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Exercise capacity, physical activity, and health-related quality of life in adults with CHD

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Abstract

Objectives: The aim of this study was to assess exercise capacity, physical activity, and health-related quality of life within a broad and unselected group of adults with CHD. *Design:* From April 2009 to February 2014, 1310 patients were assessed for suitability to participate in this single-centre cross-sectional study. Seven hundred and forty-seven (57%) patients were included, performed a submaximal bicycle test, and answered questionnaires regarding physical activity and health-related quality of life. Exercise capacity, physical activity, and health-related quality of life were compared with reference values and correlations were studied. *Results:* The exercise capacities of men and women with CHD were 58.7 and 66.3%, respectively, of reference values. Approximately, 20–25% of the patients did not achieve the recommended amount of physical activity. In addition, men scored significantly less points on 7 out of 10 scales of health-related quality of life and women in 6 out of 10 scales, compared with reference values. The strongest correlation was between exercise capacity and the Short Form-36 (physical function). *Conclusions:* Exercise capacity was impaired in all adults with CHD, including those with less complicated CHD. One-quarter of the patients did not achieve the recommended levels of physical activity. Exercise tests followed by individualised exercise prescriptions may be offered to all patients with CHD aiming to increase exercise capacity, levels of physical activity, improve health-related quality of life, and reduce the risk of acquired life-style diseases.

Adult patients with CHD show reduced exercise capacity[1–3] which is related to a worse prognosis in these patients.[4] According to the World Health Organization, the recommendations for physical activity for adults (aged 18–64 years) are the following: at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity physical activity each week, or an equivalent combination of moderate- and vigorous-intensity physical activity.[5] The physical activity in adult patients with CHD has been reported as lower[6] or equal to healthy peers.[7] Differences in published findings about levels of physical activity in adults with CHD may be due to published data being from tertiary centres with referred patients, possibly having above average problems and below average exercise capacities. Age also impacts the human body and health-related quality of life, which declines with increasing age.[8]

For adults with CHD, a diminished exercise capacity, measured as peak VO_2, also predicts the frequency and duration of hospitalisation or death.[4] As well as having a large impact on the patient's prognosis and activities of daily living, a diminished exercise capacity is also known to be a risk factor for developing other acquired life-style diseases.[9] These patients also have reduced muscle function compared with healthy adults.[10] As adults with CHD now live longer,[11,12] there is also a decline in exercise capacity with advancing age that is also seen in healthy individuals.[13] Gratz[14] showed that self-estimated exercise capacity poorly predicts actual capacity. The correlation, if any, between self-estimated physical activity and exercise capacity has not been assessed in Swedish adults with CHD. The correlation between health-related quality of life and exercise capacity is modest in adults with CHD.[14]

The aims of this study were to assess exercise capacity, self-reported physical activity level, and health-related quality of life within a broad and unselected group of adults with CHD and to compare these values with published reference values from healthy individuals as well as to study the correlations between exercise capacity, physical activity level, and health-related quality of life.

Patients and methods

The adult CHD unit at Sahlgrenska University Hospital, Östra serves a population of 1.5 million and is a regional unit within that area.

Study population

From April 2009 to February 2014, all outpatients with CHD seen for regular visits in our CHD unit were assessed once for potential contraindications and, if none, patients were asked to see a specially trained physical therapist connected to the unit. Patients who came for revisits were not assessed or included more than once.

Exclusion criteria were severe arrhythmias, patients waiting to undergo surgery, advanced heart failure, severe cerebral lesions, and intellectual disabilities resulting in difficulties in performing the submaximal ergometer bicycle test, or if previously included in the study.

This study was a single-centre cross-sectional study. Patients were given oral and written information about the study, and each patient signed a letter of informed consent. Patients of the CHD unit agreed to have their data registered in the national Swedish Registry of CHD, which made it possible to analyse data for patients who opted not to participate in this study.

