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Comparison of functional exercise capacity, quality of life and respiratory and peripheral muscle strength between patients with stable angina and healthy controls

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Abstract

Objective: We aimed to compare functional exercise capacity, respiratory and peripheral muscle strength, pulmonary function and quality of life between patients with stable angina and healthy controls.

Methods: We compared 33 patients with stable angina (55.21 ± 6.12 years old, Canada Class II–III, left ventricular ejection fraction: 61.92 ± 7.55) and 30 healthy controls (52.70 ± 4.22 years old). Functional capacity (6-minute walk test (6-MWT)), respiratory muscle strength (mouth pressure device), peripheral muscle strength (dynamometer), pulmonary function (spirometer) and quality of life (Short Form 36 (SF-36)) were evaluated.

Results: 6-MWT distance (499.20 ± 51.91 m versus 633.05 ± 57.62 m), maximal inspiratory pressure (85.42 ± 20.52 cmH_2O versus 110.44 ± 32.95 cmH_2O), maximal expiratory pressure (83.33 ± 19.05 cmH_2O versus 147.96 ± 54.80 cmH_2O) and peripheral muscle strength, pulmonary function and SF-36 sub-scores were lower in the angina group versus the healthy controls, respectively.

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Conclusion: Impaired peripheral and respiratory muscle strength, reduction in exercise capacity and quality of life are obvious in patients with stable angina. Therefore, these parameters should be considered in stable angina physiotherapy programmes to improve impairments.

Keywords

Stable angina, respiratory muscle strength, exercise capacity, quality of life, spirometry, muscle strength

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Introduction

Stable angina is a disturbing and life-restricting condition of coronary heart disease (CHD). Stable angina may become a life-threatening aetiology if the patient develops heart failure. Clinically, stable angina may manifest as exercise dyspnoea, fatigue, weakness, heart failure symptoms, ventricular arrhythmias and other conditions.[1,2] There is no significant change in the frequency, severity or duration of symptoms over time in patients with stable angina pectoris, which arises when myocardial oxygen consumption increases (with exercise, stress, smoking or after heavy meals).[3] During exercise, inspiratory demands increase in concert with expiration, resulting in the increased recruitment of inspiratory and expiratory muscles, further elevating the need for oxygen uptake and delivery. Therefore, ventilatory demand increases and lung volume and breathing frequency change.[4] Franssen et al.[5] stated that most patients with ischaemic heart disease had airflow limitation, and this problem was associated with increased respiratory symptoms, impaired health status and more frequent emergency room admissions. Exercise performance, lower levels of physical activity related to lifestyle and lower values in multiple domains of health-related quality of life in patients with stable angina have been investigated, but there is still a lack of information regarding pulmonary function and peripheral and respiratory muscle strength in patients with stable angina.[6] Reducing the incidence of acute thrombotic events and ventricular dysfunction development form the major core of prevention of myocardial infarction and death in angina patients.[7] Recently, it has become obvious that disease severity should not be estimated from impaired cardiac function alone. However, what has not been clearly investigated is the fact that functional exercise capacity, pulmonary function and respiratory and peripheral muscle strength are impaired, and activities of daily living in patients with cardiac disease are also decreased.[6,7] Hence, in this prospective study, we aimed to compare the aforementioned symptoms and findings in patients with stable angina with those in healthy controls. We hypothesised that functional exercise capacity, pulmonary function and respiratory and peripheral muscle strength are impaired and reduce the quality of life of patients with stable angina.

Materials and Methods

This study was approved by our University Ethics Committee (Protocol number: 2020/12), and the study was performed in accordance with the Declaration of Helsinki. Written informed consent to participate in the study was obtained from all patients and controls.

Participants

Individuals aged 18 to 65 years diagnosed with atherosclerotic stable angina and age-matched healthy individuals were included in this study.

The inclusion criteria were: patients with stable angina, Canada Class II–III, clinically stable for at least 8 weeks, with no change in medications over 3 months and all comorbid conditions, such as hypertension and diabetes, controlled.

The healthy controls were invited to participate in this study via an announcement, and all were volunteers with regular routine medical examinations data and no cardiac problems.

