Physical Activity During Daily Life and Functional Decline in Peripheral Arterial Disease

Parveen K. Garg, MD, MPH; Kiang Liu, PhD; Lu Tian, ScD; Jack M. Guralnik, MD, PhD; Luigi Ferrucci, MD, PhD; Michael H. Criqui, MD, MPH; Jin Tan, MS; Mary M. McDermott, MD

Background—Few modifiable behaviors have been identified that are associated with slower rates of functional decline in persons with lower-extremity peripheral arterial disease. We determined whether higher levels of physical activity during daily life are associated with less functional decline in persons with peripheral arterial disease.

Methods and Results—The study population included 203 peripheral arterial disease participants who underwent vertical accelerometer–measured physical activity continuously over 7 days and were followed up annually for up to 4 years (mean, 33.6 months). Outcomes were average annual changes in 6-minute walk performance, usual-paced and fast-paced 4-m walking velocity, and the short performance physical battery. Analyses were adjusted for age, sex, race, comorbidities, body mass index, ankle brachial index, smoking, and walking exercise frequency. Higher baseline physical activity levels measured by a vertical accelerometer were associated with significantly less average annual decline in 6-minute walk performance ($P$ for trend=0.010), fast-paced 4-m walking velocity ($P$ for trend=0.002), and the short performance physical battery ($P$ for trend=0.001). Compared with the lowest baseline quartile, those in the highest baseline quartile of physical activity had less annual decline in 6-minute walk performance ($-0.582$ versus $-107.0$ ft/y; $P=0.019$), fast-paced 4-m walking speed ($-0.0034$ versus $-0.111$ m/s$^-1$·y$^{-1}$; $P=0.002$), and the short performance physical battery ($-0.074$ versus $-0.829$; $P=0.005$).

Conclusions—Higher physical activity levels during daily life are associated with less functional decline among people with peripheral arterial disease. These findings may be particularly important for the large number of peripheral arterial disease persons without access to supervised walking exercise programs. (Circulation. 2009;119:251-260.)

Key Words: claudication ■ exercise ■ peripheral vascular disease ■ risk factors

Low-extremity peripheral arterial disease (PAD) affects 8 million men and women in the United States.\(^1\) Compared with those without PAD, people with PAD have greater functional impairment and more rapid functional decline.\(^2,3\) Persons with PAD have significantly lower physical activity levels during daily life than individuals without PAD.\(^4-8\) Supervised exercise rehabilitation improves walking performance in people with PAD;\(^9\) however, barriers such as cost, transportation, and program availability limit access to exercise rehabilitation programs for most people with PAD.\(^10,11\)

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A relationship between higher levels of physical activity during daily life and lower rates of disability has been demonstrated in non-PAD populations.\(^12-15\) However, it is unknown whether, across the lower range of physical activity levels observed in people with PAD, higher physical activity levels during daily life are associated with less functional decline.\(^16\)

Among persons with PAD, we determined whether higher levels of physical activity during daily life were associated with less functional decline. If higher physical activity levels are protective against functional decline in people with PAD, then interventions to increase daily physical activity in this population may be beneficial.

Methods

Participant Identification

The institutional review boards of Northwestern University and Catholic Health Partners Hospital approved the protocol. Participants gave written informed consent.

Participants were part of the Walking and Leg Circulation Study (WALCS),\(^3,4\) a prospective, observational study designed to identify predictors of functional decline in PAD. Participants were identified from consecutive patients $\geq 55$ years of age in 3 Chicago-area noninvasive vascular laboratories. Participants had an ankle brachial index (ABI) $<0.90$ at their baseline visit.

Exclusion Criteria

Exclusion criteria have been reported elsewhere.\(^4\) Patients with dementia, recent major surgery, or foot or leg amputations were excluded. Nursing home residents and wheelchair-bound patients were excluded.

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Non–English-speaking patients were excluded because investigators were not fluent in non-English languages. Participants who underwent lower-extremity revascularization after the baseline visit were excluded from analyses after their revascularization.

