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# Responses to arm and treadmill exercise testing in patients with heart failure

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Research Report

**Purpose:** There is a paucity of research regarding the relationship between upper extremity function and exercise tolerance in patients with heart failure (HF). This study aimed to perform arm and treadmill exercise testing and to compare responses to the tests in patients with HF. **Material and methods:** Twenty-five patients with heart failure participated in the study. All patients underwent two maximal symptom-limited exercise tests with gas exchange analysis on treadmill and arm ergometer. **Results:** At peak exercise level, heart rate, systolic and diastolic blood pressures, rate-pressure product, peak oxygen consumption, and peak exercise duration were significantly higher during treadmill than during arm ergometry testing ($p<0.05$). Respiratory exchange ratio at peak exercise was higher during the arm exercise test compared to the treadmill test ($p<0.05$). **Conclusion:** Exercise capacity of the arms is lower than the exercise capacity of the legs in patients with HF. There is need for future researche carried out with larger samples, to compare the different exercise testing modalities in HF.

**Keywords**: Arm ergometry test, Exercise test, Heart failure.

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## Kalp yetmezliği olan hastaların kol ve koşubandı egzersiz testi yanıtları

**Amaç:** Kalp yetmezliği olan hastalarda üst ekstremitelerin fonksiyonu ve egzersiz toleransı arasındaki ilişkiye yönelik araştırmalar kısıtlıdır. Bu çalışma kalp yetmezliği olan hastalarda kol ve koşubandı egzersiz testlerini uygulamayı ve bu testlere cevapları karşılaştırmayı amaçladı. **Gereç ve yöntem:** Kalp yetmezliği olan 25 hasta çalışmaya katıldı. Tüm hastalar koşubandı ve kol ergometresinde gaz değişim analizleri ile birlikte maksimal semptomla limitli iki egzersiz testine girdi. **Sonuçlar:** Koşubandı egzersiz testindeki zirve egzersiz düzeyinde kalp hızı, sistolik ve diastolik kan basınçları, hız-basınç çarpımı (double product), zirve oksijen tüketimi, ve zirve egzersizin süresi kol ergometresi egzersiz testinden anlamlı düzeyde daha yüksekti ($p<0.05$). Kol egzersiz testi esnasındaki respiratuar değişim oranı koşubandı testine kıyasla daha yüksek bulundu ($p<0.05$). **Tartışma:** Kalp yetmezliği olan hastalarda kolların egzersiz kapasitesi bacakların egzersiz kapasitesinden daha düşüktür. Kalp yetmezliğinde farklı egzersiz testi modalitelerini karşılaştırmak için daha geniş örneklemlerle yapılan gelecek araştırmalara ihtiyaç vardır.

**Anahtar kelimeler:** Kol ergometre testi, Egzersiz testi, Kalp yetmezliği.

Exercise testing with ventilatory expired gas analysis is a popular and widely used tool to determine prognosis and functional capacity in patients with heart failure (HF).[1-5] Although arm ergometer tests are typically used to evaluate exercise capacity of paraplegic individuals and patients with chronic obstructive pulmonary diseases,[6-7] the treadmill and leg cycle are preferred over the arm ergometer for patients with HF.[2,8-9] One report indicates that patients with HF have some symptoms such as dyspnea, fatigue and sore muscles during housework/yardwork.[10] Sunnerhagen et al found that a reduction in muscle performance was present in muscle groups, but specifically in the hand grip.[11] Myers states that exercise test can provide information for support important recommendation that engage in an exercise program.[12] Based on the information we thought that there is a need to use arm ergometer test for evaluating physical performance related to upper extremities in HF.

The present study was planned to compare the responses of patients with HF during arm and treadmill test. We hypothesized that exercise capacity of arms would be lower than exercise capacity of legs.

## Material and methods

**Patients:**

The study included twenty-five ambulatory patients with HF. All patients were clinically stable for at least 3 months before the study and had New York Heart Association class II or III chronic HF. Exclusion criteria were; valvular heart disease, exercise-induced cardiac arthymias, symptomatic myocardial ischemia and taking beta-blocker drugs. Ten of the patients were considered ischemic cardiomyopathy who had a myocardial infarction or had angiographic evidence of coronary artery disease that could explain the extent of ventricular dysfunction. The other 15 patients, those who did not meet the above criteria, were considered as having idiopathic dilated cardiomyopathy. All patients gave written informed consent before participating.

**Exercise testing:**

All patients underwent two maximal symptom-limited exercise tests (treadmill and arm ergometer) with expiratory gas analysis. Before the tests, a medical examination was completed including clinical examination (height, body mass index), blood pressure, cardiopulmonary auscultation, and a resting 12-lead electrocardiogram. Patients were informed about all of the testing procedures including the two exercise tests. Subjects were called to our laboratory to perform tests in two separate days. The tests were done at the same time of each day. A monitorized treadmill (Max1 Marquette, 1995 Milwaukee, USA) a Monark arm ergometer (Model 881 E, Monark, Sweden) and a SensorMedics $V_{max}$ 29 Ergospirometry System (SensorMedics, Yorba Linda, California, USA), calibrated before the start of each study, were used in the study.