Neither angina patients nor healthy individuals engaged in professional sports, and all performed only irregular moderate physical activity.

The exclusion criteria for all participants were: active infection; orthopaedic problems; rheumatological and neurological disease with the potential to affect functional capacity; comorbidities, such as asthma, chronic obstructive pulmonary disease (COPD), acute infections or pneumonia; physician-scheduled revascularisation within the next 6 months; dilated or hypertrophic cardiomyopathy; heart failure symptoms; reduced left ventricular ejection fraction (LVEF) of $<40\%$; left main coronary artery stenosis of $>50\%$; proximal left anterior descending artery stenosis of $>50\%$ and functional single epicardial vessel.

Study design. This descriptive study was conducted to compare patients with stable angina with healthy controls. In the first stage, patients' and volunteers' clinical evaluations were conducted by the same cardiologist at the Department of Cardiology, Faculty of Medicine, Hatay Mustafa Kemal University. In the second stage, all participants were assessed by a physical therapist who specialised in cardiopulmonary physiotherapy, using measurements of respiratory and peripheral muscle strength, pulmonary function, functional capacity and quality of life.

Procedures. Demographic data and all of the participants' analysis results were recorded from medical records and evaluation forms.

Respiratory muscle strength

Maximal inspiratory and expiratory respiratory muscle strength (MIP and MEP, respectively) were evaluated with a portable electronic mouth pressure measuring device (MicroRPM, Micro Medical, Kent, UK) according to the American Thoracic Society (ATS) and European Respiratory Society (ERS) criteria.[8] MIP and MEP measurements were used to evaluate the respiratory muscles. MIP was measured by rapid and deep inspiration of residual volume after maximum expiration. MEP was evaluated by rapid and deep expiration of total lung capacity after maximum inspiration. The patients were verbally encouraged to perform to the best of their ability. If there was more than a 5% or 5-cmH_2O difference between the two best measured values, the measurement was repeated, and the best measurements were selected for analysis. The minimal clinically important difference (MCID) value for MIP was considered 11 cmH_2O, according to the literature.[9] The presence of respiratory muscle weakness was accepted if the predicted maximal pressures were $<70\%$.[10]

Peripheral muscle strength

The muscle strength of the participants' knee extensors, hip flexors, shoulder abductors and elbow flexors was evaluated using a digital dynamometer (Commander Powertrack II; JTECH Medical, Midvale, UT, USA). The test was repeated three times for the right and left sides. The obtained values were recorded in Newtons (N), and the percentage of normal values determined by age and gender was used when interpreting the measurements.[11] Hand grip strength was assessed with a hand-held dynamometer (Jamar®; Fabrication Enterprises Inc., White Plains, NY, USA), in accordance with the American Society of Hand Therapist recommendations. The participants sat comfortably in a standard chair with leg and back supports and fixed arms and were asked to rest their forearm on the arm of the chair with the wrist just over the end of the arm of the chair and to position the wrist in a neutral position with the thumb facing upward. They were then encouraged to squeeze the device for as long and as tightly as possible, starting with the right hand. The measurements were repeated for the left hand, and further measurements were performed for each hand to obtain the best three readings. The values obtained were recorded in lbs. The highest result and the mean value of the three measurements were used for analysis.[12,13]

Pulmonary function test

Respiratory function was evaluated using a portable spirometer (Spirobank II®; Medical International Research, Rome, Italy). All participants' forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), ratio of forced expiratory volume in the first second to forced vital capacity (FEV_1/FVC), peak expiratory flow rate (PEF) and forced expiratory medium flow rate ($FEF_{25\%-75\%}$) were measured in a sitting position, and the data were recorded. Three technically acceptable and 95% compatible manoeuvres were chosen for the statistical analysis.[14]

Functional capacity

Functional capacity was evaluated with a six-minute walk test (6-MWT). Patients rested for at least 30 minutes before starting the test, which was performed in accordance with the ATS criteria.[14] Oxygen saturation (SpO_2), heart rate, blood pressure, respiratory frequency, fatigue and dyspnoea perception were recorded before and after the test. The start and end points were determined in the 30-m straight corridor where the 6-MWT was performed. The patients were asked to walk as fast as possible without running. Standard verbal expressions were used to encourage the patients during the test. The 6-MWT distance reached was recorded in metres (m), and the greatest distance was chosen for analysis.[15]