One thousand three hundred and ten outpatients seen at a specialised CHD unit were assessed. The demographics of this population are given in the Supplementary Table S1. Two hundred and twenty-three (17%) patients did not perform the tests due to one of the following reasons: musculoskeletal disorders (n = 9), intellectual/cerebral disability (n = 31), psychiatric disorders (n = 7), unstable or severe cardiac condition (n = 23), pregnancy (n = 31), discontinuation of planned care (i.e., moving outside catchment area) (n = 17), or other or unknown reasons (n = 105). Three hundred and forty (26%) patients declined to participate. No significant differences were seen between included and not-included patients (Supplementary Table S1).

Reference group

A description of the specific reference values used for comparison with the results of adults with CHD is provided along with an explanation of each test or questionnaire used. If patients were older or younger than the age range for the available reference values, these patients were grouped together and calculated with the nearest reference value available for levels of exercise capacity, physical activity level, and health-related quality of life.

Measurements

Patients performed a submaximal ergometer bicycle test to evaluate exercise capacity. On the same occasion, patients answered two questionnaires, one concerning levels of physical activity and the other regarding health-related quality of life. Standardised instructions were given by the physiotherapist leading the test. All included patients did not perform all tests and questionnaires. To clarify this, the number of patients who performed each test is listed in the tables.

Exercise capacity

A submaximal ergometer bicycle test (Monark 828 E, Varberg, Sweden) was used to assess exercise capacity. The protocol used was designed according to the World Health Organization[15] and is a stepwise test with increasing loads with an almost steady circulatory state at each level.[16,17] Resting heart rate and blood pressure were recorded before the test with the patient in a supine position. The initial load was 25 or 50 watts in a few patients. Speed was set to 60 revolutions per minute. The load increased every 4.5 or 5 minutes by 25 watts. Time was set for 4.5 or 5 minutes to reach steady state.[18] Blood pressure was recorded manually with a sphygmomanometer every 2 minutes (H.E AB, Bandhagen, Sweden). Heart rate was measured via a pulse strap sending impulses to the bicycle (Polar T31; Polar, Bromma, Sweden). Heart rate and blood pressure were registered up until 5 minutes after ending the test. The exercise test was ended when patients reached 15–17 on Borg's rating scale of perceived exertion.[19] Other reasons for ending the submaximal test before reaching an perceived exertion of 15–17 were decreased blood pressure, chest pain, or if the patient's cardiologist had indicated that the patient should only be permitted to reach a lower level of exertion.

Due to some patients ending the submaximal ergometer bicycle test before the level of watt was finished, that is, 4.5 or 5 minutes, the results of the submaximal bicycle test were calculated according to Strandell.[20] Thereafter, calculations were made to compare the results of patients included in the study with maximal reference values.[21] All calculations are presented in the Supplementary material.

Reference values

Reference values were from Swedish 18- to 80-year olds.[21] The reference values were from the maximal exercise test on a bicycle and, since 2014, are the current reference values used in the Clinical Physiology departments in Sweden. Patients were divided into the following age groups: 18–30, 31–40, 41–50, 51–60, 61–70, and >70 years.[21]

Physical activity

The patient's level of physical activity was assessed with the International Physical Activity Questionnaire – Short Form.[22] Each patient's self-reported physical activity is counted in Metabolic Equivalent of Tasks and divided into one of following three subgroups: *low*, *moderate*, or *high*. Descriptions of each group and calculations can be found in the Supplementary material. The questionnaire has been tested for validity[23,24] and reliability.[22]

Reference values

The results for the adults with CHD were compared with reference values for Swedish men and women aged 18–74 years.[25,26] In accordance with the reference values, patients were divided into the following three age groups: 18–34, 35–54, and 55–74 years.

