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Claudication distances and the Walking Impairment Questionnaire best describe the ambulatory limitations in patients with symptomatic peripheral arterial disease

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Background: **Claudication secondary to peripheral arterial disease leads to reduced mobility, limited physical functioning, and poor health outcomes. Disease severity can be assessed with quantitative clinical methods and qualitative self-perceived measures of quality of life. Limited data exist to document the degree to which quantitative and qualitative measures correlate. The current study provides data on the relationship between quantitative and qualitative measures of symptomatic peripheral arterial disease.**

Method: **This descriptive case series was set in an academic vascular surgery unit and biomechanics laboratory. The subjects were symptomatic patients with peripheral arterial disease patients presenting with claudication. The quantitative evaluation outcome measures included measurement of ankle-brachial index, initial claudication distance, absolute claudication distance, and self-selected treadmill pace. Qualitative measurements included the Walking Impairment Questionnaire (WIQ) and the Medical Outcomes Study Short Form-36 (SF-36) Health Survey. Spearman rank correlations were performed to determine the relationship between each quantitative and qualitative measure and also between the WIQ and SF-36.**

Results: **Included were 48 patients (age, 62 ± 9.6 years; weight, 83.0 ± 15.4 kg) with claudication (ABI, 0.50 ± 0.20). Of the four WIQ subscales, the ankle-brachial index correlated with distance (r = 0.29) and speed (r = 0.32); and initial claudication distance and absolute claudication distance correlated with pain (r = 0.40 and 0.43, respectively), distance (r = 0.35 and 0.41, respectively), and speed (r = 0.39 and 0.39 respectively). Of the eight SF-36 subscales, no correlation was found for the ankle-brachial index, initial claudication distance correlated with Bodily Pain (r = 0.46) and Social Functioning (r = 0.30), and absolute claudication time correlated with Physical Function (r = 0.31) and Energy (r = 0.30). The results of both questionnaires showed reduced functional status in claudicating patients.**

Conclusions: **Initial and absolute claudication distances and WIQ pain, speed, and distance subscales are the measures that correlated the best with the ambulatory limitation of patients with symptomatic peripheral arterial disease. These results suggest the WIQ is the most specific questionnaire for documenting the qualitative deficits of the patient with claudication while providing strong relationships with the quantitative measures of arterial disease. Future studies of claudication patients should include both quantitative and qualitative assessments to adequately assess disease severity and functional status in peripheral arterial disease patients. (J Vasc Surg 2008;47:550-5.)**

Peripheral arterial disease (PAD) affects approximately 8 to 12 million people in the United States.[1] In addition to its association with increased cardiovascular morbidity and mortality, PAD leads to reduced mobility, reduced physical functioning, and poor health outcomes.[1-3] Disease severity and functional status of PAD patients can be assessed using quantitative clinical measures, such as ankle-brachial index (ABI) and claudication distances, and qualitative, self-perceived measures of quality of life (QOL). Despite a wealth of studies documenting either quantitative or qualitative measures in patients with PAD, few studies have documented the degree to which quantitative and qualitative measures correlate. Conflicting data exist, with several studies demonstrating significant correlations[4-8] whereas others show minimal if any correlation.[9,10]

What is clear is an absence of standardization in studies evaluating PAD patients, evidenced by a variety of reported quantitative test protocols and similar variation of qualitative questionnaires. This lack of standardization makes it difficult for physicians to choose the most appropriate measures to evaluate patients, determine indications for treatment, and consistently document and report treatment outcomes. The purpose of this study was to determine the relationship between the most commonly used

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quantitative variables and the currently recommended self-reported qualitative measures of physical function in PAD patients. We also examined the correlation between the two qualitative measures most commonly used in PAD.