Quality of life

Quality of life was evaluated with the Short Form 36 (SF-36) General Health Survey. The scale, which can be used for different patient groups and healthy individuals, is reliable and valid in Turkish.[16] Scoring of the scale consists of three stages. The first stage involves scoring each question individually from lowest to highest (0 to 100). In the second stage, the averages of the same subscales (physical function, role limitations due to physical problems, general health, bodily pain, social function, role limitations due to emotional problems, mental health and vitality) are calculated, and in the third stage, the percentages of these items are calculated. The lowest percentage corresponds to poor quality of life.[17]

Statistical Analyses. All statistical analyses were performed using the SPSS 20.0 statistical package (IBM Corp., Armonk, NY, USA). Normality of the data was tested using the Shapiro–Wilk's test. Demographic and clinical characteristics of the groups were compared using the independent samples test, and differences between the groups were reported as mean ± standard deviation (mean ± SD) or as mean difference and 95% confidence intervals (95% CI). Nominal data were analysed using the Chi-square test. Non-normally-distributed data were expressed as median (quartiles) and were compared using the Mann–Whitney U test. Correlations between 6-MWT distance, pulmonary function, respiratory muscle strength and clinical characteristics were analysed using Pearson's and Spearman's rank correlation coefficients, as appropriate.[18]

The G*Power package software programme (G*Power, version 3.1.9.4; Franz Faul, Universität Kiel, Kiel, Germany) was used to calculate the required sample size for the study. According to a previous study (Graetz et al., 2012),[19] we calculated that a sample size constituting 24 subjects (12 per group) was required to obtain 80% power with an effect size of 1.074628, type I error (α) = 0.05 and type II error (β) = 0.20.

Results

Forty patients with stable angina pectoris were enrolled in the current study. Of these, five did not meet the inclusion criteria, and two declined to participate. Forty healthy controls were asked to participate, five of whom were excluded because they were not age-matched, and five declined to participate. In total, 33 patients and 30 controls were recruited and compared (Figure 1). The demographics, clinical characteristics and physical activity participation of the stable angina and healthy control groups were similar (Table 1). However, cigarette exposure was higher in patients with stable angina than in healthy controls ($p < 0.01$, Table 1).

Regarding pulmonary function, measured and predicted FVC (L) ($p = 0.040$), FVC (%) ($p = 0.037$), PEF (L) ($p = 0.030$), PEF (%) ($p = 0.080$) and FEV_1/FVC (%) ($p = 0.009$) values were significantly lower in the patients with stable angina compared with healthy controls (Table 2).

We found significant differences in respiratory muscle strength in measured MIP ($p = 0.001$), and MEP ($p < 0.001$), predicted

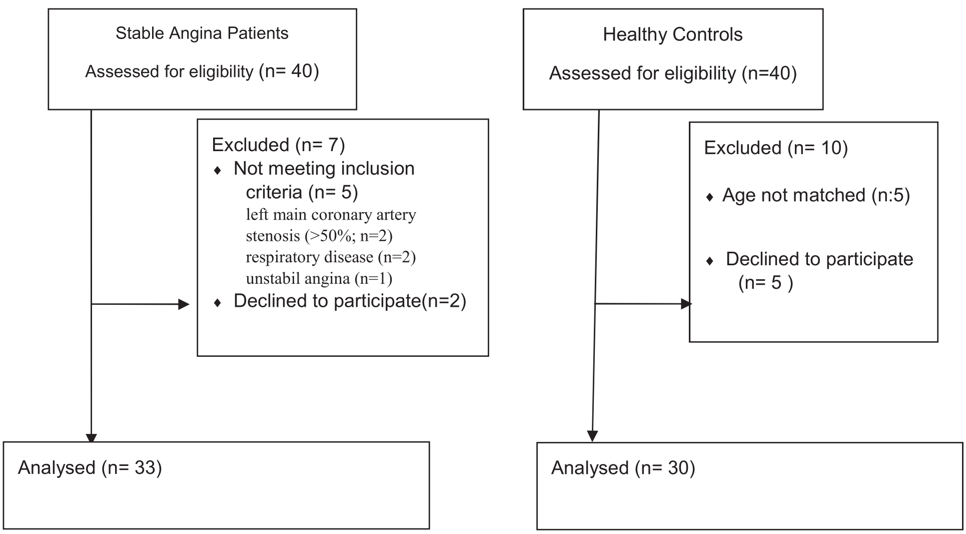

Figure 1. Flow diagram of the patients with stable angina and healthy controls.

