Research Paper

JRSM Cardiovascular Disease
Volume 8: 1–9

DOI: 10.1177/2048004019841971
journals.sagepub.com/home/cvd
SAGE

Low Walking Impairment Questionnaire score after a recent myocardial infarction identifies patients with polyvascular disease

Birgitta Jönelid[1], Björn Kragsterman[2], Lars Berglund[3], Bertil Andrén[4], Nina Johnston[1], Bertil Lindahl[1,3], Jonas Oldgren[1,3] and Christina Christersson[1]

Abstract

Objectives: To evaluate whether the Walking Impairment Questionnaire score could identify patients with polyvascular disease in a population with recent myocardial infarction and their association with cardiovascular events during two-year follow-up.

Design: A prospective observational study.

Setting: Patients admitted to the acute coronary care unit, the Department of Cardiology, Uppsala University Hospital.

Participants: Patients admitted with acute Non-STEMI- or STEMI-elevation myocardial infarction.

Main outcome measures: The Walking Impairment Questionnaire, developed as a self-administered instrument to assess *walking distance*, *speed*, and *stair climbing* in patients with peripheral artery disease, predicts future cardiovascular events and mortality. Two hundred and sixty-three patients with recent myocardial infarction answered Walking Impairment Questionnaire. Polyvascular disease was defined as abnormal findings in the coronary- and carotid arteries and an abnormal ankle–brachial index. The calculated score for each of all three categories were divided into quartiles with the lowest score in first quartile.

Results: The lowest (worst) quartile in all three Walking Impairment Questionnaire categories was associated with polyvascular disease, fully adjusted; *distance*, odds ratio (OR) 5.4 (95% confidence interval (CI) 1.8–16.1); *speed*, OR 7.4 (95% CI 1.5–36.5); *stair climbing*, OR 8.4 (95% CI 1.0–73.6). In *stair climbing score*, patients with the lowest (worst) score had a higher risk for the composite cardiovascular endpoint compared to the highest (best) score; hazard ratio 5.3 (95% CI 1.5–19.0). The adherence to medical treatment was high (between 81.7% and 99.2%).

Conclusions: The Walking Impairment Questionnaire is a simple tool to identify myocardial infarction patients with more widespread atherosclerotic disease and although well treated medically, stair climbing predicts cardiovascular events.

Keywords

Peripheral vascular disease, cardiovascular disease, coronary artery disease, polyvascular disease

Received 22 February 2018; Revised received 7 March 2019; accepted 12 March 2019

Introduction

Atherosclerosis is a systemic disease that often affects arteries in more than one location. Polyvascular disease (PvD) (i.e. at least two major affected arterial beds), or multisite artery disease as referred to in recent guidelines[1,2] is associated with an increased risk for cardiovascular (CV) events, both short and long term.[3] PvD has been associated with an adverse prognosis also in

[1]Department of Medical Sciences, Cardiology, Uppsala University, Uppsala, Sweden
[2]Department of Surgical Sciences, Vascular Surgery, Uppsala University, Uppsala, Sweden
[3]Uppsala Clinical Research Center, Uppsala University, Uppsala, Sweden
[4]Department of Medical Sciences, Clinical Physiology, Uppsala University, Uppsala, Sweden

Corresponding author:
Birgitta Jönelid, Department of Medical Sciences, Cardiology, Uppsala University, SE 75185 Uppsala, Sweden.
Email: birgitta.jonelid@medsci.uu.se

patients who have suffered from an episode of acute coronary syndrome.[3,4]

Peripheral artery disease (PAD), with manifestation of atherosclerotic disease predominately in the legs, has a rising global prevalence.[5] PAD is diagnosed as an ankle–brachial index (ABI) < 0.9 (or > 1.4).[6] The majority of patients with PAD are asymptomatic.[7] Symptomatic patients, categorized in intermittent claudication or critical limb ischemia, as well as patients with asymptomatic PAD run an increased risk for CV event[8] and will benefit from most CV preventive strategies.[9] Although the evidence for antiplatelet treatment in patients with asymptomatic PAD is less clear,[1] the strict control of risk factors is the cornerstone of care. Therefore, it is important to assess patients with a high risk of PAD, even if they are asymptomatic, to detect clinically masked PAD.[2]

The Walking Impairment Questionnaire (WIQ) was developed as a self-administered and self-reported instrument to assess patients with PAD and their ability related to walking distance, walking speed, and ability to climb stairs in the outpatient setting. WIQ is a validated correlate of objective walking ability[10–12] and is associated with the risk of future CV events;[13–16] however, there is no published study evaluating WIQ in a population with recent myocardial infarction (MI).

The aims of this present study were to examine in a cohort of patients with recent MI: whether WIQ is a useful clinical tool to identify MI patients with PAD; the associations between WIQ scores and atherosclerotic burden (i.e. PvD); and whether WIQ scores identify patients with an increased risk for new CV events.