METHODS

Peripheral arterial disease subjects. The study comprised of 48 symptomatic PAD patients diagnosed with moderate arterial occlusive disease who experienced claudication in at least one leg. Patients were recruited from the vascular surgery clinics of the Nebraska and Western Iowa Veterans Affairs Medical Center and the University of Nebraska Medical Center. All study patients were symptomatic and had been seen for initial evaluation of their PAD with no prior treatment.

Patients were specifically evaluated and screened by two vascular surgeons. This included a detailed history, physical examination, and a direct assessment/observation of the patient's walking impairment. A vascular surgeon observed the patient walking and recorded all symptoms and signs affecting ambulation, ensuring that ambulatory limitation was secondary to vasculogenic claudication. Excluded were those patients with ambulation-limiting cardiac, pulmonary, neuromuscular, or musculoskeletal disease or those who experienced any pain or discomfort (even mild) during walking for any reason other than claudication, such as arthritis, low back pain, musculoskeletal problems, and neuropathy.

The presence and extent of disease was documented with standard lower extremity noninvasive evaluation that included measurement of ABI, femoropopliteal and tibial duplex ultrasound imaging, and evaluation of Doppler waveforms at the femoral, popliteal, and pedal levels. In selected patients this was supplemented by computed tomography (CT), magnetic resonance imaging (MRI), or invasive angiography. The level of disease was established by the vascular surgeon after review of all available studies.

The study was approved by the Institutional Review Boards of the Nebraska/Western Iowa VA Medical Center and the University of Nebraska Medical Center. Written informed consent was obtained from all subjects before data collection.

Quantitative measures

Ankle-brachial index. The ABI values obtained during the patient's evaluation were used for the correlations. The highest ABI value from the most symptomatic leg was reported as the ABI for each subject.

Claudication distance. To determine the initial and absolute claudication distances, patients walked on a treadmill at 0.67 m/s (1.5 mph) and 10% grade.[11] The first indication of claudication pain was recorded as initial claudication distance, and the total distance the patients could walk on the treadmill before stopping because of pain was the absolute claudication distance.[12] During the test, the technician asked the patient to confirm the presence or absence of pain to ensure the correct initial claudication distance was recorded.

Self-selected speed. Subjects were given ample time to familiarize themselves with walking on the treadmill before beginning the test.[13] To determine self-selected speed, subjects walked on the treadmill at 1.61 km/h (1.0 mph) and were asked to adjust the speed up or down until it matched their typical pace. Before walking on the treadmill, the subjects were shown how to adjust the speed. Subjects were encouraged to choose the speed in a timely manner (≤10-20 seconds) to avoid the onset of claudication while determining the preferred pace. This has been shown to be enough time to attain a steady state for knee kinematics and most spatial-temporal variables on a treadmill.[14] The determination of the self-selected treadmill pace was conducted as a separate test before the onset of any claudication.

Qualitative measures

Physical function and health-related QOL were assessed using the Walking Impairment Questionnaire (WIQ)[15] and the Medical Outcomes Study Short Form 36 (SF-36) Health Survey.[16-18]

Walking Impairment Questionnaire. The WIQ is a disease-specific questionnaire validated in patients with intermittent claudication.[4] It consists of four subcategories: pain, distance, walking speed, and stair climbing.

Short Form 36. Eight health domains are assessed with the SF-36: Physical Function, limitation due to Physical Health, limitation due to Emotional Problems, Energy, Mental Health, Bodily Pain, General Health, and Social Function. The SF-36 has been extensively evaluated and tested with a variety of populations and is able to distinguish between groups of varying health status.[16,19]

The WIQ and SF-36 both use a scale from 0 to 100, with a score of 0 representing the low score and 100 being the high score. Specific descriptions of each subscale can be found in the Appendix (online only). In the beginning of our study, the SF-36 forms given to both PAD patients and controls were missing the questions for the Limitations-Physical and Limitations-Emotional domains. This was corrected after more than half of all subjects were recruited in the study.

