The Relation of Peripheral Arterial Disease to Leg Force, Gait Speed, and Functional Dependence Among Older Adults

Hsu-Ko Kuo¹,² and Yau-Hua Yu³,⁴

¹Department of Geriatrics and Gerontology and Department of Internal Medicine, National Taiwan University Hospital, Taipei.
²Division of Gerontology Research, National Health and Research Institutes, Taipei, Taiwan.
³School of Dentistry, National Yang Ming University, Taipei, Taiwan.
⁴Department of Dentistry, Veteran General Hospital, Taipei, Taiwan.

Background. Atherosclerotic peripheral arterial disease (PAD), common among older adults, is associated with poor low-extremity functioning. In considering functional status, varying domains exist, including activities of daily living (ADL), instrumental activities of daily living (IADL), low-extremity mobility (LEM), and leisure and/or social activities (LSA). However, little is known about how PAD is related to functional status beyond low-extremity functioning.

Methods. A total of 1798 participants 60 years old or older was selected from the population-based National Health and Nutrition Examination Survey 1999–2002 in the United States. ADL, IADL, LSA, LEM, and general physical activities (GPA) were obtained by self-report. Peak leg force was obtained from an isokinetic dynamometer. Habitual gait speed was obtained from a 20-foot timed walk. PAD was defined as an ankle–brachial blood pressure index <0.9 in either leg.

Results. After multivariable adjustment, the odds ratios (ORs) for dependence in IADL, LSA, and LEM comparing participants with PAD to those without were 1.60 (95% confidence interval [CI], 1.11–2.29), 1.63 (95% CI, 1.08–2.44), and 2.29 (95% CI, 1.64–3.18), respectively. Additional adjustment of peak leg force and/or habitual gait speed diminished the relations of PAD to dependence in IADL and LSA. PAD was associated with an 18.06 Newton reduction (p = .003) in peak leg force and a 0.05 m/s reduction (p = .002) in habitual gait speed.

Conclusion. PAD was independently associated with multiple domains of functional dependence. The association between PAD and dependence in IADL and LSA was to a large extent mediated by leg force and gait speed.

Key Words: Peripheral arterial disease—Muscle strength—Gait speed—Disability—National Health and Nutrition Examination Survey.

Atherosclerotic peripheral arterial disease (PAD) is common in older adults. According to the Cardiovascular Health Study, the prevalence of PAD, defined as an ankle–brachial blood pressure index (ABPI) <0.9, was 12.4% in adults 65 years old and older from four U.S. communities (1). PAD can cause disabling exertional leg pain and can progress to rest ischemia with ulceration, gangrene, or even limb loss. Moreover, PAD is often associated with other cardiovascular diseases such as carotid atherosclerosis, myocardial infarction, or stroke, indicating the systematic nature of atherosclerosis in individuals afflicted by PAD (1–4).

Increasing evidence has supported the notion that, in addition to cardiovascular implications, PAD plays a crucial role in functional status among older adults. The Study of Osteoporotic Fractures by Vogt and colleagues (5) suggested that PAD was associated with impaired walking ability, low muscle strength, and difficulty in instrumental activities of daily living (IADLs). By examining a population-based cohort (6) as well as hospital-based populations (7,8), McDermott and colleagues found that lower ABPI levels were associated with less physical activity (7), walking impairment (6–8), and poorer standing balance (6,7). Scherer and colleagues (9) demonstrated that patients with symptomatic PAD had reduced 6-minute walking distance and reduced self-reported physical function as assessed by Short Form questionnaire (SF-36). Recent longitudinal studies by McDermott and colleagues (10,11) further supported the cross-sectional associations by demonstrating that participants with low ABPI at baseline had greater decline in walking performance during follow-up.