Methods

Patient population

The design of the REBUS (The RElevance of Biomarkers for future risk of thromboembolic events in UnSelected post-MI patients)[17] study has been previously published. The REBUS study was a prospective observational study of patients with recent MI (NCT01102933, ClinicalTrials.gov)[17] with both Non-ST-elevation (NSTEMI) or ST-elevation (STEMI) admitted to the acute coronary care unit at the Department of Cardiology, Uppsala University Hospital, during 2010–2012. The patients were included 3–5 days after the index MI and followed-up for two years. The first visit was performed at 2–3 weeks after inclusion in the study.

The composite CV endpoint consisted of all-cause death, new MI, stroke, and congestive heart failure (CHF), after the usual definition previously described.[17] All participants signed an informed consent form, and the study was approved by the local ethical committee and conducted in accordance with the ethical principles of the Declaration of Helsinki (Dnr 2009/210).

Evaluation of atherosclerosis

Atherosclerosis in the vascular beds was categorized as previously described in detail.[18] In summary:

(i) Coronary artery disease (CAD) was classified based on findings from coronary angiography performed during hospitalisation for the index MI. The patients were categorized into two groups: (a) normal findings or (b) abnormal findings, including all stenosis or occlusions.
(ii) The carotid arteries were examined on both sides with duplex ultrasonography three months after the index event. The patients were divided into two groups after examination: (a) normal findings and (b) abnormal findings, including all atherosclerotic lesions (plaques, stenosis, or occlusions) and patients with a previous history of carotid endarterectomy.
(iii) PAD was evaluated in all patients, 2–3 weeks after the index MI, by measuring the ABI at rest. PAD was defined as an abnormal ABI score (<0.9 or >1.4) on at least one leg.

Poly vascular disease (*PvD*) was defined as abnormal findings, as defined above, in all three examined arterial beds (i.e. coronary, carotid, and lower extremity).

Walking Impairment Questionnaire

In this study, we used a revised version of the WIQ, adapted and validated for the metric system, and translated to Swedish.[12,19] The questionnaire is included in the Appendix.

Participants were distributed the WIQ forms at the follow-up visit 2–3 weeks after inclusion and completed in privacy at the hospital.

The WIQ score contains three domains measuring important factors of walking impairment: walking distance, walking speed, and ability to climb stairs. All subdomains are graded from 0 (worst/inability) to 4 (best/without limitations). *Walking distance* score assess the degree of difficulty in walking a specific distance the last week, ranging from walking 15 to 500 meters or five blocks. In the walking *speed scores*, the patients are asked to assess the degree of difficulty of walking a block in a specific speed (walking slowly to jogging). The *stair climbing* score reports the difficulty in climbing a specific number of flights of stairs (one to three).

Individual scores are calculated stepwise: first the graded scale is multiplied by a pre specified weight for each question. Second, the products are summed and then divided by the maximum possible score, ranging from 0 (when the patient is unable to perform any of the tasks) to a maximum of 100 in all questions. The individual scores were divided into quartiles and our main analyses were comparing the lowest (worst) versus the highest (best) quartile.

Statistics

Data were presented as means and standard deviations for continuous variables and as numbers and percentages for categorical variables. All continuous variables were normally distributed.

Scores for each subdomain of the WIQ were determined and divided into quartiles. Given the large number of patients with a WIQ distance score of 100, we grouped participants scoring at both third and fourth quartiles into one group (third/fourth quartile). The correlation between all three WIQ questions was examined with the Spearman rank correlation coefficient.

A linear regression model was used for comparisons of age and BMI at baseline between WIQ quartiles. For other baseline variables, Fisher's exact test was used for comparisons of characteristics between WIQ quartiles.

Univariate associations and adjusted associations between atherosclerotic burden and WIQ score quartiles were assessed with logistic regression models. In Model 1, the adjusted variables were age and gender and in Model 2, age, gender, CHF, atrial fibrillation, and diabetes. Results from logistic regression models are presented as estimated odds ratio (OR), comparing the lowest (worst) quartile to the highest (best), with 95% confidence intervals (CIs) and p-values.

Proportional hazards Cox regression models were used to compare differences in rates of CV composite endpoint, occurring between 2–3 weeks after index MI and 2 years after, across WIQ score quartiles. Results from Cox regression models are presented as estimated hazard ratio (HR), comparing the lowest (worst) quartile to the highest (best), with 95% CIs and p-values.

All statistical tests and CIs were two sided, and a statistically significant result was declared if the p-value < 0.05. All analyses were performed with the statistical program package, SPSS Statistics 22 and SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

The present study included the 263 patients, who completed the WIQ questionnaire 2–3 weeks after the index MI and who had all three arterial beds (coronary, carotid, and peripheral arteries) evaluated.

Tables 1 to 3 list the baseline characteristics by WIQ *walking distance*, *speed*, and *stair climbing* quartiles. The cohort consisted of 66 (25.1%) women and 197 (74.9%) men, 125 (47.5%) had an STEMI and 138 (52.5%) an NSTEMI as index event.