Table 1. Demographics, characteristics and physical activity participation of patients with stable angina and healthy controls.

Variable	Patients $X \pm SD$/ Median (IQR)	Controls $X \pm SD$ Median(IQR)	Mean difference (95% CI)/U/x^2	p
Age (years)	55.21 ± 6.12	52.70 ± 4.22	2.51 [(−0.16)–(−5.18)]	0.06
Weight (kg)	85 (76.5–95.5)	78 (73.5–84.25)	357.5	0.05
Height (cm)	170.87 ± 4.78	169.60 ± 8.21	1.27 [(−2.27)–(4.83)]	0.47
Body mass index (kg/m^2)	28.73 (26.23–31.54)	27.59 (25.91–29.58)	103	0.20
Female/Male, n (%)	3 (9.1%)/30 (90.9%)	5 (16.7%)/25 (83.3%)	0.814	0.46
Smoking exposure (packxyear)	**28 (0–50)**	**0 (0–27)**	**279***	**0.01***
Smoking n (%)			4.53	
Current	10 (30.3%)	5 (16.7%)		0.10
Ex-smoker	13 (39.4%)	8 (26.7%)		
Non-smoker	10 (30.3%)	17 (56.27%)		
Moderate intensity physical activity n (%)	11 (33%)	6 (20%)	1.41	0.23
Canada Class II/III, n/%	27/81.8%, 6/18.2%			
LVEF, %	61.92 ± 7.55			
DM, n (%)	16 (48.5%)			
HT, n (%)	21 (63.6%)			
Medication, n (%)				
Acetylsalicylic acid (ASA), n (%)	26 (78.8%)			
ACE-I, n (%)	18 (54.5%)			
Beta blockers, n (%)	10 (30.3%)			
Calcium-channel blockers, n (%)	3 (9.1%)			
Long-acting nitrates, n (%)	2 (6.1%)			
Antilipid drugs, n (%)	22 (66.7%)			
Antidiabetic medications, n (%)	16 (48.5%)			
NSAIDs, n (%)	3 (9.1%)			
Antithrombotic drugs, n (%)	24 (72.7%)			
Trimetazidine, n (%)	3 (9.1%)			
Ranolazine, n (%)	2 (6.1%)			

*$p < 0.05$. Boldfaced values indicate the significance.
ACE-I, angiotensin converting enzyme inhibitors; CI, confidence interval; DM, diabetes mellitus; HT, hypertension; IQR, interquartile range; MI, myocardial Infarction; LVEF, left ventricular ejection fraction; NSAIDs, nonsteroidal anti-inflammatory drugs; SD, standard deviation; X, mean.

MIP ($p < 0.001$) and predicted MEP ($p < 0.001$) between the groups (Table 2). The mean difference between the groups for MIP (25.02 cmH_2O) was higher than MCID (11 cmH_2O). Thirteen (39.4%) patients had values lower than 70% of predicted MIP, and 33 (100%) patients had values lower than 70% of predicted MEP.

Regarding peripheral muscle strength, there were no significant differences in measured hip flexor muscle and left hand grip strength between the groups (Table 2). However, the mean difference between the groups for quadriceps femoris muscle strength (22 N) was higher than MCID (17 N). Measured ($p = 0.002$) and % predicted ($p < 0.001$) strength in the quadriceps femoris, measured ($p < 0.001$) and % predicted ($p < 0.001$) shoulder abductor strength, measured ($p < 0.001$) and % predicted ($p < 0.001$) elbow flexor muscle strength, % predicted hip flexor strength ($p = 0.03$) and % predicted hand grip strength (right) ($p = 0.03$) values were

Table 2. Comparison of pulmonary function and respiratory and peripheral muscle strength in patients with stable angina and healthy controls.