Studies of PAD with functional status as the outcome have currently focused on low-extremity functioning, mobility disability, or IADL. However, in considering the concept of functional status, varying domains of functional dependence exist, including ADL, IADL, lower extremity mobility (LEM), and leisure and social activities (LSA). In the current body of literature, it is becoming clear that PAD is predictive of impairment in low-extremity functioning such as walking endurance, gait speed, and balance among older people (10,11). Unfortunately, little is known about the association between PAD and different aspects of functional dependence beyond low-extremity functioning. The relationship of PAD to various domains of functional status has not been comprehensively examined.

An important theoretical model of the pathway to late-life dependence was proposed by Nagi in 1965 (12). Nagi’s construct of disablement consists of four related but distinct
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categories that represent the causal connection between pathology and actual dependence. These are: “active pathology” (such as PAD), “impairment” (such as low leg force), “functional limitation” (such as slow gait speed), and “disability” (such as dependence in ADL, IADL, and LSA) (12–14). Nagi’s model of disablement is useful to explain how active pathology evolves into physical impairment, functional limitations, and finally into disability (12–14). Although PAD is related to mobility disability and functional decline, the roles of performance-based measures of impairment and functional limitations, such as leg force and gait speed, in the association between PAD and disability have not been examined.

Therefore, we hypothesize that PAD is associated with multiple domains of functional dependence and that leg force and gait speed to some extent mediate the association between PAD and functional dependence. We will investigate the study hypotheses by analyzing data from the U.S. National Health and Nutrition Examination Survey (NHANES) 1999–2002.

METHODS

Data Source and Study Design

The NHANES 1999–2002 is a population-based, cross-sectional survey designed to collect information on the health and nutrition of the U.S. household population. The NHANES used a stratified, multistage, and cluster sampling design to obtain a representative sample of the non-institutionalized civilian U.S. population. NHANES consists of a detailed home interview and a health examination conducted in a mobile examination center (MEC). Beginning in 1999, the NHANES became a continuous, annual survey rather than the periodic survey that it had been in the past. Detailed Survey Operations Manuals, Consent Documents, and Brochures of the NHANES 1999–2002 are available on the NHANES Web site (15,16).

ABPI Measurements

The ABPI examination was performed by trained health technicians in a specially equipped room. Participants lay supine on the examination table during the ABPI measurement. Supine systolic blood pressure (BP) was measured on the right arm (brachial artery) and both ankles (posterior tibial arteries). Systolic BP was measured once at each site for participants aged ≥60 years. If the participant had a condition associated with the right arm that would interfere with measurement, the left arm was used for brachial artery pressure measurement. Left and right ABPI measurements were obtained by dividing systolic BP in the right and left ankle by BP in the arm. The lowest ABPI obtained from either leg was taken as the ABPI measurement for that patient. PAD was defined as an ABPI <0.9. Details of the NHANES ABPI measurement are available online (17).

Isokinetic Peak Leg Force and Habitual Gait Speed

Maximal right leg force (Newtons) was measured at an angular velocity of 60°/second by a Kinetic Communicator isokinetic dynamometer (Chattecx Corp., Chattanooga, TN). Ideally, each participant would have a total of six trials during the strength test: three practice warm-ups and three trials for maximal voluntary effort. Highest peak force (PF) in Newton was obtained according to the following algorithm: for examinees with ≥4 trials, one highest PF was selected from trials 4–6 (trials for maximal voluntary effort); for examinees with <4 trials, a highest PF was selected from the completed trials (warm-up trials). The 20-foot timed walk test was performed at the participant’s usual pace. Participants were allowed to use a walker or cane if needed. Habitual gait speed was calculated as walking distance (20 feet = 6.15 m) divided by time in seconds.

Functional Dependence

Participants ≥60 years were asked 19 questions (Physical Functioning Questionnaire), available online (18) and designed to measure their functional status. These questions were phrased to assess the individual’s level of difficulty in performing a task without using any special equipment. The 19 questions of functional dependence were categorized into five major domains: (i) ADL (eating, walking, dressing, and getting up of bed), (ii) IADL (managing money, housekeeping, and food preparation), (iii) LSA (attending social events, going out to movies, in-home leisure activities), (iv) LEM (walking one-quarter mile, and walking up 10 steps), and (v) general physical activities (GPA: stooping, bending, standing, sitting, lifting, reaching, and grasping). A participant’s answer to a given question was coded as “no difficulty,” “some difficulty,” “much difficulty,” or “unable to do.” Functional dependence was defined as any difficulty in performing one or more activities within a given domain.