Health-related quality of life

Self-reported health-related quality of life was assessed with the 36-item Short Form-36[27] consisting of eight scales and has good validity and reliability.[27]

Reference values

The results of the adults with CHD were compared with age- and gender-related reference values in Swedish men and women. Patients were divided into age groups according to the manual of the Short Form-36: 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, and 75+ years.[8]

Statistical methods

Data were analysed using Statistical Package for Social Sciences 20.0 for Windows (IBM Corp., Armonk, NY, United Sates of America), and RStudio[28] for the multiple regression analysis. Demographic data are presented as the mean value and one

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standard deviation. Diagnosis groups were formed based on the division used by the Swedish Registry of CHD.[29]

Classification of CHDs

To form larger groups, CHD categories were combined into the following three groups: *Less complicated*, *Corrected*, and *Complex* diagnoses. The *Less complicated* diagnosis consisted of simple shunts, aortic valve malformations, aortic anomalies, mitral valve lesions, pulmonary valve lesions, and tricuspid valve lesions. The *Corrected* diagnosis consisted of right ventricular/tetralogy of Fallot and transposition of the great arteries. The *Complex* diagnosis consisted of truncus arteriosus, univentricular repair, and others. This arbitrary but prospective division was made to investigate whether differences in exercise capacity could be related to the degree and severity of malformations and to facilitate statistical analysis. The functional class of all patients was determined according to the classification system of the NYHA.[30]

Spearman's rank correlation coefficient was used to calculate correlations for the Short Form-36, and Pearson's correlation coefficient was used to calculate correlations between exercise capacity and physical activity. Correlations were interpreted according to Munro as follows: 0.00–0.25 *Little if any*, 0.26–0.49 *Low*, 0.50–0.69 *Moderate*, 0.70–0.89 *High*, or 0.90–1.00 *Very high*.[31]

The type of multiple linear regression used was Enter, which is a model that allows the authors to include variables thought to explain the dependent variables. It was used to assess the associations between exercise capacity (watt), International Physical Activity Questionnaire (total metabolic equivalent of tasks minutes/week), Short Form-36, sex, age, different diagnosis groups, and NYHA classification which was dichotomised into two groups, NYHA I and NYHA II–IV. Confidence interval was 95%. R^2 is the coefficient of determination and the degree of explanation of each variable.

The independent-samples t-test was used for comparisons of exercise capacity between adults with CHD and reference values. The Mann–Whitney U test was used for calculations with non-parametric data (International Physical Activity Questionnaire and Short Form-36). Tests were two-sided and the significant p-value was set to <0.05.

Results

Recruitment and demographics

Seven hundred and forty-seven (57%) patients performed the tests and 390 patients were men (52%), see Table 1. The medications were as follows: Beta-blockers (21.4%), Angiotensin-converting enzyme inhibitor (10.7%), Warfarin (11%), Aspirin (10.8%), Diuretics (6.7%), Angiotensin 2 blockers (2.1%), Aldosterone inhibitors (1%), Digitalis (2.4%), and other (1.7%).

Exercise capacity

Five hundred and forty-five patients performed the submaximal ergometer bicycle test (251 women, 46%), and the results are presented in Table 2. Furthermore, 88% of the patients reached 15–17 on the Borg ratings of perceived exertion scale when performing the submaximal bicycle test, 7% of the tests were ended prior to reaching 15–17 on the ratings of perceived exertion scale, and 5% of the tests reached more than 15–17. The exercise capacity of patients within the *Less complicated* diagnosis group was 64% (SD ± 17.9) of predicted reference values, while it was 56% (SD ± 16.9) in the *Corrected* group and 51% (SD ± 19.6) in the *Complicated* group.

Physical activity

The International Physical Activity Questionnaire was filled out by 538 patients (279 men, 51.9%). The level of physical activity was determined as *Low* (33%), *Moderate* (38%), or *High* (29%), and each patient's metabolic equivalent of tasks minutes/week was calculated (Table 2).