Control subjects. The study recruited 25 healthy controls matched for age, height, and weight. Controls had an ABI >0.9 and absence of subjective or objective ambulatory dysfunction. Similar to PAD patients, control subjects were excluded for the same ambulation-limiting conditions. Control patients did not undergo treadmill testing for the determination of claudication distances or self-selected speed, but they did have a lower extremity noninvasive evaluation to document the absence of appreciable occlusive disease. They also completed the WIQ and SF-36.

Statistical analysis. Scores for ABI, initial claudication distance, absolute claudication distance, self-selected walking speed, and the subscores of the WIQ and SF-36 were ranked for each subject. Spearman rank correlations were performed between ABI, initial claudication distance, absolute claudication distance, self-selected walking pace, and each subscore of the questionnaires. In addition, rank

Table 1. Averaged demographics and functional clinical measurements for peripheral arterial disease patients

Demographic characteristic[a]	*Control*	*PAD*	P
Age, years	61.5 ± 12.0	62.1 ± 9.61	.834
Height, cm	174.2 ± 7.7	169.8 ± 16.2	.200
Weight, kg	84.0 ± 22.1	83.0 ± 15.4	.831
Ankle-brachial index	1.1 ± .1	0.50 ± 0.20	<.001
Aortoiliac disease, %	NA	19.6	NA
Fem-pop disease, %	NA	28.3	NA
Tibial disease, %	NA	0	NA
Aortoiliac, fem-pop, tibial disease combined, %	NA	52.1	NA
Claudication distance, m			
Absolute	NA	181.72 ± 122.31	NA
Initial	NA	47.61 ± 22.79	NA
Self-selected treadmill speed, km/h	2.28 ± .53	2.47 ± .58	<.001

NA, Not applicable; *PAD,* peripheral arterial disease.
[a]Continuous data are reported as the mean ± standard deviation.

Table II. Averaged scores for each component of the Medical Outcomes Survey Short Form 36 Health Survey and the Walking Impairment Questionnaire for peripheral arterial disease patients and controls[a]

Questionnaire scale	*PAD patients*	*Patients, no.*	*Controls*	*Controls, no.*	P[b]
SF-36					
Physical Function	41.5 ± 20.1	48	95.3 ± 6.2	25	<.001
Limitations-Physical	33.3 ± 44.0	16[c]	95.8 ± 14.4	12[c]	<.001
Limitations-Emotional	71.1 ± 45.2	16[c]	97.2 ± 9.6	12[c]	.061
Bodily Pain	46.1 ± 27.6	48	75.0 ± 12.5	25	<.001
Energy	51.1 ± 20.0	48	85.0 ± 12.0	25	.022
Social Functioning	75.5 ± 25.0	48	93.3 ± 10.0	25	<.001
Mental Health	75.3 ± 18.8	48	94.1 ± 12.5	25	.001
General Health	53.8 ± 21.1	48	81.1 ± 14.2	25	<.001
WIQ					
Pain	52.6 ± 23.6	48	99.5 ± 2.5	25	<.001
Distance	55.0 ± 42.3	48	99.8 ± 0.6	25	<.001
Speed	48.3 ± 30.4	48	96.8 ± 6.6	25	<.001
Stairs	56.5 ± 47.1	48	98.1 ± 4.6	25	<.001

PAD, peripheral arterial disease; *SF-36,* Medical Outcomes Survey Short Form 36 Health Survey; *WIQ,* Walking Impairment Questionnaire.
[a]Significance levels are reported for *t* tests between patients with peripheral arterial disease and controls; significance level was $P < .05$. Continuous data are reported as mean ± SD.
[b]Significance level was $P < .05$.
[c]The questions for these subscales were missing from the SF-36 forms at the beginning of the study. This was corrected after more than half of all subjects were recruited in the study.

correlations were calculated between the WIQ and SF-36. If questions were not answered on the WIQ or SF-36, the patient was excluded from the specific subscale analysis. All analyses were performed using SPSS 14 statistical software (SPSS Inc, Chicago, Ill) and tested at $P < .05$.