Covariates

Age, gender, race/ethnicity, and smoking status were obtained by self-report. Diabetes was defined by self-report of a physician’s diagnosis, the presence of a random plasma glucose level >200 mg/dL, or the use of diabetogenic medications (including insulin injection and/or oral hypoglycemic agents). Three or sometimes four BP determinations were taken using a mercury sphygmomanometer. BP was measured in the right arm unless specific conditions prohibit the use of the right arm. Averaged systolic and diastolic BPs were obtained. The presence of hypertension was defined by a self-report doctor’s diagnosis, the use of antihypertensive medications, or averaged BP >140/90 mmHg. Body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters, was categorized according to the National Institutes of Health obesity standards: <18.5 = underweight, 18.5–24.9 = normal weight, 25.0–29.9 = overweight, and >30 = obese (19). Chronic medical conditions including myocardial infarction, coronary heart disease, congestive heart failure, angina, chronic bronchitis, emphysema, and arthritis were ascertained by self-report questionnaires. Heart disease was determined if participants had myocardial infarction, coronary heart disease, congestive heart failure, or angina; chronic obstructive pulmonary
disease (COPD) was determined if participants had chronic bronchitis or emphysema. Alcohol intake was determined by the questionnaire ‘‘In any one year, have you had at least 12 drinks of any type of alcohol beverage?’’ and was dichotomized. C-reactive protein (CRP) was quantified by utilizing latex-enhanced nephelometry with a Behring Nephelometer Analyzer System (Behring Diagnostics, Frankfurt, Germany). Levels of total cholesterol were obtained by using a standard biochemistry method. Levels of CRP and total cholesterol were natural-log-transformed in the analyses because of the right-skewed distribution.

Analysis
Multiple logistic regression was used to determine the odds ratios (ORs) of functional dependence in five domains comparing participants with PAD to those without. We used an extended-model approach for covariates adjustment: Model 1 = age, sex, race, BMI categories, educational level, health behaviors (smoking status and alcohol consumption), chronic diseases (hypertension, diabetes, heart disease, COPD, and arthritis), and natural-log-transformed CRP and total cholesterol levels; Model 2 = Model 1 + peak leg force; Model 3 = Model 1 + habitual gait speed; Model 4 = Model 1 + peak leg force + habitual gait speed. We also assessed the relationship of PAD to peak leg force and habitual gait speed by using multiple linear regression while adjusting for Model 1 covariates. We additionally adjusted for peak leg force in the association between PAD and habitual gait speed to observe possible change of association.

We further divided study participants into three groups based on ABPI, namely ABPI <0.75 (91 participants), ABPI from 0.75 to <0.9 (115 participants), and ABPI from 0.9 to 1.5 (1592 participants), to assess the association between ABPI and functional dependence. The ORs for functional dependence were obtained using multiple logistic regression with participants from 0.9 to 1.5 as the reference group. Adjusted means of peak leg force and habitual gait speed in three groups of participants were obtained by multiple linear regression.

Because the NHANES population weights are only applicable to analyses that use the entire population and because we limited our analyses to a special subset of participants, we did not use the NHANES 1999–2002 population weights for the purposes of this study. Data management and analysis were performed using STATA 8.0 software (STATA Corporation, College Station, TX).

