing, MS; Scott Rushing; Michael P. Walkup, MS

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

Yale University: Thomas M. Gill, MD
 Dr. Gill is the recipient of a Midcareer Investigator Award in Patient-Oriented Research (K24AG021507) from the National Institute on Aging.

REFERENCES