**ABI Measurement**
A handheld Doppler probe (Nicolet Vascular Pocket Dop II, Nicolet Biomedical Inc, Golden, Colo) was used to obtain systolic pressures in the right and left brachial, dorsalis pedis, and posterior tibial arteries.17,18 Each pressure was measured twice. The ABI was calculated by dividing the mean of the dorsalis pedis and posterior tibial pressures in each leg by the mean of the 4 brachial pressures.17 Average brachial pressures in the arm with highest pressure were used when 1 brachial pressure was higher than the opposite brachial pressure in both measurement sets and the 2 brachial pressures differed by $\geq 10$ mm Hg in at least 1 measurement set because, in such cases, subclavian stenosis was possible.17,18 The lowest leg ABI was used in analyses.

**Exertional Leg Symptoms**
Participants were categorized into the following leg symptom categories based on previous study3,4,19: asymptomatic (no exertional leg symptoms), classic intermittent claudication symptoms, leg pain on exertion and rest (exertional leg pain that sometimes begins at rest), exertional leg pain/carry on (exertional leg pain that does not cause the patient to stop walking), and atypical exertional leg pain (exertional leg pain that is not consistent with any of the previous).

**Depressive Symptoms**
Depressive symptoms were measured annually with the Geriatric Depression Scale Short Form, a 15-item questionnaire assessing the number of depressive symptoms.20 The Geriatric Depression Scale Short Form score ranges from 0 to 15, with 0 indicating no depressive symptoms and 15 indicating that all depressive symptoms in the Geriatric Depression Scale Short Form are present.

**Functional Measures**
Functional performance measures were administered at baseline and annually during follow-up.

**Six-Minute Walk**
Following a standardized protocol,21,22 participants walked up and down a 100-ft hallway for 6 minutes after instructions to cover as much distance as possible.

**Repeated Chair Rises**
Participants sat in a straight-backed chair with their arms folded across their chests and stood 5 times consecutively as quickly as possible. The time to complete 5 chair rises was measured.

**Standing Balance**
Participants were asked to hold 3 increasingly difficult standing positions for 10 seconds each: standing with feet together side by side and parallel (side-by-side stand), standing with feet parallel with the toes of 1 foot adjacent to and touching the heel of the opposite foot (semitandem stand), and standing with 1 foot directly in front of the other with both feet in a straight line (tandem stand).23,24

**Four-Meter Walking Velocity**
Walking velocity was measured with a 4-m walk performed at "usual" and "fastest" pace. For the usual-paced walk, participants were instructed to walk at their usual pace “as if going down the street to the store.” Each walk was performed twice. The faster walk in each pair was used in analyses.23,24

**Short Physical Performance Battery**
The short physical performance battery combines data from the usual-paced 4-m walking velocity, time to rise from a seated position 5 times, and standing balance. Individuals receive a score of 0 for each task that they are unable to complete. Scores of 1 to 4 are assigned for remaining tasks based on quartiles of performance for $>6000$ participants in the Established Populations for the Epidemiologic Study of the Elderly.23,24 Scores are summed to obtain the short physical performance battery score, ranging from 0 to 12.

**Physical Activity**

**Accelerometer-Measured Physical Activity**
Physical activity levels were measured objectively and continuously over 7 days with a vertical accelerometer (Caltrac, Muscle Dynamics Fitness Network Inc, Rocklin, Calif).5,25–29 After 7 days, participants reported the number of activity units displayed on the accelerometer by telephone to investigators and mailed their accelerometer back to investigators. We programmed the accelerometer identically for all participants, which allowed us to compare physical activity levels between participants regardless of individual variations in age, weight, height, and sex.6,25–27,28 Programmed in this way, the accelerometers measured “activity units.”6,25,27,28 This method of measuring physical activity in people with PAD has been validated previously.6,25 Because of limited numbers of accelerometers, we distributed them to participants (49%) whenever available.

**Patient-Reported Physical Activity Measures**
Patient-reported physical activity was measured with a questionnaire derived from the Harvard Alumni Activity Survey that has previously been validated in the Cardiovascular Health Study and the Women’s Health and Aging Study.30–32 The physical activity questionnaire asked, “During the last week, how many city blocks or their equivalent did you walk? Let 12 city blocks equal 1 mile.” It also asked, “In the last week, about how many flights of stairs did you climb up? A flight is 10 steps.”