RESULTS

Demographic characteristics and results of the quantitative clinical tests are summarized in Table I, and the mean scores for each subscale of the SF-36 and the WIQ are listed in Table II. Findings from noninvasive lower extremity testing supplemented by data from CT, MRI, or invasive angiography revealed that 52.1% of the patients had multilevel disease consisting of a combination of aortoiliac, femoropopliteal, and tibial levels of occlusive disease (Table I). The remaining patients had single level disease, of which 19.6% had aortoiliac occlusive disease, 28.3% had femoropopliteal disease, and no patients had solely tibial occlusive disease. No significant relationship was found between occlusive disease levels and SF-36 and WIQ measures ($P > .05$).

Three of the four quantitative measures had significant correlations with one or more of the questionnaire subscales (Tables II and III). The ABI had significant correlations with the distance and speed components of the WIQ but did not correlate with any of the SF-36 domains or with any of the claudication distances. Initial claudication distance and absolute claudication distance had significant correlations with several WIQ and SF-36 subscales. More specifically, initial claudication distance and absolute claudication distance both had significant correlations with the pain, distance, and speed subscales of the WIQ. In addition, absolute claudication distance correlated with Physical Function and Energy, and initial claudication distance correlated with Bodily Pain and Social Functioning domains of the SF-36.

Table III. Correlation matrix between quantitative clinical measures and the qualitative self-perceived measures of functional status

		Quantitative measure			
Qualitative measure	*Patients, no.*	*ABI*	*Absolute claudication distance*	*Initial claudication distance*	*SS pace*
SF-36					
Physical Function	48	0.26	0.31[a]	0.23	0.01
Limitations-Physical	16[b]	−0.01	0.38	0.15	−0.15
Limitations-Emotional	16[b]	0.10	0.26	0.24	−0.05
Bodily Pain	48	0.13	0.26	0.46[a]	0.07
Vitality	48	0.10	0.30[a]	0.26	0.06
Social Functioning	48	0.07	0.28	0.30[a]	−0.10
General Mental Health	48	0.05	0.21	0.24	0.02
General Health	48	0.08	0.09	0.01	0.13
WIQ					
Pain	48	0.01	0.43[a]	0.40[a]	−0.07
Distance	48	0.29[a]	0.41[a]	0.35[a]	0.01
Speed	48	0.32[a]	0.39[a]	0.39[a]	0.08
Stairs	48	0.11	0.21	0.19	0.05

SF-36, Medical Outcomes Survey Short Form 36 Health Survey; *SS,* self-selected pace; *WIQ*, Walking Impairment Questionnaire.
[a]Significant correlations ($P < .05$).
[b]The questions for these subscales were missing from the SF-36 forms at the beginning of the study. This was corrected after more than half of the subjects were enrolled.

Table IV. Correlation matrix between the Medical Outcomes Survey Short Form 36 Health Survey and the Walking Impairment Questionnaire subscales

		Walking impairment questionnaire			
SF-36	*Patients, no.*	*Pain*	*Distance*	*Speed*	*Stairs*
Physical Function	48	0.36[a]	0.47[a]	0.42[a]	0.51[a]
Limitations-Physical	16[b]	0.19	0.36	0.33	0.41
Limitations-Emotional	16[b]	0.57[a]	0.28	0.31	0.64[a]
Bodily Pain	48	0.34[a]	0.44[a]	0.53[a]	0.48[a]
Energy	48	0.54[a]	0.65[a]	0.52[a]	0.60[a]
Social Functioning	48	0.43[a]	0.45[a]	0.40[a]	0.38[a]
General Mental Health	48	0.36[a]	0.42[a]	0.40[a]	0.27[a]
General Health	48	0.42[a]	0.30[a]	0.24	0.32[a]

SF-36, Medical Outcome Study Short Form 36 Health Survey.
[a]Significant correlations ($P < .05$).
[b]The questions for these subscales were missing from the SF-36 forms at the beginning of the study. This was corrected after more than half of all subjects were recruited in the study.