	Patients	Controls		
Characteristic	X ± SD/Median (IQR)	X ± SD/Median (IQR)	Mean difference (95% CI)/U	p
FEV_1, % predicted	88.59 ± 17.49	94.93 ± 16.43	−6.33 (−15.05–2.38)	0.151
FVC, L	3.40 ± 0.84	3.89 ± 0.95	−0.48 (−0.94–0.02)	0.040*
FVC, % predicted	86.56 ± 16.59	94.58 ± 16.44	−9.02 (−17.50 to −0.54)	0.037*
FEV_1/FVC, %	89.15 (79.57–97.40)	81 (72.25–88.45)	283	0.009*
PEF, L	5.71 ± 1.69	6.82 ± 2.21	−1.11 (−2.12 to −0.11)	0.030*
PEF, % predicted	69.28 ± 18.37	83.37 ± 21.69	−14.09 (−24.36 to −3.82)	0.008*
$FEF_{25\%–75\%}$	3.17 (2.40–4.28)	3.27 (2.54–4.19)	462.5	0.983
$FEF_{25\%–75\%}$, % predicted	87.75 ± 23.18	86.37 ± 26.00	1.37 (−11.22–13.97)	0.828
MIP, cmH2O	85.42 ± 20.52	110.44 ± 32.95	−25.02 (−38.79 to −11.25)	0.001*
MIP, % predicted	78.56 ± 17.62	99.50 ± 25.84	−20.94 (−32.06 to −9.81)	<0.001*
MEP, cmH2O	83.33 ± 19.05	147.96 ± 54.80	−64.63 (−84.96 to −44.29)	<0.001*
MEP, % predicted	39.07 ± 8.72	68.53 ± 23.09	−29.45 (−38.12–20.79)]	<0.001*
6-MWT, m	499.20 ± 51.91	633.05 ± 57.62	−133.84 (−162.65 to −105.02)	<0.001*
6-MWT, % predicted	84.85 ± 8.79	103.99 ± 7.80	−19.14 (−23.55 to −14.74)	<0.001*
Quadriceps femoris (Left), N	149 (123.75–187.75)	184.5 (149–261)	265	0.002*
Quadriceps femoris, % predicted	33.49 (24.64–38.68)	42.90 (34.81–60.32)	217	<0.001*
Hip flexors (Left), N	166 (125.25–180)	169 (147–193)	302.5	0.263
Hip flexors, % predicted	86.45 ± 28.25	101.71 ± 22.88	−15.25 (−29.60 to −0.91)	0.03*
Shoulder abductors (Left), N	90.41 ± 25.57	135.43 ± 36.93	−45.01 (−61.90 to −28.12)	<0.001*
Shoulder abductors, % predicted	42.91 ± 12.54	69.32 ± 19.75	−26.40 (−35.14 to −17.67)	<0.001*
Elbow flexors (Left), N	11.67 ± 30.09	154.87 ± 47.33	−43.20 (−64.38 to −22.03)	<0.001*
Elbow flexors, % predicted	42.88 ± 10.92	65.44 ± 17.06	−22.55 (−30.20 to −14.90)	<0.001*
Hand grip strength (Left), lbs	65.51 ± 21.08	76.69 ± 20.93	−10.18 (−21.63–1.29)	0.08
Hand grip, % predicted	87.39 ± 24.60	102.42 ± 26.11	−15.03 (−28.77 to −1.29)	0.03*

*significant value: $p<0.05$.

CI, confidence interval; $FEF_{25\%–75\%}$, forced expiratory flow from 25% to 75%; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; MEP, maximal expiratory pressure; MIP, maximal inspiratory pressure; PEF, peak expiratory flow; SD, standard deviation; X, mean; 6MWT, 6-minute walk test.

significantly lower in patients with stable angina compared with healthy controls (Table 2). Thirty-three (100%) patients had values less than 80% of the predicted quadriceps femoris strength, and 31 (93.9%) patients had values of less than 80% of the predicted shoulder abductor strength.