Men with CHD were not significantly less physically active than healthy reference values for the four following domains: Vigorous, Moderate, Walking, or Total metabolic equivalent of tasks minutes/week. However, they spent significantly more time sitting than healthy men ($p = 0.012$). The physical activity values for women with CHD were significantly less than reference values in the following domains: Vigorous ($p < 0.001$), Moderate ($p < 0.001$), and Total metabolic equivalent of tasks, minutes/week ($p < 0.001$). They also spent significantly more time sitting than healthy women ($p = 0.002$). Approximately, one-quarter, 66 (21.5%) of men and 65 (25.1%) of women with CHD, did not achieve the recommended minimum amount of 500 metabolic equivalent of tasks, minutes/week.[32]

Health-related quality of life

The Short Form-36 was filled out by 545 patients (266 women, 48.8%), the results in relation to healthy reference values are shown in Table 3. Men with CHD scored significantly lower than healthy men in 7 of the 10 scales, and women with CHD scored significantly lower scores in 6 of the 10 scales.

Exercise capacity, physical activity, and health-related quality of life

The strongest correlation was seen between exercise capacity (watt) and the Short Form-36 (physical function) and was a *Moderately* strong correlation ($r = 0.56$). The remaining correlations were either *Little if any* or *Low*. The correlation between exercise capacity and total metabolic equivalent of tasks minutes/week was $r = 0.20$, while the correlation between exercise capacity and following scales of the Short Form-36 is indicated: role physical ($r = 0.29$), bodily pain ($r = 0.24$), general health ($r = 0.37$), vitality ($r = 0.24$), social function ($r = 0.26$), role emotional ($r = 0.23$), mental health ($r = 0.16$), physical component score ($r = 0.42$), and mental component score ($r = 0.1$). The correlation between total metabolic equivalent of tasks, minutes/week, and the following items of the Short Form-36 is indicated: physical function ($r = 0.22$), role physical ($r = 0.07$), bodily pain ($r = 0.12$), general health ($r = 0.20$), vitality ($r = 0.12$), social function ($r = 0.18$), role emotional ($r = 0.12$), mental health ($r = 0.15$), physical component score ($r = 0.16$), and mental component score ($r = 0.13$).

The results of the multiple linear regression analysis are shown in the Supplementary Table S2. The physical components of the Short Form-36 had more statistically significant explanations in the model than did the mental components of the Short Form-36. The R^2 showed the strongest degree of explanation for the Short Form-36 scale physical function for both men and women.

Discussion

Exercise capacity

We found that the exercise capacity, evaluated with a submaximal exercise test, was impaired in adults with CHD when compared with reference values and this finding is consistent with the results from other studies.[3,14] Women had a significantly lower exercise

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Table 1. Descriptive data for the included patients, n = 747

	All patients (n = 747)	Men (n = 390)	Women (n = 357)	p-Values (sex difference)
Age (in years), mean (standard deviation)	35 (13.8)	33 (12.8)	37 (14.7)	0.001
Diagnosis group				
Less complicated (%)	568 (76%)	279 (71.5%)	289 (81%)	0.001
Corrected (%)	139 (18.6%)	92 (23.6%)	47 (13.2%)	
Complex (%)	40 (5.4%)	19 (4.9%)	21 (5.9%)	
NYHA I (%)	618 (82.7%)	340 (87.2%)	278 (77.9%)	0.003
NYHA II (%)	111 (14.9%)	44 (11.3%)	67 (18.8%)	
NYHA III (%)	18 (2.4%)	6 (1.5%)	12 (3.4%)	
NYHA IV (%)	0 (0%)	0 (0%)	0 (0%)	
Reconstructive cardiac surgery (n (%))	577 (77.2%)	316 (81%)	261 (73.1%)	0.010
Smokers (n (%))	68 (9.2%)	34 (8.8%)	34 (9.7%)	ns
Medication (n (%))	328 (43.9%)	173 (44.4%)	155 (43.4%)	ns

Diagnosis groups: *Less complicated* diagnosis consisted of simple shunts, aortic valve malformations, aortic anomalies, mitral valve lesions, pulmonary valve lesions, and tricuspid valve lesions; *Corrected* diagnosis consisted of right ventricular/tetralogy of Fallot and transposition of the great arteries; and *Complex* diagnosis consisted of truncus arteriosus, univentricular repair, and others.