Of all correlations, those between claudication distances (initial and absolute) and the WIQ pain, distance, and speed components were the strongest. Weaker were the correlations between claudication distances and SF-36 domains, and the weakest correlation was noted between the ABI and the WIQ subscales. Self-selected pace had no significant correlations with any of the questionnaires' subscales.

The correlation coefficients between the questionnaire subscales indicated that many subscales from the questionnaires had significant correlations (Table IV). The WIQ pain, distance, speed, and stair components were each correlated with six or more domains of the SF-36. Both the WIQ and the SF-36 results indicated reduced functional status in PAD patients compared with healthy controls (Table II). Compared with controls, PAD patients exhibited significantly ($P < .5$) lower scores for all four subscales of the WIQ and for seven of the SF-36 domains, with the eighth domain approaching significance ($P = .061$).

DISCUSSION

Our study demonstrates that initial and absolute claudication distances are the quantitative tests with the highest and most consistent correlation with qualitative measures. Furthermore, the WIQ is the qualitative measure that best reflects actual ambulatory performance of the PAD patients. More specifically, pain, distance, and speed (with the pain subscale being the strongest) appear to be the WIQ subscales that more thoroughly describe the ambulation-related limitations of PAD patients. When we compared quantitative clinical measures with questionnaire subscale scores, we found 12 of 48 comparisons (25.0%) were significantly related. Of the quantitative measures, the absolute claudication distance and initial claudication distance were related with the largest number of subscales of the questionnaires. The pain, distance, and speed components of the WIQ all correlated with both the absolute and initial claudication distances. Our finding is in agreement with previous work on WIQ validation[5] and suggests that either test (absolute and initial claudication distances) could be used as a quantitative measure of physical function.

The ABI correlated significantly with two WIQ subscales, again indicating the WIQ may be the most specific questionnaire to capture both the physiologic (reflected by ABI) and quantitative ambulatory dysfunction (reflected by claudication distances) associated with PAD and claudication. Different domains of SF-36 demonstrated correlation with the quantitative measures, but unlike WIQ subscales, no single SF-36 subscale consistently related with them, again suggesting that the SF-36 (as a general QOL measure) is less suitable than WIQ in fully describing the ambulatory limitation of claudicant patients.

In contrast with claudication distances, self-selected speed did not correlate with any qualitative measures. Our data demonstrated that self-selected pace exhibited no significant correlation with the WIQ or SF-36 scores. Therefore, our results suggested that self-selected walking pace itself is not a predictor of QOL in patients with symptomatic claudication.

Previous studies have compared different quantitative measures with self-reported QOL measures, and our results strengthen and add to their findings. Izquierdo-Porrera et al[6] calculated Pearson correlations between the ABI, time to maximal claudication, and distance walked in 6 minutes with all domains of the SF-36 and with the distance, stair, and speed components of the WIQ (the WIQ pain subscale was not included in their study). Of the 36 associations evaluated, 18 were found to be significant.

A study by Regensteiner et al[5] related maximal walking time and time to onset of claudication with individual questions from the WIQ in 26 PAD patients. A total of 22 comparisons were made and 10 were significant. McDermott et al[20] performed linear regression analysis between ABI category (0.9 to $<$1.5, 0.4 to $<$0.9, and $<$0.4) and subscales of the WIQ and SF-36 in 158 PAD patients with a variety of leg symptoms. Results of the regression analyses between ABI and WIQ found that ABI was a predictor of walking distance and speed when the PAD group was evaluated in its entirety. However, when the effect of leg symptoms, comorbidities, and previous revascularization were removed, ABI only predicted walking distance. For the analyses with SF-36 domains, ABI was not independently associated when controlling for leg symptoms and comorbid diseases.