Significant correlations were observed between the WIQ scores, *walking distance* versus *speed* ($r = 0.61$, $p < 0.0001$), *walking distance* versus *stair climbing* ($r = 0.39$, $p < 0.0001$), and between *walking speed* and *stair climbing* ($r = 0.52$, $p < 0.0001$).

Baseline characteristics in relation to WIQ score

There was an association between increased age and a higher proportion of women in all domains with the highest age and the larger proportion of women in the lowest (worst) quartile compared to the highest (best) quartile. The proportion of current smokers and the distribution of index type of MI (STEMI/NSTEMI) was similar comparing the lowest (worst) and highest (best) quartiles in all score domains.

Distance score (Table 1): There was an association between patients with diabetes ($p = 0.008$), previous MI ($p = 0.008$), and previous CHF ($p = 0.001$) with a higher proportion in the lowest (worst) quartile. This was also true for atrial fibrillation, renal failure, and of impaired LV-EF after the index, event.

Speed score (Table 2): There was an association between previous stroke ($p = 0.006$) and previous CHF ($p = 0.002$), with a higher proportion in the lowest (worst) quartile. The same was true for renal failure and of impaired LV-EF.

Stair climbing score (Table 3): There was an association between previous CHF ($p = 0.016$) and atrial fibrillation with a higher proportion in the lowest (worst) quartile.

Medical treatment and WIQ score

The adherence to guideline recommended medical treatment for secondary prevention was high; at visit 1, 99.2% were treated with antiplatelet drugs, 92.8% with statins, 91.6% with beta blockers, and 81.7% were treated with angiotensin converter enzyme inhibitor or angiotensin II receptor blocker. The adherence to medical treatment persisted during follow-up at two years.

Atherosclerotic burden and WIQ score

Two hundred and fifty-seven (97.7%) out of the 263 patients had an abnormal coronary angiogram. Fifty-two (19.8%) patients had an abnormal ABI and 136 (51.7%) patients had an abnormal carotid duplex. PvD, with three affected arterial beds, was found in

Table 1. Clinical characteristics for WIQ *walking distance* at visit 1, 2–3 weeks after index MI.

Mean 73.2 (SD 35.01)	Q1 (0–48.59)	Q2 (48.6–99.99)	Q3–4 (100)	p-Value[a]
N (%) = 263	65	60	138	
Age (mean, SD)	72.4 (10.6)	66.5 (10.8)	65.6 (9.3)	0.0001
Female	24 (36.9)	23 (38.3)	19 (13.8)	0.0001
Male	41 (63.1)	37 (61.7)	119 (86.2)	
BMI (SD)	26.9 (4.8)	27.1 (4.0)	26.5 (3.8)	0.378
Smoking, current	18 (27.7)	22 (36.7)	29 (21.0)	0.085
NSTEMI	34 (52.3)	33 (55.0)	71 (51.4)	0.9
STEMI	31 (47.7)	27 (45.0)	67 (48.6)	
Diabetes	16 (24.6)	5 (8.3)	14 (10.1)	0.008
Hypertension	45 (69.2)	26 (43.3)	72 (52.2)	0.011
Previous MI	21 (32.2)	11 (18.3)	19 (13.8)	0.008
Previous stroke	7 (10.8)	2 (3.3)	5 (3.6)	0.079
Previous PAD	4 (6.2)	2 (3.3)	2 (1.4)	0.188
Previous CHF	15 (23.1)	0	5 (3.6)	0.0001
Atrial fibrillation	12 (18.5)	5 (8.3)	7 (5.1)	0.008
Renal disease	8 (12.3)	1 (1.7)	1 (0.7)	0.0001
LV-EF, N = 224[b]	58	48	118	0.012
Normal function	34 (58.6)	36 (75.0)	6 (12.5)	
Mildly impaired	9 (15.5)	6 (12.5)	16 (13.6)	
Moderately impaired	15 (25.9)	6 (12.5)	8 (6.8)	

MI: myocardial infarction; PAD: peripheral artery disease; CHF: congestive heart failure; LV-EF: left ventricular ejection function.
[a]p-Value for trend.
[b]The echocardiogram was performed in 224 out of the 263 patients after the index event, before discharge.

Table 2. Clinical characteristics for WIQ *speed* at visit 1, 2–3 weeks after index MI.