Table 2. Exercise capacity and level of physical activity according to International Physical Activity Questionnaire in adults with CHD

Variable	All patients	Men	Women	p-Values (sex difference)
Submaximal exercise capacity (Watt), mean (SD), n	98.5 (36.6), n = 545	112.4 (37), n = 294	82.1 (28.4), n = 251	<0.001
Submaximal exercise capacity (% of reference values) (SD)	62.2% (18.8)	58.7% (17)	66.3% (20)	
Categories of physical activity				
Low (n (%))	178 (33.1%)	86 (30.8%)	92 (35.5%)	0.001
Moderate (n (%))	204 (37.9%)	92 (33%)	112 (43.2%)	
High (n (%))	156 (29%)	101 (36.2%)	55 (21.2%)	
Total MET (minutes/week), median (25th–75th percentile), n	1416 (584–3021), n = 538	1671 (638–3540), n = 279	1200 (495–2466), n = 259	0.008
Vigorous MET (minutes/week), median (25th–75th percentile), n	160 (0–1050), n = 512	480 (0–1440), n = 264	0 (0–600), n = 247	<0.001
Moderate MET (minutes/week), median (25th–75th percentile), n	160 (0–720), n = 508	240 (0–1440), n = 261	80 (0–480), n = 246	<0.001
Walking MET (minutes/week), median (25th–75th percentile), n	462 (132–1188), n = 517	396 (40–990), n = 267	577.5 (198–1386), n = 249	0.005
Time spent sitting MET (minutes/week), median (25th–75th percentile), n	300 (180–480), n = 418	300 (210–540), n = 222	300 (180–480), n = 196	0.046

MET = metabolic equivalent of tasks; SD = standard deviation.

capacity compared with men, and this is in accordance with the results from healthy persons and from previous studies of adults with CHD.[3]

Previous studies have shown that patients' self-estimated physical function poorly predicts exercise capacity,[14] and exercise capacity needs to be objectively assessed before giving advice or recommendations for exercise. The importance of an exercise test prior to starting an aerobic exercise training programme has also been strongly emphasised[18] so that a valid individual exercise training programme can be prescribed and evaluated. Individualised exercise programmes for patients' unaccustomed to exercise or previously restricted from exercise can be prescribed by physical therapists and may help patients increase their exercise capacity. Exercise capacity was lower in the "*Less complicated*" diagnosis group, thus demonstrating the need to provide all patients the opportunity to have their exercise capacities evaluated.

Patients aged 35 years performed at 62.2% of the age-adjusted reference values for exercise capacity (Table 2), thus we must consider how exercise capacity continues to develop and impact these patients' activities of daily living with advancing age. In addition, an impaired exercise capacity impacts the prognosis of these patients.[4]

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Table 3. Health-related quality of life according to the Short Form 36 in adults with CHD

	Men			Women			p-Values (men and women with CHD)
	With CHD (n = 279)	Reference value	p-Values	With CHD (n = 266)	Reference value	p-Values	
Physical function	92.3	93.3	0.004	85.4	89.2	0.003	<0.001
Physical role function	86.2	89.4	<0.001	74.9	84.4	<0.001	<0.001
Bodily pain	84.2	80	<0.001	74.9	74.4	0.063	<0.001
General health	73.7	79.5	0.062	67.2	77.1	<0.001	<0.001
Vitality	66	71.8	0.009	59.4	67.1	<0.001	<0.001
Social function	89.2	90.7	<0.001	84.7	88.3	0.022	0.003
Role emotional	85.4	89.2	<0.001	77.7	85.3	<0.001	<0.001
Mental health	79.2	82.2	0.975	75.1	79.9	0.339	0.003
Mental component score	48.1	50.4	0.006	46.4	49.2	0.715	0.036
Physical component score	52.3	52.4	<0.001	48.4	50.5	0.278	<0.001

Higher scores are indicative of a better health-related quality of life.