RESULTS

Selection of Study Population
The Physical Functioning Questionnaire was administered to 3703 participants 60 years old or older to assess the individual’s level of difficulty in performing various tasks without using any special equipment. Of these, 471 participants did not come to the MEC for examination, which included an assessment of the right isokinetic quadriceps muscle strength, a 20-foot timed walk test, as well as the ABPI measurements. Of the 3232 participants who came to the MEC, 457 were excluded from muscle strength examination because of the following safety reasons: chest or abdominal surgery in the past 3 weeks (20 participants); heart attack in the past 6 weeks (10 participants); brain aneurysm or stroke (173 participants); current neck or back pain (90 participants); difficulty in bending or straightening right knee (76 participants); or right knee or right hip replacement (88 participants). We further excluded 886 participants with missing data on leg force, gait speed, or measurement of ABPI because of participants’ refusal, limited time to do the examinations, bilateral amputation, weight over 400 pounds (equipment limitations), swollen leg/ankle edema, bandage/stocking or other obstruction, participants’ coming late or leaving early, examinations being interrupted, equipment or data capture failure, technician/software/supply error, communication problems, or other reasons. We further excluded two participants with ABPI values >1.5, values usually related to noncompressible vessels in the legs (1), and 89 participants with missing values in other covariates (specifically total cholesterol and CRP), leaving 1798 older participants as the final analytic sample. Participants excluded for any reasons (N = 1905) were older (74.1 years vs 70.3 years, p < .001) and were more disabled in all domains of functional dependence (p < .001) compared to 1798 enrolled participants.

Characteristics of Study Population
Selected baseline characteristics of the study participants as a whole (N = 1798) and by presence of PAD are summarized in Table 1. Mean ABPI level was 0.73 + 0.14 (standard deviation [SD]) for 206 participants with PAD and 1.11 + 0.10 (SD) for 1592 participants without PAD. The mean age was 70.3 years, and the mean BMI was 27.8 Kg/m², representing a somewhat overweight population. In the context of chronic conditions, 66.4% of the participants had evidence of hypertension, 15.2% had diabetes, 16.1% had heart diseases, 8.5% had COPD, and 42.4% had arthritis.

Participants with evidence of PAD were older, tended to be current smokers, and had higher levels of CRP, lower leg force, lower habitual gait speed, as well as a higher prevalence of hypertension, diabetes mellitus, and functional dependence compared to those without PAD. There was no difference in total cholesterol levels, alcohol intake, or comorbidities such as COPD or arthritis.