The measured and % predicted 6-MWT distances were significantly ($p < 0.001$) shorter in the stable angina group compared with the healthy control group (Table 2). Eleven (33.3%) patients had values less than 80% of the predicted 6-MWT distance.

Regarding quality of life, physical functioning ($p < 0.001$), role–physical ($p = 0.001$), role–emotional ($p < 0.001$), vitality ($p = 0.002$), mental health ($p = 0.014$), bodily pain ($p = 0.041$) and general health ($p = 0.004$) SF-36 subscale scores were significantly lower in patients with stable angina compared with healthy controls (Table 3). There was no significant difference in social functioning SF-36 subscale scores between patients and controls (Table 3).

6-MWT was positively correlated with gender ($r^2 = 0.508$; $p = 0.004$), MIP ($r^2 = 0.405$; $p = 0.024$), MEP ($r^2 = 0.348$; $p = 0.047$), hip flexors (left) ($r^2 = 0.395$; $p = 0.028$), measured FVC ($r^2 = 0.417$; $p = 0.024$), predicted PEF ($r^2 = 0.519$; $p = 0.003$), measured PEF ($r^2 = 0.621$; $p = 0.001$) and SF 36 subscale scores for role–physical ($r^2 = 0.313$; $p = 0.046$), bodily pain ($r^2 = 0.522$; $p = 0.004$) and general health ($r^2 = 0.449$; $p = 0.014$; Table 4).

Discussion

To best of our knowledge, this is the first study of peripheral and respiratory muscle strength, functional capacity and quality of life in patients with stable angina. The most important findings in the present study are the impaired functional exercise capacity and quality-of-life scores; weakened muscle strength in the shoulder abductors, elbow flexors and quadriceps femoris and decreased hand grip strength and MIP and MEP values in patients with stable angina. The mean difference between the groups for MIP (25.02 cmH_2O) was higher than the MCID (11 cmH_2O).[9] Pulmonary function test results were similar between the groups except for the FVC, FEV_1/FVC and PEF values.

Pharmacological treatment, lifestyle modifications and coronary revascularisation procedures are all targeted at reliving anginal symptoms and increasing quality of

Table 3. Comparison of quality of life in patients with stable angina and healthy controls.

Characteristic SF-36 (0–100)	Patients X ± SD/Median (IQR)*	Controls X ± SD/Median (IQR)*	Mean difference (95% CI (U statistic*))	p
Physical functioning	75 (65–90)	95 (85–100)	140.5	**<0.001***
Role–physical	100 (0–100)	100 (100–100)	189.0	**0.001***
Role–emotional	33.3 (0–100)	100 (100–100)	155.0	**<0.001***
Vitality	55.16 ± 24.34	74.04 ± 13.74	−18.88 (−30.67 to −7.09)	**0.002***
Mental health	61.41 ± 17.84	74.09 ± 17.23	−12.67 (−22.66 to −2.68)	**0.014***
Social functioning	100 (50–100)	100 (75–100)	275.5	0.309
Bodily pain	77.50 (55–100)	90 (77.50–100)	218.5	**0.041***
General health	65 (45–70)	85 (65–85)	172.0	**0.004***

*significant value: $p < 0.05$. Boldfaced values indicate the significance.
CI, confidence interval; IQR, interquartile range; SD, standard deviation; SF-36, Short-Form 36; X, mean.

Table 4. Correlations between 6-MWT distances and demographic and clinical characteristics of patients with stable angina.

	6-MWT distance	
Characteristic	r value	p-value
Age, years	0.083	0.657
Male/female	0.508	**0.004***
BMI, kg/m^2	–0.253	0.170
Smoking, pack-years	0.389	**0.030***
LVEF, %	–0.015	0.939
FEV1, % predicted	0.213	0.251
FVC, L	0.417	**0.020***
FEV1/FVC, %	–0.078	0.677
PEF, L	0.621	**0.001***
PEF % predicted	0.519	**0.003***
MIP, cmH2O	0.405	**0.024***
MEP, cmH2O	0.348	**0.047***
Quadriceps femoris (left), N	0.311	0.089
Shoulder abductors (left), N	0.323	0.076
Hip flexors (Left), N	0.395	**0.028***
Hand-grip strength (Right) lbs	0.355	**0.050***
Canada Class II/III	−0.232	0.209
SF-36 Role–physical	0.373	**0.046***
SF-36 Bodily pain	0.522	**0.004***
SF-36 General health	0.449	**0.014***