Physical activity

One-quarter (23.2%) of the patients in this study were physically active less than 500 metabolic equivalent of tasks, minutes/week, and therefore did not achieve the recommended levels of physical activity for healthy persons. Low levels of physical activity are a risk factor as inactive persons have a higher risk of cardiovascular disease compared to active persons.[33] On the other hand, three-quarters (76.8%) were actually active enough to meet the recommendations of at least 500 metabolic equivalent of tasks, minutes/week.[34] Other authors have also found a decreased level of physical activity in adults with CHD.[6] However, a Swedish study using accelerometers showed that adults with CHD follow the same physical activity pattern as healthy controls.[35]

There is presently a lack of recommendations regarding physical activity and exercise for adults with CHD. The recommendations for healthy persons might not be optimal as adults with CHD might be more susceptible to diabetes,[36] hypertension, obesity, and coronary artery disease.[37] To reduce mortality in patients with chronic heart failure and cardiovascular disease, secondary preventive efforts, such as more exercise, are needed once ill.[38] Therefore, special physical activity and exercise recommendations for adults with CHD might be desirable.

Health-related quality of life

In this article, we present values for health-related quality of life measured with the Short Form-36 in Swedish adults with CHD. Men with CHD had significantly lower scores in seven scales compared with healthy men. In the scale bodily pain, men with CHD surprisingly scored pain significantly less than healthy men. Women with CHD had a significantly lower score in six scales compared with healthy women (Table 3). Women with CHD also scored less in the bodily pain scale than healthy women.

Previous studies found ambiguous results concerning health-related quality of life in adults with CHD. In some studies, health-related quality of life in adults with CHD did not differ from healthy persons,[39] while it was also reported as lower, especially the physical function scale.[14,40] Swedish studies in adults with CHD have investigated health-related quality of life using the EuroQol five dimension scale, but the Short Form-36 has not been used before in Swedish adults with CHD. Using multiple regression analysis, we found that age was significant regarding all five of the physical components of the Short Form-36 for men. However, in women, the NYHA classification was more frequently associated with the physical components than age was.

The strongest correlation in this study was between exercise capacity and the Short Form-36 physical function scale, indicating that exercise capacity is important for the health-related quality of life of these patients.

Limitations of the present study

The results of the submaximal tests were derived from calculations of the maximal reference values, which is a limitation. However, the study described an equation which made comparisons between two tests possible. If patients were older or younger than the available reference values, these patients were grouped together and calculated with the nearest reference value available, as opposed to excluding these values from analysis. Different types of categorisations of CHD have been published; however, when this study was conducted, there was no consensus in classifications why this classification was used. The reasons why patients opted to decline were not registered, which is a limitation. All included patients, did not complete all tests, that is, the exercise test as well as both questionnaires, and the reasons why were not registered. Self-reported levels of physical activity are known to be overestimated when correlated to objective measures of physical activity [24]; therefore, when calculating the results of International Physical Activity Questionnaire, if the patient had written an estimation of the time or day spent on physical activity, the lowest number the patient had estimated was used.

Conclusion

Exercise capacity was impaired in all adults with CHD, including those with less complicated CHD. One-quarter of the patients did not achieve the recommended levels of physical activity. Exercise tests followed by individualised exercise prescriptions may be offered to all patients with CHD aiming to increase exercise capacity, levels of physical activity, improve health-related quality of life, and reduce the risk of acquired life-style diseases.

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Conflicts of Interest. None.

Ethical Standards. The authors assert that all procedures contributing to this work comply with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the regional ethics board in Gothenburg, Sweden.[41]

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S104795112000075X

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