These results are consistent with our findings showing that the WIQ more appropriately describes problems caused by flow limitations than the SF-36, which is a more general measure of QOL. McDermott et al[20] also pointed out that ABI is less predictive of leg function in patients with claudication (similar to our study population) compared with PAD patients with varying leg symptoms, including asymptomatic, claudication, and rest pain. This is consonant with our finding that claudication distances are more related with QOL than ABI values.

Our study is also in agreement with prior work demonstrating PAD patients have reduced QOL[1,6] and that this QOL deterioration is similarly reflected in both WIQ and SF-36 scores. When relating the SF-36 and the WIQ, 26 of the 32 comparisons (81.3%) were significantly related. Our results are in accordance with those of Izquierdo-Porrera et al,[6] which demonstrated significant correlations between 22 of the 24 comparisons between WIQ and SF-36.

Although the SF-36 is a generic measure of health-related QOL and the WIQ is a disease-specific measure, the significant correlations in $>$80% of the comparisons between them shows that both questionnaires can be useful in providing information about the QOL of PAD patients. In the absence of SF-36 data, WIQ can adequately reflect an overall drop in QOL in claudicant patients.

Our study is unique because careful screening was used to exclude patients with any gait dysfunction—even mild ones—other than claudication. Because of this strict exclusion criterion, our data accurately reflect that the ambulatory and QOL limitation are due solely to claudication. Our results, however, may not be reflective of the overall PAD population because claudicant patients frequently have comorbidities, such as osteoarthritis, neurogenic claudication, and peripheral neuropathy, that affect walking in varying degrees.[21-23]

CONCLUSION

Our data demonstrated that absolute and initial claudication distances, and WIQ pain, speed, and distance subscales are the measures with the best ability to describe the ambulatory limitation of claudicant patients and also closely relate to their QOL. It is our opinion that future claudication research should include, at a minimum, both quantitative and qualitative measures consisting of claudication distances and WIQ scores. These complementary measures are essential and requisite tools to adequately characterize and determine the degree of a PAD patient's impairment.

AUTHOR CONTRIBUTIONS

Conception and design: JM, NS, IP
Analysis and interpretation: SM, JM, NS, IP
Data collection: SM, JM, TL, GL, IP
Writing the article: SM
Critical revision of the article: SM, JM, NS, TL, GL, IP
Final approval of the article: SM, JM, NS, TL, GL, IP
Statistical analysis: SM
Obtained funding: JM, NS, IP
Overall responsibility: IP

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APPENDIX (online only). Description of the scales from the Medical Outcomes Study Short Form 36 (SF-36) Health Survey and the Walking Impairment Questionnaire (WIQ). For the SF-36, a low score of represents significant limitations and problems in the particular scale, and a score of 100 means no problems or limitations for that scale. The WIQ scales each range from 0 to 100, with 0 meaning inability to complete the specific task and 100 representing no difficulty in completing the task

Questionnaire subscale	*Description of scale concepts*
SF-36	
Physical functioning	Represents levels and types of limitations in performing physical activities
Limitations due to physical problems	Defines role limitations because of physical health problems
Limitations due to emotional problems	Defines role limitations because of personal and emotional health problems
Bodily pain	Represents frequency of pain and the extent that pain interferes with normal activities
Vitality	Summarizes energy level and fatigue
Social functioning	Assesses the impact of physical health problems on social activities
General mental health	Summarizes mental health by assessing anxiety, depression, loss of control and psychological well-being
General health	Overall assessment of health perceptions
WIQ	
Pain	Describes amount of difficulty with walking due to pain in lower extremities
Distance	Expresses amount of difficulty to walk specific distances, ranging from less than 50 feet to 1500 feet
Speed	Describes amount of difficulty to cover 1 block at different speeds, from walking slowly to a run or jog
Stairs	Assesses difficulty to climb 1, 2, and 3 flights of stairs