PAD and Functional Dependence
PAD was associated with multiple domains of functional dependence in older adults. After controlling for Model 1 covariates, PAD was associated with functional dependence in IADL, LSA, and LEM. The ORs for functional dependence in IADL, LSA, and LEM comparing participants with PAD to those without were 1.60 (95% confidence interval [CI], 1.11–2.29), 1.63 (95% CI, 1.08–2.44), and 2.29 (95% CI, 1.64–3.18), respectively (Table 2). Peak leg force, habitual gait speed, or both were subsequently introduced as covariates from Model 2 to Model 4. For outcomes in IADL and LSA, the sizes of ORs decreased and the statistical significance diminished, suggesting that the associations between PAD and functional dependence in IADL and LSA could be explained by peak leg force and habitual
Table 1. Population Characteristics by Status of Peripheral Arterial Disease (PAD)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Prevalent PAD (N = 206)</th>
<th>No PAD (N = 1592)</th>
<th>Total (N = 1798)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous variables*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>74.2 (7.6)</td>
<td>74.6 (7.3)</td>
<td>70.3 (7.5)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>27.0 (4.7)</td>
<td>28.0 (4.8)</td>
<td>27.8 (4.8)</td>
<td>.007</td>
</tr>
<tr>
<td>Peak leg force, Newtons</td>
<td>277 (90)</td>
<td>331 (111)</td>
<td>325 (110)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Habitual gait speed, m/s</td>
<td>0.869 (0.245)</td>
<td>0.994 (0.233)</td>
<td>0.980 (0.238)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>C-reactive protein, mg/dL</td>
<td>0.33 (0.49)</td>
<td>0.26 (0.40)</td>
<td>0.27 (0.40)</td>
<td>.001</td>
</tr>
<tr>
<td>Total cholesterol, mg/dL</td>
<td>211 (45)</td>
<td>212 (50)</td>
<td>212 (50)</td>
<td>.836</td>
</tr>
<tr>
<td>Categorical variables†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>103 (50.0)</td>
<td>773 (48.6)</td>
<td>876 (48.7)</td>
<td>.696</td>
</tr>
<tr>
<td>Education level</td>
<td>58 (28.2)</td>
<td>612 (38.4)</td>
<td>670 (37.3)</td>
<td>.021</td>
</tr>
<tr>
<td>Current smoker</td>
<td>48 (23.3)</td>
<td>188 (11.8)</td>
<td>236 (13.1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Alcohol intake ≥12 drinks/y</td>
<td>129 (62.6)</td>
<td>997 (62.6)</td>
<td>1126 (62.6)</td>
<td>.348</td>
</tr>
<tr>
<td>Hypertension</td>
<td>159 (77.2)</td>
<td>1035 (65.0)</td>
<td>1194 (66.4)</td>
<td>.001</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>45 (21.8)</td>
<td>229 (14.4)</td>
<td>274 (15.2)</td>
<td>.005</td>
</tr>
<tr>
<td>Heart diseases</td>
<td>43 (20.9)</td>
<td>247 (15.5)</td>
<td>290 (16.1)</td>
<td>.049</td>
</tr>
<tr>
<td>COPD</td>
<td>21 (10.2)</td>
<td>132 (8.3)</td>
<td>153 (8.5)</td>
<td>.357</td>
</tr>
<tr>
<td>Arthritis</td>
<td>90 (43.7)</td>
<td>672 (42.2)</td>
<td>762 (42.4)</td>
<td>.814</td>
</tr>
<tr>
<td>Self-reported functional dependence‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activities of daily living</td>
<td>43 (20.9)</td>
<td>233 (14.6)</td>
<td>276 (15.4)</td>
<td>.019</td>
</tr>
<tr>
<td>Instrumental activities of daily living</td>
<td>62 (30.1)</td>
<td>282 (17.7)</td>
<td>344 (19.1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Leisure and social activities</td>
<td>44 (21.4)</td>
<td>192 (12.1)</td>
<td>236 (13.1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Lower extremity mobility</td>
<td>98 (47.6)</td>
<td>407 (25.6)</td>
<td>505 (28.1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>General physical activities</td>
<td>133 (64.6)</td>
<td>827 (52.0)</td>
<td>960 (53.4)</td>
<td>.001</td>
</tr>
</tbody>
</table>

Notes: *Values in the continuous variables were expressed as mean (standard deviation) unless otherwise specified.
†Values were expressed as median (interquartile range) due to right skewness.
‡Values in the categorical variables were expressed as number (percent).
§Dependence in a specific functional domain was defined if a person reported any difficulty in one or more activities in a given domain.
ABPI = ankle–brachial blood pressure index; BMI = body mass index; COPD = chronic obstructive pulmonary disease.

We further categorized study participants into three groups based on ABPI, namely ABPI <0.75 (91 participants), ABPI 0.75 to <0.9 (115 participants), and ABPI 0.9–1.5 (1592 participants), to examine the association between ABPI and functional dependence. There were inverse, dose-dependent relationships between ABPI and functional dependence in IADL, LEM, and LSA (Figure 1).

gait speed. Additional adjustment of peak leg force and habitual gait speed mildly attenuated the association between PAD and LEM dependence. PAD still remained a significant correlate for LEM independent of both peak leg force and habitual gait speed (OR 2.03; 95% CI, 1.43–2.88).

Table 2. Logistic Regression Models Testing the Association Between Peripheral Arterial Disease and Functional Dependence