**Other Measures**
Height and weight were measured at baseline. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Education and pack-years of cigarette smoking were determined by patient report. Participants were categorized according to their exercise behavior as follows: no walking for exercise, walking for exercise once or twice per week, or walking for exercise $\geq 3$ times per week.

**Follow-Up**
Participants were contacted annually for follow-up visits. Final follow-up visits were completed between November 2002 and September 2004. On the basis of previous study, individuals whose data collection forms indicated that they were unable to complete functional measures at follow-up as a result of wheelchair confinement, exhaustion, or other significant symptoms were classified as too disabled to complete functional measures.4,16 When no information was provided for the reason that a participant refused to complete functional tests, those who met at least 2 of the following criteria were considered too disabled to walk: The participant reported walking $<5$ blocks during the previous week; the score for repeated chair rises equaled 0 or 1; or the score for the standing balance test equaled 0 or 1. The criteria were defined before data analyses. Individuals who refused functional testing at follow-up and met 2 of these criteria were assigned the minimum value for each test not completed. The minimum value for each test was equivalent to the poorest performance among those who completed testing at the corresponding visit.

**Statistical Analyses**
Baseline physical activity levels for each physical activity measure were categorized into quartiles. The fourth quartile represented the highest activity level. Baseline characteristics between participants who wore vertical accelerometers and those who did not wear vertical accelerometers were compared with general linear models for continuous variables and chi² tests for categorical variables with adjustment for age and sex.

In comparing change in functioning (eg, 6-minute walk distance) across different patient groups, we carried out a longitudinal or repeated-measures ANCOVA using the mixed-effects linear regres-
sion analysis. Analyses adjusted for baseline covariates (sex, age, and race) and a time-dependent covariate representing functional performance at the immediately preceding visit were carried out on these successive differences. Similar analyses were repeated with additional adjustment for baseline comorbidities, leg symptoms, education, depressive symptoms, and time-dependent covariates (BMI, ABI, and pack-years of smoking). Associations of accelerometer data with decline in functional performance were analyzed using baseline measures of physical activity. Vertical accelerometer data were not available for most participants at subsequent follow-up visits. In contrast, patient-reported physical activity (stair flights climbed during the past week and blocks walked during the past week) were obtained annually. Therefore, time-dependent analyses were used for analyses of associations of patient-reported physical activity with functional decline. We also performed t test pairwise comparisons for both accelerometer-measured and patient-reported data using participants in the lowest quartile of activity as the reference.

Analyses were repeated among PAD participants who were asymptomatic to determine whether associations were maintained in this subset of PAD participants. To determine whether associations between accelerometer-measured physical activity and functional decline were consistent across levels of functional performance, analyses were repeated after participants were stratified according to tertile for each baseline functional measure.

**Mixed-Effects Regression and Handling Missing Data**

Associations between physical activity and changes in functional measures were evaluated with mixed-effects models in which a subject-specific random effect was used to account for the potential correlations among successive annual differences in each functional measure of the same participant. Dependent variables in each mixed-effect regression analysis were the successive annual differences in each functional measure. Under this initial mixed-effects regression analysis, statistically valid inference is guaranteed, provided that missing data caused by patient dropout are unrelated to unobserved data (ie, any missing data are missing at random). As a safeguard against violations to this assumption that missing data are missing at random, we repeated the fully adjusted comparisons using a repeated-measures pattern-mixture ANCOVA model. Because data were analyzed using successive differences, multiple patterns of missing differences were observed in our analyses. The different patterns of missing data were included as 2 binary indicator covariates (centered about their means). By including patterns of