Mean 40.5 (SD 23.5)	Q1 (0–30.29)	Q2 (30.3–35.89)	Q3 (35.9–56.49)	Q4 (56.5–100)	p-Value[a]
N (%) = 263	65	66	51	81	
Age (mean, SD)	70.8 (11.5)	67.4 (10.9)	64.9 (9.6)	65.4 (8.8)	0.001
Female	25 (38.5)	23 (34.8)	12 (23.5)	6 (7.4)	0.0001
Male	40 (61.5)	43 (65.2)	39 (76.5)	75 (92.6)	
BMI (SD)	26.8 (4.8)	26.9 (3.4)	27.5 (4.4)	26.5 (3.6)	0.358
Smoking, current	16 (24,6)	21 (31.8)	19 (37.3)	13 (16.0)	0.086
NSTEMI	35 (53.8)	33 (50.0)	29 (56.9)	41 (50.6)	0.869
STEMI	30 (46.2)	33 (50.0)	22 (43.1)	40 (49.4)	
Diabetes	12 (18.5)	9 (13.6)	6 (11.8)	8 (9.9)	0.487
Hypertension	38 (58.5)	34 (51.5)	29 (56.9)	42 (51.9)	0.804
Previous MI	17 (26.2)	8 (12.1)	11 (21.6)	15 (18.5)	0.228
Previous stroke	8 (12.3)	5 (7.6)	0	1 (1.2)	0.006
Previous PAD	3 (4.6)	2 (3.0)	3 (5.9)	0	0.214
Previous CHF	12 (18.5)	2 (3.0)	2 (3.9)	4 (4.9)	0.002
Atrial fibrillation	10 (15.4)	5 (7.6)	3 (5.9)	6 (7.4)	0.241
Renal disease	6 (9.2)	1 (1.5)	1 (2.0)	2 (2.5)	0.07
LV-EF, N = 224[b]	53	62	46	63	0.033
Normal function	34 (64.2)	41 (66.1)	36 (78.3)	53 (84.4)	
Mildly impaired	6 (11.3)	12 (19.4)	6 (13.0)	7 (11.1)	
Moderately impaired	13 (24.5)	9 (14.5)	4 (8.7)	3 (4.8)	

MI: myocardial infarction; PAD: peripheral artery disease; CHF: congestive heart failure; LV-EF: left ventricular ejection function.
[a]p-Value for trend.
[b]The echocardiogram was performed in 224 out of the 263 patients after the index event, before discharge.

Table 3. Clinical characteristics for WIQ *stair climbing* at visit 1, 2–3 weeks after index MI.

Mean 50.5 (SD 36.6)	Q1 (0–16.69)	Q2 (16.7–49.99)	Q3 (50.0–87.49)	Q4 (87.5–100)	p-Value[a]
N (%) = 263	48	76	57	82	
Age (mean, SD)	72.2 (11.2)	66.3 (11.3)	66.4 (10.1)	65.5 (8.4)	0.003
Female	18 (37.5)	21 (27.6)	17 (29.8)	10 (12.2)	0.007
Male	30 (62.5)	55 (72.4)	40 (70.2)	72 (87.8)	
BMI (SD)	27.1 (4.7)	26.8 (4.4)	26.7 (4.0)	26.4 (3.4)	0.364
Smoking, current	8 (16.7)	17 (22.4)	17 (29.8)	27 (32.9)	0.38
NSTEMI	24 (50.0)	45 (59.2)	31 (54.4)	38 (46.3)	0.42
STEMI	24 (50)	31 (40.8)	26 (45.6)	44 (53.7)	
Diabetes	10 (20.8)	9 (11.8)	8 (14.0)	8 (9.8)	0.331
Hypertension	32 (66.7)	40 (52.6)	27 (47.4)	44 (53.7)	0.245
Previous MI	9 (18.8)	18 (23.7)	11 (19.3)	13 (15.9)	0.667
Previous stroke	6 (12.5)	4 (5.3)	3 (5.3)	1 (1.2)	0.054
Previous PAD	4 (8.3)	1 (1.3)	2 (3.5)	1 (1.2)	0.098
Previous CHF	9 (18.8)	4 (5.3)	3 (5.3)	4 (4.9)	0.016
Atrial fibrillation	10 (20.8)	7 (9.2)	4 (7.0)	3 (3.7)	0.011
Renal disease	4 (8.3)	4 (5.3)	1 (1.8)	1 (1.2)	0.152
LV-EF, N = 224[b]	39	70	51	64	0.258
Normal function	22 (56.4)	52 (74.3)	41 (80.4)	49 (76.6)	
Mildly impaired	9 (23.1)	9 (12.9)	6 (11.8)	7 (10.9)	
Moderately impaired	8 (20.5)	9 (12.9)	4 (7.8)	8 (12.5)	

MI: myocardial infarction; PAD: peripheral artery disease; CHF: congestive heart failure; LV-EF: left ventricular ejection function.
[a]p-Value for trend.
[b]The echocardiogram was performed in 224 out of the 263 patients after the index event, before discharge.

34 (12.9%) patients. The proportion of patients with PAD and PvD was higher in the lowest (worst) quartile for all WIQ scoring domains (Figure 1(a) and (b)).

Distance score: In patients with PAD, there was an association between scoring the lowest (worst) quartile relative to the highest (best) quartile, after adjustment for age, gender, CHF, atrial fibrillation, and diabetes (fully adjusted), OR 3.9 (95% CI 1.6–9.2, p = 0.002) (Figure 2(a)). Similar results were found in patients with PvD with an association between scoring the lowest (worst) score relative to highest (best) score after full adjustment, OR 5.4 (95% CI 1.8–16.1, p = 0.002) (Figure 2(b)).

Speed score: The lowest (worse) quartile was associated with PAD relative to the highest (best) quartile after full adjustment OR 3.2 (95% CI 1.2–8.6, p = 0.022) (Figure 2(a)). In patients with PvD, the association with the lowest (worst) quartile relative to the highest (best) remained after full adjustment OR 7.4 (95% CI 1.5–36.5, p = 0.015) (Figure 2(b)).