*significant value: $p < 0.05$. Boldfaced values indicate the significance.
BMI, body mass index; FEV1, forced expiratory volume in one second; FVC, forced vital capacity; LVEF, left ventricular ejection fraction; MEP, maximal expiratory pressure; MIP: maximal inspiratory pressure; PEF, peak expiratory flow; r, Pearson's/Spearman's correlation coefficients; SF-36, Short Form 36; 6-MWT, 6-minute walk test.

life. When compared with optimal medical therapy only, there is no obvious superiority of a combination of optimal medical therapy and revascularisation procedures on survival and myocardial infarction.[1,2] However, one study recently demonstrated and reported an incremental deterioration in patient survival associated with an increased degree of anginal severity. Furthermore, increased angina severity is associated with increased rates of atrial fibrillation, hospitalisation and further acute coronary syndromes.[20] Hence, relieving anginal symptoms and improving functional status has become more valuable in patients with stable angina. According to our findings, 6-MWT and quality-of-life results in patients with angina are lower than in healthy controls, and these results are supported by the literature.

Pulmonary lung function is indirectly related to CHD and cardiovascular disease (CVD). Several studies have demonstrated that pulmonary function abnormalities are prevalent in patients with ischaemic heart disease.[21] In a recent study, the FEV_1, FVC and FEV_1/FVC values were assessed as predictors of CHD events in 1548 older community-dwelling adults, who were followed for up to 22 years (mean age: 73.6 ± 9.2 years). The authors of the study stated that decreased pulmonary function was a risk factor for CVD in older community-dwelling adults.[22] In contrast, we assessed younger patients with angina; aged 55.21 ± 6.12 years. According to our results, there were reductions in pulmonary function, and we consider that age and smoking status may affect the status of the coronary arteries.

In an earlier study (1995), Hamilton et al.[23] showed that patients with stable angina have inspiratory and expiratory muscle weakness and respiratory muscle pump insufficiency leading to dyspnoea in daily living activities; patients with angina also had reduced respiratory muscle strength. The authors stated that the peripheral and respiratory muscle weakness appeared to be associated with concomitant pulmonary and cardiac disorders rather than with the presence of angina, and that muscular weakness in patients with cardiorespiratory disorders was not restricted to the respiratory muscles but was present in both respiratory and peripheral limb muscles.[23] In contrast, we did not include patients with respiratory disorders in our study, to eliminate respiratory problems. However, similar to other studies, we found that 13 (39.4%) patients had values less than 70% of predicted MIP, and 33 (100%) had values less than 70% of predicted MEP. We hypothesise that smoking status associated with lower PEF values and a history of diabetes or hypertension may affect respiratory muscle strength in patients with stable angina.

Myocardial oxygen consumption, which is a determinant of exercise capacity, is associated with peripheral muscle weakness and impaired cardiac function. In a recent study, researchers showed that cardiorespiratory capacity in patients with coronary artery disease (CAD) is related to impaired skeletal muscle function measured by isokinetic dynamometry. In particular, deconditioning of peripheral muscles (quadriceps and hamstring) induced poor adaptation to exercise,[24] while in another study, quadriceps muscle strength was similar between patients with CAD and healthy controls, but isometric endurance was lower.[25] For both upper and lower extremity evaluation, one study stated that leg extensor muscle strength was weaker in patients with cardiac problems (post-myocardial infarction, CHD, left ventricular hypertrophy, cardiomyopathy and congestive heart failure) than in healthy controls. However, arm flexor muscle strength was similar between cardiac patients and healthy controls.[26] In our study, 33 (100%) patients had values less than 80% of predicted quadriceps femoris strength, and 31 (93.9%) had values less than 80% of predicted shoulder abductor strength. To the best of our knowledge, no studies have reported weakened muscle strength in patients with stable angina relative to healthy individuals. Measured and % predicted quadriceps femoris muscle strength values were also lower in patients with angina pectoris. Quadriceps femoris muscle strength was clinically impaired (22 N) in patients with angina compared with healthy controls. The results of both upper- and lower extremity muscle strength testing in patients with stable angina are still unclear. Comprehensive upper-limb muscle assessments should be considered for patients with angina, and the effects of upper-extremity training should be investigated in future studies.