<table>
<thead>
<tr>
<th>Functional Dependence</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR* (95% CI)</td>
<td>p Value</td>
<td>OR* (95% CI)</td>
<td>p Value</td>
</tr>
<tr>
<td>ADL</td>
<td>1.36 (0.91–2.01)</td>
<td>.131</td>
<td>1.26 (0.85–1.88)</td>
<td>.257</td>
</tr>
<tr>
<td>IADL</td>
<td>1.60 (1.11–2.29)</td>
<td>.011</td>
<td>1.48 (1.03–2.13)</td>
<td>.034</td>
</tr>
<tr>
<td>LSA</td>
<td>1.63 (1.08–2.44)</td>
<td>.019</td>
<td>1.49 (0.99–2.25)</td>
<td>.057</td>
</tr>
<tr>
<td>LEM</td>
<td>2.29 (1.64–3.18)</td>
<td>&lt;.001</td>
<td>2.11 (1.51–2.96)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>GPA</td>
<td>1.38 (0.99–1.94)</td>
<td>.060</td>
<td>1.29 (0.92–1.81)</td>
<td>.146</td>
</tr>
</tbody>
</table>

Notes: Functional dependence was categorized into five major domains based on abilities to perform the following activities: (1) activities of daily living (ADL, e.g., eating, walking, dressing, and getting out of bed), (2) instrumental activities of daily living (IADL, e.g., managing money, housekeeping, and food preparation), (3) leisure and social activities (LSA, e.g., reading, watching TV, going out to movies, visiting friends, attending clubs or meetings), (4) lower extremity mobility (LEM, e.g., walking for one-quarter mile, walking up 10 steps), and (5) general physical activities (GPA, e.g., stooping, bending, standing, sitting, lifting, reaching, grasping). Dependence in a specific functional domain was defined if a person reported any difficulty in one or more activities in a given domain. Adjusted covariates: Model 1 = age, sex, race, body mass index categories, educational level, health perception, health behaviors (smoking status and alcohol consumption), chronic diseases (hypertension, diabetes, heart disease, chronic obstructive pulmonary disease, and arthritis), and natural-log-transformed total cholesterol and C-reactive protein levels. Model 2 = Model 1 + peak leg force. Model 3 = Model 1 + habitual gait speed. Model 4 = Model 1 + peak leg force + habitual gait speed.

*OR indicates functional dependence comparing participants with peripheral arterial disease (ankle–brachial blood pressure index [ABPI] < 0.9) to those without (ABPI 0.9–1.5).

OR = odds ratio; CI = confidence interval.
Compared with participants with ABPI ranging from 0.9 to 1.5, those with ABPI ≤0.75 had 2.67-fold odds of being dependent in LEM and 2-fold odds of being dependent in IADL and LSA.

**PAD and Performance-Based Physical Measures**

PAD was inversely related to peak leg force and habitual gait speed. After controlling for Model 1 covariates, there were a 18.06 Newton reduction \((p = .003)\) in peak leg force and a 0.050 m/s reduction \((p = .002)\) in habitual gait speed, respectively, comparing participants with PAD to those without (Table 3). Additional adjustment for peak leg force mildly diminished the association between PAD and habitual gait speed. PAD still remained a strong indicator for slow gait speed in the fully adjusted model \((\beta = -0.038; p = .016)\).

We also calculated the adjusted means of peak leg force and habitual gait speed based on different categories of ABPI. There were positive associations between ABPI and magnitudes of peak leg force and habitual gait speed (Figure 2). The trends between increasing ABPI categories and performance-based measures were strongly significant \((p \text{ for trend} .001 \text{ for peak leg force and habitual gait speed})\).

**DISCUSSION**

Among the U.S. noninstitutionalized older adults, PAD was associated with dependence in IADL, LSA, and LEM. In addition, participants with PAD tended to have poorer peak leg force and habitual gait speed, compared to those without. Moreover, our results suggested that the association between PAD and functional dependence in IADL and LSA, to a large extent, can be explained by peak leg force and walking speed.

**Table 3. Relation of Peripheral Arterial Disease to Performance-Based Physical Measures**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(\beta^* (SE))</th>
<th>(p) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak leg force</td>
<td>-18.06 (5.98)</td>
<td>.003</td>
</tr>
<tr>
<td>Habitual gait speed</td>
<td>-0.050 (0.016)</td>
<td>.002</td>
</tr>
<tr>
<td>Habitual gait speed, controlling for peak leg force</td>
<td>-0.038 (0.016)</td>
<td>.016</td>
</tr>
</tbody>
</table>

Notes: All models were adjusted for age, sex, race, body mass index categories, educational level, health perception, health behaviors (smoking status and alcohol consumption), and chronic diseases (hypertension, diabetes, heart disease, chronic obstructive pulmonary disease, and arthritis), and natural-log-transformed total cholesterol and C-reactive protein.