Stair climbing score: In contrast to the distance and speed score, the association between PAD and the lowest (worst) quartile relative to highest (best) quartile did not persist after full adjustment (Figure 2(a)). In patients with PvD, the association with the lowest (worst) quartile attenuated after full adjustment (Figure 2(b)).

Cardiovascular events and WIQ score

Forty-three (16.3%) out of 263 patients reached a composite CV endpoint during the two-year follow-up. Six (2.3%) of these patients died. Twenty-one (8.0%) had a new MI, 17 (6.5%) were hospitalized for CHF, and 6 (2.3%) had a stroke.

Distance score (Figure 3): In the fully adjusted model, there was no association between lowest (worst) score and risk for the composite CV endpoint, compared to the highest (best) score, HR 1.9 (95% CI 0.8–4.5, p = 0.118).

Speed score (Figure 3): We found no association with the lowest (worst) score relative to the highest (best) score and the composite endpoint after full adjustment, HR 1.8 (95% CI 0.8–4.6, p = 0.166).

Stair climbing score (Figure 3): Patients with the lowest (worst) score had a higher risk for the composite CV endpoint compared to the highest (best) score, HR 5.3 (95% CI 1.5–19.0, p = 0.011) in the fully adjusted model.

Discussion

In this prospective observational study of patients with recent MI using the self-assessing WIQ, we found that PvD, as well as PAD manifested as abnormal ABI, was associated with the lowest (worst) score categories in both *distance and speed*, even after adjustment for age

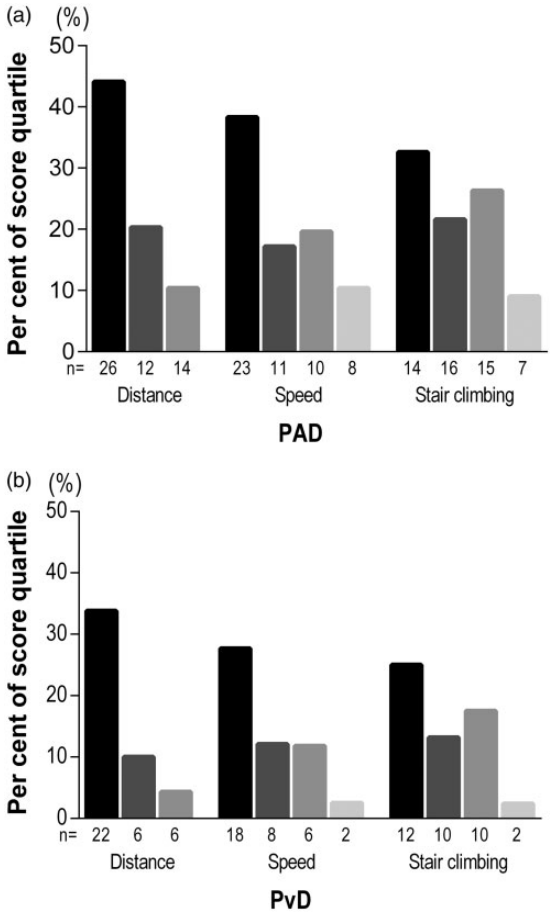

Figure 1. (a) Peripheral artery disease (PAD) and (b) polyvascular disease (PvD) show distribution of WIQ score with the lowest (worst) score to the left and the highest (best) score to the right in each WIQ question. Given the large number of patients with a WIQ distance score of 100, we grouped participants scoring at both third and fourth quartiles into one group (third/fourth quartile).

and sex and comorbidities. Furthermore, the majority of patients with PvD were found in the lowest (worst) score in *stair climbing*.

Overall, patients in the lowest (worst) score had an increased risk for a CV outcome, even after full adjustment for other comorbidities.

The WIQ questionnaire has been validated against objective measures of walking ability in several studies,[10–12,20,21] but only a few studies have examined the usefulness of WIQ scores for predicting outcomes.[15,16] A limited number of studies have evaluated the WIQ in patients without PAD with varying results,[13,14,16] but so far no study has evaluated WIQ in a population with recent MI.

The different WIQ domain scores have in the present study somewhat different implications, in line with what has also been reported by others.[14,22] The *walking distance and speed scores* seem better at identifying patients with PAD and those with PvD even after adjustment for age, sex, and comorbidities closely associated with CV disease, such as diabetes and CHF.