<p>| Table 1. Characteristics of Study Participants With PAD According to Use of Vertical Accelerometers at Baseline |</p>
<table>
<thead>
<tr>
<th>All Participants (n=417)</th>
<th>No Accelerometer Use (n=214)</th>
<th>Vertical Accelerometer Use (n=203)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y 71.9 (8.4) 71.3 (8.5) 72.5 (8.3)</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, % 59.2 54.7 64.0</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black race, % 15.8 15.9 15.8</td>
<td>0.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABI 0.652 (0.14) 0.655 (0.14) 0.649 (0.15)</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m² 27.4 (4.9) 27.5 (4.7) 27.4 (5.1)</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigarette smoking, pack-y 37.7 (33.7) 35.3 (32.6) 40.3 (34.8)</td>
<td>0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus, % 31.4 30.4 32.5</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac or cerebrovascular disease, % 57.8 56.5 59.1</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthritis, % 40.8 42.5 38.9</td>
<td>0.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary disease, % 31.7 32.7 30.5</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer, % 14.6 14.5 14.8</td>
<td>0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level, %</td>
<td></td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Less than high school 11.5 11.3 11.8</td>
<td>11.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or college 68.0 69.0 67.0</td>
<td>67.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate/professional school 20.4 19.7 21.2</td>
<td>21.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statin use, % 45.8 49.1 42.4</td>
<td>0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression score* 3.14 (3.12) 3.07 (3.34) 3.21 (2.89)</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise, % 0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking &gt;3 times/wk 34.1 32.2 36.0</td>
<td>36.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking &lt;3 times/wk 20.1 22.4 17.7</td>
<td>17.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No walking 45.8 45.3 46.3</td>
<td>46.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City blocks walked past week, n 33.5 (53.9) 31.4 (46.7) 35.6 (60.6)</td>
<td>0.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stair flights climbed in the past week, n 17.5 (27.0) 16.0 (25.9) 19.1 (28.2)</td>
<td>0.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-min Walk distance, ft 1126 (389) 1136 (423) 1116 (346)</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-m Walk, normal pace, m/s 0.881 (0.21) 0.886 (0.24) 0.876 (0.18)</td>
<td>0.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-m Walk, fast pace, m/s 1.204 (0.28) 1.211 (0.31) 1.196 (0.25)</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short physical performance battery (score, 0–12 score; 12=best) 9.6 (2.6) 9.8 (2.6) 9.5 (2.6)</td>
<td>0.29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values shown are mean (SD) unless otherwise indicated. Cardiac or cerebrovascular diseases included myocardial infarction, heart failure, angina, and stroke. Arthritis diseases included knee arthritis, hip arthritis, hip fracture, spinal stenosis, and disk disease. P values for comparisons across the exercise categories were performed with ANOVA for continuous variables and χ² test for categorical variables. *Depression was measured with the 15-item Geriatric Depression Scale Short Form, the scores for which ranged from 1 (lowest) to 15 (highest). A higher score indicated more depressive symptoms.
missing data in analyses as centered covariates and averaging over these patterns using adjusted least-squares means, one can obtain an unbiased estimate of the marginal means adjusted for covariates. Analyses were performed with SAS statistical software (version 9.1, SAS Institute Inc, Cary, NC).

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

### Results

Four hundred sixty participants with PAD completed baseline testing in the WALCS. Of these 460 participants, 26 died or were lost to follow-up before the first follow-up visit, and 17 underwent lower-extremity revascularization before their first follow-up visit and were excluded from analyses, leaving 417 PAD participants for analyses. Of these 417, 203 had baseline vertical accelerometer data. As shown in Table 1, no significant differences were found in characteristics of participants who wore the accelerometer and those who did not.

Table 2 shows characteristics of the study population across quartiles of accelerometer-measured physical activity levels. Higher baseline physical activity was associated with more blocks walked during the past week, higher ABI values, lower Geriatric Depression Scale Short Form scores, and...
better performance on each measure of lower-extremity functioning at baseline.

Adjusting for age, sex, race, ABI, BMI, pack-years of smoking, comorbidities, leg symptoms, patterns of missing data, education, and depressive symptoms, we observed significant, graded associations between accelerometer-measured physical activity at baseline and average annual decline in 6-minute walk performance, fast-paced walking velocity, and the short performance physical battery (Figure 1). Compared with participants in the lowest baseline quartile of physical activity, those in the highest (fourth) quartile had less decline in 6-minute walk performance ($P=0.019$), fast-paced walking speed ($P=0.002$), and short physical performance battery ($P=0.005$).

Among the 39 asymptomatic PAD participants who wore vertical accelerometers at baseline, those who were more physically active had significantly less decline in 6-minute walk performance and in usual- and fast-paced walking velocity (Figure 2).