According to our knowledge, grip strength measurement is a useful tool to assess overall muscle strength. There is a linear association between grip strength and chronic diseases, such as hyperlipidaemia, ischaemic heart disease and diabetes, as described by Cheung et al.[27] Sokrans et al.[28] showed that there are interactions between hand grip strength and oxygen consumption before and after surgery in patients with CAD, and hand grip strength may be a useful predictor to evaluate oxygen consumption among cardiac patients. A recent study showed that the grip strength of the dominant hand was lower in patients with myocardial infarction and angina pectoris than in healthy controls.[29] As in these studies, we compared hand grip strength between patients with stable angina and healthy individuals, and we found significantly lower hand grip strength in patients with stable angina. In healthy individuals, grip strength and leg muscle strength are weaker for current smokers than for nonsmokers.[30] In our study, smoking status was higher in patients with angina pectoris than in healthy controls. Therefore, in addition to cardiac dysfunction, smoking exposure may affect hand grip strength. Future studies are planned to investigate which factors influence hand grip strength in patients with stable angina.

Patients with stable angina have lower exercise capacity, and impaired exercise capacity is a predictor of mortality.[6,25,31] Cardiopulmonary exercise testing (CPET) provides important information in stable CHD.[32,33] However, 6-MWT, which is a simple field test, is commonly used to determine functional exercise capacity. In addition, 6-MWT results were found to be similar to CPET.[34] In one study, exercise capacity was assessed by 6-MWT, and patients with stable angina showed shorter 6-MWT distances (449 ± 96 m) than controls (485 ± 100 m).[6] Ghroubi et al.[24] reported that 6-MWT distance was significantly shorter in CAD patients (425.93 ± 52.77 m) than in healthy controls (551.46 ± 57.94 m). In the current study, patients with stable angina walked shorter distances (499.20 ± 51.91 m) than did healthy controls (633.05 ± 57.62 m). We believe that our stable angina patients walked much further because they were younger than participants in the other two studies.[6,24] Despite our patients being younger, their exercise capacity was still lower; 33.3% of patients had values less than 80% of predicted 6-MWT. The positive correlation between gender, MIP, MEP, FVC and PEF values, SF 36 subscales (general health and bodily pain), quadriceps femoris and shoulder abductor muscle strength, Canada classification and 6-MWT results suggests that functional capacity may be negatively affected by angina. Therefore, patients with angina should be directed to early rehabilitation programmes.

Quality-of-life impairment in patients with CAD has been shown in several studies.[6,35,36] In addition, health-related quality of life is related to the severity of CAD.[35] One study showed that physical function, role limitations due to physical problems, general health and SF-36 vitality subscale scores were lower in participants with stable angina.[6] Another study stated that health-related quality of life was affected in CAD patients, especially for older and female parients.[36] In accordance with other studies,[6,36] in our study, physical functioning, role–physical, role–emotional, vitality, mental health, bodily pain and SF-36 general health subscale scores were lower in patients with angina than in healthy controls. According to our results, impaired exercise capacity might contribute to impaired quality of life.

Limitations

The main imitation in this study is that maximal exercise testing should be performed to determine maximal exercise capacity to clearly detect the presence of angina symptoms during the test. We did not perform this test, in this study.

In conclusion, impaired peripheral upper- and lower-limb muscle strength, decreased exercise capacity and quality of life, especially inspiratory and expiratory respiratory muscle strength, are obvious in patients with stable angina. Therefore, measurements of respiratory muscle strength, exercise capacity, peripheral extremity muscle strength and quality of life should guide the planning of appropriate exercise interventions within cardiac rehabilitation programmes. In future studies, comparative investigation of different classes of angina according to the Canadian Cardiovascular Society angina classification involving larger populations is required.

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