There is a strong correlation between all of the three WIQ domains, especially *distance and speed scores* and conditions that deteriorate walking ability could consequently be of importance. The importance of heart failure in this context is difficult to interpret. Multiple pathways are linking PAD and heart failure, with several risk factors in common such as diabetes and hypertension[23,24] where elevated afterload, due to hypertension and elevated aortic stiffness, in the end could lead to heart failure.[23,24] Also, PAD associated with overt atherosclerosis involving coronary atherosclerosis increases the risk for heart failure.[25] Several studies and a meta-analysis also show that the presence of PAD in patients with heart failure is an independent predictor of hospitalizations and mortality.[26,27] The *stairs score* has also been suggested as a surrogate marker of the patients' cardio-pulmonary capacity and consequently prognosis.[14,28] In this study, 20 (7.6%) patients suffered from CHF at inclusion with significantly more patients in the lowest (worst) score in all three WIQ domains. The echocardiography after the index event also showed a larger proportion of impaired left ventricular ejection fraction in the *walking distance* and *speed score*s and among these patients significantly more in the lowest (worst) score, but surprisingly not in the *stairs score*. This could have influenced the results.

In patients with PAD, the WIQ score predicts future CV events and mortality;[15,16] Schiano et al.[15] showed an association between CV events and *speed and stair climbing* score and a study from Gardner et al.[22] showed association between *stair climbing* score with all-cause mortality. Jain et al.[14] monitored patients with and without PAD and found that in patients with PAD those with the lowest (worst) baseline quartile of WIQ *stair climbing* score had an increased all-cause and CV mortality, as compared to those in the highest (best) baseline quartile. In patients without PAD, there were no such association. In the only study to our knowledge evaluating WIQ in coronary angiography patients, Nead et al.[13] found that any reported deficit score (i.e. score <100% vs. 100%) in all three WIQ domains had a significantly increased risk of both all-cause and CV mortality. Interestingly, they also showed that WIQ score, when added to established risk models, significantly improved risk discrimination and reclassification. In our study, the *stairs climbing score* had a greater association with CV events/mortality than *walking distance and speed scores*.

The patients in our cohort were all well medically treated, with a high proportion of

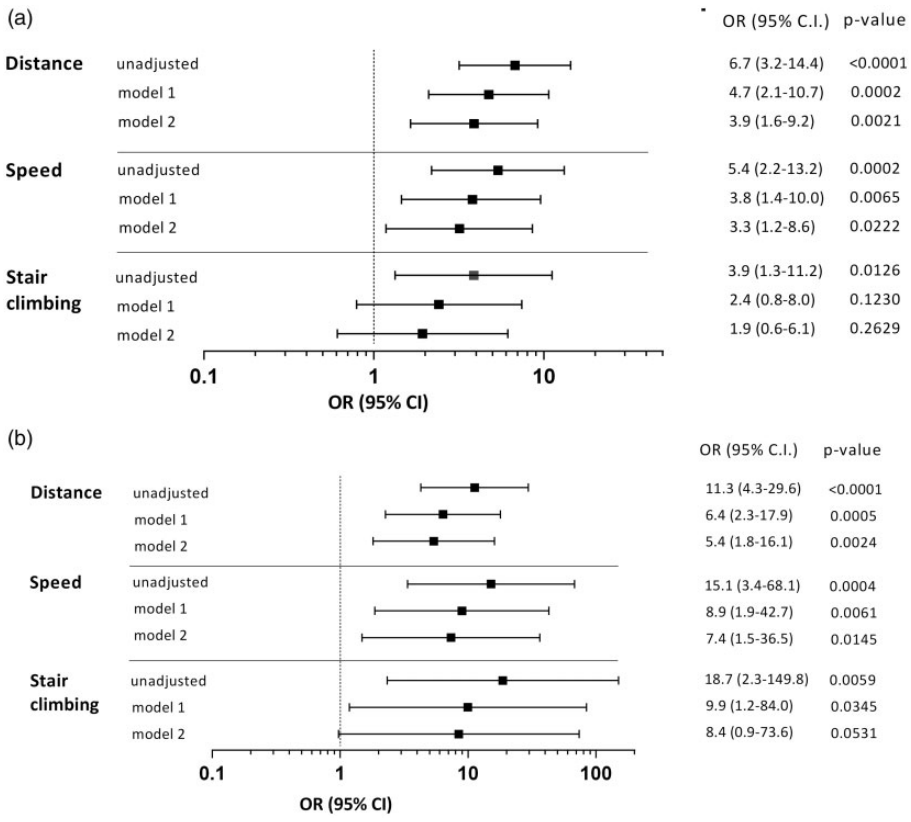

Figure 2. The risk of atherosclerotic disease in patients scoring in the lowest (worst) group/quartile. (a) Peripheral artery disease (PAD) and (b) polyvascular disease (PvD). Model 1: adjusted for age and gender. Model 2: adjusted for age, gender, congestive heart failure, atrial fibrillation, and diabetes.