We repeated the analyses after stratifying participants according to tertiles of baseline functional performance (Table 3). Within these tertiles, significant associations between accelerometer-measured physical activity and average annual functional decline were observed among participants in either or both of the lowest or middle tertiles of baseline perfor-
performance for all measures except usual-paced 4-m walking velocity. Thus, higher physical activity during daily life may be of greatest benefit to PAD persons with greatest functional limitation.

Table 4 shows associations between time-dependent patient-reported physical activity and average annual functional decline. After adjustment for age, sex, race, prior year’s performance, ABI, BMI, pack-years of smoking, comorbidities, leg symptoms, patterns of missing data, education, and depressive symptoms, more blocks walked during the previous week were associated with less average annual decline in the short performance physical battery ($P$ for trend = 0.004). More stair flights climbed during the previous week were associated with less decline in the usual-paced ($P$ for trend = 0.010) and fast-paced ($P$ for trend = 0.022) 4-m walking velocities.

Discussion
Among people with PAD, higher levels of physical activity during daily life, measured over 7 days with a vertical accelerometer, were associated with significantly less average annual decline in objectively measured functional performance at the 4-year follow-up compared with lower baseline levels of physical activity. Results also suggest that persons with PAD who have greatest functional impairment may benefit most from higher physical activity levels. Significant associations of higher physical activity with less functional decline also were observed within the subset of participants with asymptomatic PAD. To the best of our knowledge, no prior studies have reported associations between physical activity during daily life and functional decline in people with PAD.
No medications are approved by the Food and Drug Administration for improving walking performance in persons with asymptomatic PAD, despite the previously established finding that persons with PAD who are asymptomatic are at particularly high risk of functional decline. Although supervised treadmill exercise programs significantly improve walking performance in people with intermittent claudication, barriers such as cost and transportation limitation access to exercise rehabilitation programs for most people with PAD. Thus, few persons with PAD participate in supervised exercise programs. Identifying modifiable behaviors associated with slower rates of functional decline provides new opportunities that are noninvasive and inexpensive for preserving lower-extremity performance in people with PAD.

Several mechanisms may explain the relative preservation of lower-extremity functional performance in persons with PAD who are more physically active during daily life. First, in persons without PAD, higher levels of physical activity may reduce systemic atherosclerosis by improving risk factors like hypertension, hyperlipidemia, and diabetes. If higher rates of physical activity during daily life slow the progression of lower-extremity atherosclerosis, that may explain findings presented here. Second, in persons without PAD, physical activity is associated with improved peripheral arterial endothelial function and increased lower-extremity blood flow. Third, physical activity may improve metabolic efficiency and improve oxygen extraction within the muscle tissue. Fourth, increased levels of physical activity could favorably alter gait, resulting in more efficient walking techniques. Third, physical activity may improve metabolic efficiency and improve oxygen extraction within the muscle tissue. Fourth, increased levels of physical activity could favorably alter gait, resulting in more efficient walking techniques.

Finally, higher physical activity levels are inversely associated with inflammatory markers in persons with PAD. These physiological and metabolic changes associated with physical activity may explain the association of higher physical activity with lower functional decline among persons with PAD. However, further study is needed.

### Table 3. Adjusted Associations Between Accelerometer-Measured Physical Activity and Average Annual Decline Over the 4-Year Follow-Up According to Baseline Performance