*Coefficients (\(\beta\)) can be interpreted as differences in mean knee extensor power or gait speed comparing participants with peripheral arterial disease (ankle–brachial blood pressure index \([\text{ABPI}]\) < 0.9) to those without (ABPI 0.9–1.5).

Our findings support and extend previous studies examining the functional implications of PAD. Low ABPI levels were cross-sectionally associated with poorer low-extremity performance and less physical activity (7,20). By
analyzing a group of disabled women, the Women’s Health and Aging Study (WHAS) investigators suggested that lower ABPI levels were cross-sectionally associated with lower, but not upper, extremity functioning (6). Similarly, the Italian population-based InCHIANTI Study demonstrated that PAD was associated with a poorer low-extremity functioning and that leg power mediated the association (21). McDermott and colleagues (10) further followed the WHAS cohort for 3 years and found that a low ABPI was associated with a greater incidence of severe disability in walking-specific functional outcomes compared with a normal ABPI. In another prospective study of 676 older individuals consecutively identified from three Chicago area medical centers, researchers demonstrated that lower baseline ABPI values were associated with greater mean annual decline in the 6-minute walk distance (11). However, these studies have weaknesses in terms of external validity because the study participants were limited either to disabled older women (6,10) or to hospital-based patients (7,11,20). Moreover, the role of performance-based physical function in the association between PAD and functional dependence was not examined (6,7,10,20). Although the cross-sectional InCHIANTI Study seemed to avoid these problems (21), the outcome was limited to low-extremity functioning while performance status such as ADL, IADL, or LSA was not explored. Our study has the advantage of analyzing outcomes beyond traditional measures of low-extremity functioning using a national population-based sample. Additionally, the roles of gait speed and leg force in the relationship between PAD and functional dependence were elucidated.

The finding that PAD is associated with IADL dependence but not with dependence in ADL or GPA after multivariate adjustment is of interest. Generally speaking, IADL and LSA are activities associated with cognitive function. The relationship of PAD to IADL and LSA may be explained by cerebrovascular changes (such as small stroke, leukoaraiosis, or carotid atherosclerosis) related to cognitive function, but not available in the NHANES data. In contrast, the lack of association between PAD and dependence in ADL and GPA, to a large extent, may be due to the limitations of the questionnaire because only a small number of questions in ADL and GPA are directly related to low extremity functioning. Moreover, it would seem that leg force and gait speed may be more directly relevant to LEM dependence, and the finding that adjustment for peak leg force and/or habitual gait speed diminished the relationship of PAD to IADL/LSA dependence but not to LEM dependence is of concern. Both leg force and gait speed seem explain the association between PAD and IADL/LSA dependence. The observed association between PAD and LEM dependence may be due to such unmeasured confounders as lean muscle mass and cross-sectional muscle area, both of which were not measured in the NHANES.

Our study has potential limitations deserving comment. First, due to the cross-sectional design, a prospective relationship between PAD and functional dependence can not be established. The relationship should be studied prospectively. Second, although the data were drawn from a national population-based sample, 51% of the participants (of 3703 participants who finished the Physical Functioning Questionnaire) were excluded for missing values in the muscle strength examination, ABPI measurement, or laboratory test because of any administrative, technical, physical, or safety reasons, thus limiting the analytic sample to 1798 participants >60 years with complete variable information. Therefore, our results were not generalizable to the entire U.S. elderly population.

Conclusion
Peripheral arterial disease was associated with multiple domains of functional dependence in older adults. PAD was adversely associated with peak leg force and habitual gait speed. In addition to being a surrogate of generalized atherosclerotic change, a low ABPI may be useful in identifying older adults who may require intervention to prevent physical impairment and functional dependence.

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