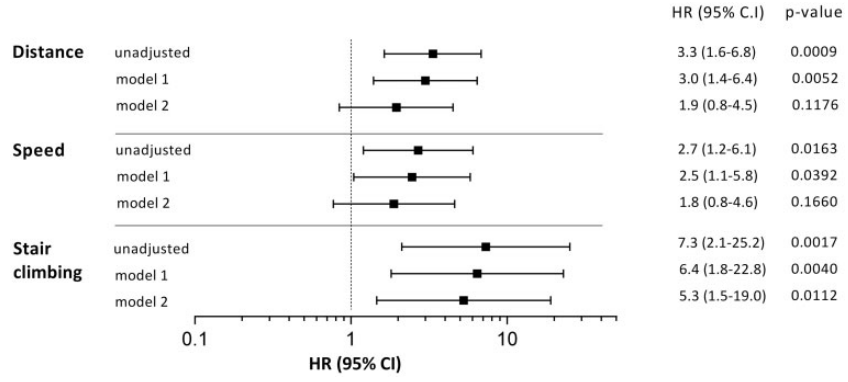

Figure 3. The risk of composite cardiovascular endpoint at 24 months if scoring in the lowest (worst) WIQ group. Model 1: adjusted for age and gender. Model 2: adjusted for age, gender, congestive heart failure, atrial fibrillation, and diabetes.

guideline-recommended secondary prevention drug therapy, with no major differences between the lowest (worst) or highest (best) quartiles and remaining high adherence after two years of follow-up.

The mortality in the present cohort is low, only 6 (2.3%) patients out of 263 died during the two-year follow-up, in comparison with previously published studies in PAD-populations[8] and post-MI patients.[29] A partial explanation might be the high prevalence of guideline-recommended secondary prevention drugs in our cohort. In post-MI patients, the prevalence of these drugs is generally higher[29] than in many PAD-populations where the secondary prevention is less prominent.[8,19,30] In the present study including

additional visits, discussing the importance of secondary prevention may have contributed to the high adherence compared to clinical praxis.

The present study is the first to evaluate the WIQ in a cohort of patients early after an MI and the results suggest that the questionnaire may be useful, to identify patients with a widespread atherosclerotic disease associated with an increased CV risk.

Limitations of the study

The study is based on one center, and the sample size of this study's patient cohort suggests a need for larger prospective studies to evaluate the WIQ score in patients with recent MI and a longer time for follow-up would also be desired. In this study, we used a combination of morphological and functional methods for the identification of atherosclerosis in the different arterial bed instead of using the same type of method, which might have influenced the results.

Conclusion

In this prospective observational study of patients with recent MI and evaluation of the WIQ score, we found that additional atherosclerotic burden with PAD and patients with PvD, respectively, was associated with scoring in the lowest (worst) score in both *walking distance and speed* scores, even after adjustment for age and sex and comorbidities. Furthermore, the majority of patients with PvD were found in the lowest (worst) score in *stair climbing*, and patients with the lowest (worst) score were associated with an increased risk for new CV events, even after adjustment for other comorbidities. The results indicate, although our patients were in recovery from his or her MI, that the WIQ score give valuable information to assess patients early after an MI for a more widespread atherosclerotic burden associated with a higher risk.

Contributorship

BJ, CC, and BK were responsible for the study design and data collection. LB assisted with data analysis. BJ wrote the first draft; all other authors made significant contributions and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

This study was approved by the Uppsala University Faculty of Medicine Ethics Committee for Clinical Researches; approval number: Dnr 2009/210.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Guarantor

BJ.

Informed consent

Written informed consent was obtained from all subjects before the study.

ORCID iD

Birgitta Jönelid http://orcid.org/0000-0001-5726-1226

References

1. Aboyans V, Ricco JB, et al. 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2018 Mar; 55(3): 305–368.
2. Aboyans V, Ricco JB, Bartelink MEL, et al. 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the European Society for Vascular Surgery (ESVS): document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries Endorsed by: the European Stroke Organization (ESO) the task force for the diagnosis and treatment of peripheral arterial diseases of the European Society of Cardiology (ESC) and of the European Society for Vascular Surgery (ESVS). *Eur Heart J* 2018; 39(9): 768–818.
3. Mukherjee D, Eagle KA, Kline-Rogers E, et al. Impact of prior peripheral arterial disease and stroke on outcomes of acute coronary syndromes and effect of evidence-based therapies (from the Global Registry of Acute Coronary Events). *Am J Cardiol* 2007; 100: 1–6.
4. Bhatt DL, Peterson ED, Harrington RA, et al. Prior polyvascular disease: risk factor for adverse ischaemic outcomes in acute coronary syndromes. *Eur Heart J* 2009; 30: 1195–1202.
5. Sampson UK, Fowkes FG, McDermott MM, et al. Global and regional burden of death and disability from peripheral artery disease: 21 world regions, 1990 to 2010. *Glob Heart* 2014; 9: 145–158.e21.
6. Aboyans V, Criqui MH, Abraham P, et al. Measurement and interpretation of the ankle-brachial index: a scientific statement from the American Heart Association. *Circulation* 2012; 126: 2890–2909.
7. Sigvant B, Wiberg-Hedman K, Bergqvist D, et al. A population-based study of peripheral arterial disease prevalence with special focus on critical limb ischemia and sex differences. *J Vasc Surg* 2007; 45: 1185–1191.
8. Sigvant B, Hasvold P, Kragsterman B, et al. Cardiovascular outcomes in patients with peripheral arterial disease as an initial or subsequent manifestation of