<table>
<thead>
<tr>
<th>Physical Activity Quartiles</th>
<th>First Quartile (Reference Group and Lowest Activity Group)</th>
<th>Second Quartile</th>
<th>Third Quartile</th>
<th>Fourth Quartile (Highest Activity Group)</th>
<th>P for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-min Walk performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile of baseline performance (≤1000 ft)</td>
<td>-160.0</td>
<td>-35.48</td>
<td>-18.46</td>
<td>113.69†</td>
<td>0.003</td>
</tr>
<tr>
<td>Middle tertile of baseline performance (1000 to ≤1301 ft)</td>
<td>-68.05</td>
<td>-152.7</td>
<td>-63.42</td>
<td>-50.48</td>
<td>0.57</td>
</tr>
<tr>
<td>Highest tertile of baseline performance (≥1301 ft)</td>
<td>-249.4</td>
<td>-235.1</td>
<td>-174.6</td>
<td>-178.2</td>
<td>0.21</td>
</tr>
<tr>
<td>Usual-paced 4-m walking velocity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile of baseline performance (≤0.80 m/s)</td>
<td>-0.044</td>
<td>0.005</td>
<td>0.057</td>
<td>0.023</td>
<td>0.23</td>
</tr>
<tr>
<td>Middle tertile of baseline performance (0.80 to ≤0.94 m/s)</td>
<td>-0.010</td>
<td>-0.041</td>
<td>-0.014</td>
<td>-0.081</td>
<td>0.22</td>
</tr>
<tr>
<td>Highest tertile of baseline performance (≥0.94 m/s)</td>
<td>-0.110</td>
<td>-0.119</td>
<td>-0.094</td>
<td>-0.090</td>
<td>0.61</td>
</tr>
<tr>
<td>Fast-paced 4-m walking velocity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile of baseline performance (≤1.10 m/s)</td>
<td>-0.042</td>
<td>-0.000</td>
<td>0.074</td>
<td>0.109</td>
<td>0.01</td>
</tr>
<tr>
<td>Middle tertile of baseline performance (1.10 to ≤1.33 m/s)</td>
<td>-0.094</td>
<td>-0.144</td>
<td>-0.004</td>
<td>0.008</td>
<td>0.04</td>
</tr>
<tr>
<td>Highest tertile of baseline performance (≥1.33 m/s)</td>
<td>-0.104</td>
<td>-0.117</td>
<td>-0.133</td>
<td>-0.156</td>
<td>0.42</td>
</tr>
<tr>
<td>Short physical performance battery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile of baseline performance (score ≤9)</td>
<td>-0.491</td>
<td>-0.663</td>
<td>1.541</td>
<td>2.137†</td>
<td>0.008</td>
</tr>
<tr>
<td>Middle tertile of baseline performance (score = 10 or 11)</td>
<td>-0.963</td>
<td>-1.307</td>
<td>0.303†</td>
<td>-0.151</td>
<td>0.01</td>
</tr>
<tr>
<td>Highest tertile of baseline performance (score ≥12)</td>
<td>-0.370</td>
<td>-0.416</td>
<td>-0.169</td>
<td>-0.435†</td>
<td>1.000</td>
</tr>
</tbody>
</table>

n=203.

*Analyses adjusted for age, sex, race, prior year functioning, baseline ABI, BMI, pack-years of smoking, comorbidities, leg symptoms, patterns of missing data, education, and depressive symptoms.
†For pairwise comparison to reference group, P<0.05.
Table 4. Adjusted Associations Between Patient-Reported Physical Activity and Average Annual Decline in Objectively Measured Performance in Persons With PAD*

<table>
<thead>
<tr>
<th>No. of blocks walked during the previous week</th>
<th>6-Minute Walk, ft</th>
<th>Usual-Paced 4-m Walking Velocity, m/s</th>
<th>Fast-Paced 4-m Walking Velocity, m/s</th>
<th>Short Physical Performance Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>First quartile, n=116 (≤5 blocks) (reference group)</td>
<td>84.16</td>
<td>-0.054</td>
<td>-0.079</td>
<td>-0.606</td>
</tr>
<tr>
<td>Second quartile, n=100 (6–≤14 blocks)</td>
<td>69.98</td>
<td>-0.033</td>
<td>-0.056</td>
<td>-0.441</td>
</tr>
<tr>
<td>Third quartile, n=104 (15–≤40 blocks)</td>
<td>61.22</td>
<td>-0.034</td>
<td>-0.056</td>
<td>-0.107†</td>
</tr>
<tr>
<td>Fourth quartile, n=97 (&gt;40 blocks walked)</td>
<td>47.16</td>
<td>-0.032</td>
<td>-0.044†</td>
<td>-0.195†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of stair flights climbed during the previous week</th>
<th>6-Minute Walk, ft</th>
<th>Usual-Paced 4-m Walking Velocity, m/s</th>
<th>Fast-Paced 4-m Walking Velocity, m/s</th>
<th>Short Physical Performance Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>First quartile, n=116 (≤1 stair flight) (reference group)</td>
<td>80.71</td>
<td>-0.055</td>
<td>-0.076</td>
<td>-0.474</td>
</tr>
<tr>
<td>Second quartile, n=100 (2–≤7 stair flights)</td>
<td>58.65</td>
<td>-0.043</td>
<td>-0.068</td>
<td>0.270</td>
</tr>
<tr>
<td>Third quartile, n=104 (8–≤26 stair flights)</td>
<td>71.83</td>
<td>-0.031</td>
<td>-0.051</td>
<td>-0.456</td>
</tr>
<tr>
<td>Fourth quartile, n=97 (&gt;26 stair flights)</td>
<td>56.27</td>
<td>-0.024†</td>
<td>-0.045†</td>
<td>-0.258</td>
</tr>
</tbody>
</table>

P for trend: 0.26 0.01 0.02 0.32

n=417.

*Analyses adjusted for age, sex, race, prior year functioning, baseline ABI, BMI, pack-years of smoking, comorbidities and leg symptoms, patterns of missing data, education, and depressive symptoms.
†For pairwise comparison to reference group, P<0.05.

Patient-reported measures of physical activity were less strongly associated with rates of functional decline compared with associations of the vertical accelerometer measure with functional decline. Objective measures of physical activity are likely to be more accurate than patient-reported physical activity levels.

This study has limitations. Only 49% of participants wore the vertical accelerometer device because of the limited availability of these monitors for study participants. However, no differences in baseline characteristics were found between participants who wore the accelerometer and those who did not. Second, these data are observational. Associations of lower levels of physical activity with greater functional decline cannot be construed as causal. Although we adjusted for confounders including comorbidities, we cannot rule out the possibility that residual confounding, unidentified characteristics, or greater illness severity among participants with lower physical activity levels contributed to the observed differences in functional decline across physical activity groups. Third, we did not collect data on intensity of physical activity.

Conclusions

Persons with PAD with higher levels of physical activity during daily life had less annual decline in objectively measured functional performance measures at 4-year follow-up. These findings suggest that physicians should encourage patients with PAD to increase their daily physical activity levels because higher physical activity may protect against functional decline. On the basis of our findings, physicians should encourage their PAD patients to increase activity within their homes, to choose stairs rather than the escalator or elevator, and to walk rather than drive when traveling short distances. Future study with a clinical trial is necessary to determine whether interventions that increase physical activity levels reduce rates of functional decline in patients with PAD.

Disclosures

None.

References

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34. Garg et al Daily Physical Activity and Functional Decline in PAD 259

35. Garg et al Daily Physical Activity and Functional Decline in PAD 259


43. Hiatt WR, Wolfel EE, Meier RH, Regensteiner JG. Superiority of treadmill walking exercise versus strength training for patients with
Men and women with lower-extremity peripheral arterial disease (PAD) have greater functional limitation and faster rates of functional decline compared with persons without PAD. Few modifiable risk factors have been identified that are associated with slower rates of functional decline in persons with PAD. This study assessed the association of greater physical activity during daily life with the rate of decline in functional performance among patients with PAD. Two hundred three men and women with PAD wore a vertical accelerometer for 7 days at baseline for continuous objective monitoring of physical activity and were followed up annually for up to 4 years. Higher baseline physical activity during daily life was associated with significantly less average annual decline in 6-minute walking distance, fast-paced 4-m walking velocity, and the short performance physical battery after adjustment for confounders. Our findings suggest that greater physical activity during daily life is associated with less decline in functional performance among persons with PAD. These findings suggest that clinicians should advise their patients with PAD to maximize physical activity during daily life. However, additional study with a randomized controlled clinical trial is warranted to determine whether interventions that increase physical activity during daily life are associated with slower rates of functional decline in persons with PAD.
Physical Activity During Daily Life and Functional Decline in Peripheral Arterial Disease
Parveen K. Garg, Kiang Liu, Lu Tian, Jack M. Guralnik, Luigi Ferrucci, Michael H. Criqui, Jin Tan and Mary M. McDermott

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