atherosclerotic disease: results from a Swedish nationwide study. *J Vasc Surg* 2017; 66: 507–514.e1.
9. Pande RL, Perlstein TS, Beckman JA, et al. Secondary prevention and mortality in peripheral artery disease: National Health and Nutrition Examination Study, 1999 to 2004. *Circulation* 2011; 124: 17–23.
10. Regensteiner JG, Steiner JF and Hiatt WR. Exercise training improves functional status in patients with peripheral arterial disease. *J Vasc Surg* 1996; 23: 104–115.
11. McDermott MM, Liu K, Guralnik JM, et al. Measurement of walking endurance and walking velocity with questionnaire: validation of the Walking Impairment Questionnaire in men and women with peripheral arterial disease. *J Vasc Surg* 1998; 28: 1072–1081.
12. Regensteiner JG, Steiner JF, Panzer RJ, et al. Evaluation of walking impairment by questionnaire in patients with peripheral arterial disease. *J Vasc Med Biol* 1990; 2: 142–152.
13. Nead KT, Zhou M, Diaz Caceres R, et al. Walking Impairment Questionnaire improves mortality risk prediction models in a high-risk cohort independent of peripheral arterial disease status. *Circ Cardiovasc Qual Outcomes* 2013; 6: 255–261.
14. Jain A, Liu K, Ferrucci L, et al. The Walking Impairment Questionnaire stair-climbing score predicts mortality in men and women with peripheral arterial disease. *J Vasc Surg* 2012; 55: 1662–1673.e2.
15. Schiano V, Brevetti G, Sirico G, et al. Functional status measured by Walking Impairment Questionnaire and cardiovascular risk prediction in peripheral arterial disease: results of the Peripheral Arteriopathy and Cardiovascular Events (PACE) study. *Vasc Med* 2006; 11: 147–154.
16. Morris DR, Rodriguez AJ, Moxon JV, et al. Association of lower extremity performance with cardiovascular and all-cause mortality in patients with peripheral artery disease: a systematic review and meta-analysis. *J Am Heart Assoc* 2014; 3(4): 1–11.
17. Christersson C, Lindahl B, Berglund L, et al. The utility of coagulation activity for prediction of risk of mortality and cardiovascular events in guideline-treated myocardial infarction patients. *Ups J Med Sci* 2017; 122(4): 224–233.
18. Jonelid B, Johnston N, Berglund L, et al. Ankle brachial index most important to identify polyvascular disease in patients with non-ST elevation or ST-elevation myocardial infarction. *Eur J Intern Med* 2016; 30: 55–60.
19. Sigvant B, Lundin F, Nilsson B, et al. Differences in presentation of symptoms between women and men with intermittent claudication. *BMC Cardiovasc Disord* 2011; 11: 39.
20. Verspaget M, Nicolai SP, Kruidenier LM, et al. Validation of the Dutch version of the Walking Impairment Questionnaire. *Eur J Vasc Endovasc Surg* 2009; 37: 56–61.
21. Sagar SP, Brown PM, Zelt DT, et al. Further clinical validation of the Walking Impairment Questionnaire for classification of walking performance in patients with peripheral artery disease. *Int J Vasc Med* 2012; 2012: 190641.
22. Gardner AW, Montgomery PS and Parker DE. Physical activity is a predictor of all-cause mortality in patients with intermittent claudication. *J Vasc Surg* 2008; 47: 117–122.
23. Kahan T. The importance of myocardial fibrosis in hypertensive heart disease. *J Hypertens* 2012; 30: 685–687.
24. O'Rourke MF, Safar ME and Dzau V. The cardiovascular continuum extended: aging effects on the aorta and microvasculature. *Vasc Med* 2010; 15: 461–468.
25. Ostergren J, Sleight P, Dagenais G, et al. Impact of ramipril in patients with evidence of clinical or subclinical peripheral arterial disease. *Eur Heart J* 2004; 25: 17–24.
26. Inglis SC, Hermis A, Shehab S, et al. Peripheral arterial disease and chronic heart failure: a dangerous mix. *Heart Fail Rev* 2013; 18: 457–464.
27. Nakamura Y, Kunii H, Yoshihisa A, et al. Impact of peripheral artery disease on prognosis in hospitalized heart failure patients. *Circ J* 2015; 79: 785–793.
28. Brawner CA, Shafiq A, Aldred HA, et al. Comprehensive analysis of cardiopulmonary exercise testing and mortality in patients with systolic heart failure: the Henry Ford Hospital cardiopulmonary exercise testing (FIT-CPX) project. *J Card Fail* 2015; 21: 710–718.
29. Jernberg T, Hasvold P, Henriksson M, et al. Cardiovascular risk in post-myocardial infarction patients: nationwide real world data demonstrate the importance of a long-term perspective. *Eur Heart J* 2015; 36: 1163–1170.
30. Sigvant B, Lundin F and Wahlberg E. The risk of disease progression in peripheral arterial disease is higher than expected: a meta-analysis of mortality and disease progression in peripheral arterial disease. *Eur J Vasc Endovasc Surg* 2016; 51: 395–403.