Treadmill exercise testing was performed using the modified Bruce protocol.[13] When arm testing was performed, patients were seated in a chair with both feet placed flat on the floor. The arm ergometer was placed on a table at a height of 70 cm, and the axle of the ergometer was set at or near heart level. Workloads of the arm ergometer test began with a warm-up of 0 watts and increased by 10-watt increments. Each stage lasted three minutes, and patients were instructed to maintain a cranking rate of 50 rpm, which was monitored electronically. Endpoints of the two tests included a rating of perceived exertion ≥16 on a scale that ranges between 6 and 20 (with 6 representing little exertion and 20 representing very heavy exertion),[14] achievement of age-predicted maximal heart rate, and/or inability to maintain walking or arm cranking.[15]

During all tests, systolic and diastolic blood pressures, heart rate, rating of perceived exertion, and rate-pressure products were recorded after 30 minutes of rest, at the end of each stage of exercise, at peak exercise, and during recovery. Systolic and diastolic blood pressures were measured using a standard cuff and sphygmomanometer. Heart rate was measured using a 12-lead electrocardiogram. A rating of perceived exertion was assessed using the Borg

scale.[14] Rate-pressure products were obtained by multiplying the systolic blood pressure by the heart rate, and this value was divided by 100. Peak oxygen consumption ($VO_2$) was measured continuously by indirect calorimeter.

**Statistical Analysis:**

Continuous variables were expressed as the mean ± standard deviation. Paired *t* tests were used to compare exercise-testing parameters on the arm ergometer and on the treadmill. All statistical analyses were performed using SPSS software (Statistical Package for the Social Sciences, version 10.0, SSPS Inc, Chicago, USA). Values for *p* less than 0.05 were regarded as statistically significant.

## Results

Demographic characteristics of the panties are seen in Table 1.

**Table 1. Demographic characteristics of the patients (N=25).**

| | X±SD |
|---|---|
| **Age** (years) | 51±8.5 |
| **BMI** (kg/m$^2$) | 27.2±3.3 |
| | **n (%)** |
| **Gender** | |
| Female | 19 (76) |
| Male | 6 (24) |
| **Ischaemic cardiomyopathy** | 10 (40) |
| **Idiopathic dilated cardiomyopathy** | 15 (60) |

Resting heart rate, systolic-diastolic blood pressures, and rate-pressure product were similar between the two tests ($p>0.05$) (Table 2).

Heart rate, systolic-diastolic blood pressures, rate-pressure product, and peak $VO_2$ level were significantly higher at peak exercise during the treadmill test than they were during the arm ergometer test ($p<0.05$). Despite a lower peak exercise duration, rating of perceived exertion value during arm ergometry was not different from that of the treadmill, and respiratory exchange ratio at peak exercise was higher during the arm exercise test compared to that of the treadmill test ($p<0.05$) (Table 3).

## Discussion

Exercise intolerance is the main symptom in patients with HF. Most studies assessed exercise intolerance as related to lower extremity activities, but little research has been performed regarding the relationship between upper extremity functions and exercise tolerance.[16-17] Both upper and lower extremity functions are necessary for daily activities. However, compared with the lower extremities, the upper extremities have different physiological exercise responses and may contribute to a decrease in quality of life as a result of reduced work capacity in HF. We believed that assessing patients with HF using both exercise test modalities would yield important information with regard to work capacity. In our study we performed both arm and treadmill exercise testing to the patients and compared their results.

In this study, patients reached significantly lower peak exercise heart rate, peak rate-pressure product, peak exercise duration, and peak $VO_2$ levels on the arm ergometer than they did on the treadmill. Studies have shown that peak $VO_2$ level is closely related to prognosis in HF.[8,18-21] A peak $VO_2$ level less than 10 ml/kg/minute is an indicator of high risk; while a peak $VO_2$ level greater than 18 ml/kg/minute is indicative of low risk chronic HF. Peak $VO_2$ level less than 14 ml/kg/minute are indicator of HF patients who are candidates for transplantation.[19-22] In our samples, all patients had peak $VO_2$ levels greater than 14 ml/kg/minute on both tests.

During exercise testing, systolic blood pressure is a significant prognostic parameter.[8] According to a new report, if the peak exercise value is greater than 120 mm Hg, survival is equal to 83%; however, if it is less than 120 mm Hg, survival is 55% .[18] In the current study, during arm and treadmill tests, mean peak systolic blood pressure values were higher than 120 mm Hg. These findings should not be interpreted as arm testing can be performed to measure true peak $VO_2$ in patients with HF. Treadmill is most widely used test modality in HF. We can only say when the arm

**Table 2. Resting parameters of the patients before the tests.**

| | During arm testing X±SD | During treadmill testing X±SD | |
|---|---|---|---|
| **Heart rate** (beats/min) | 84.3±12.5 | 83±7.8 | * |
| **Systolic blood pressure** (mmHg) | 118±14.4 | 116.2±17.3 | * |
| **Diastolic blood pressure** (mmHg) | 78.6±8.7 | 79.8±10.2 | * |
| **Rate-pressure product** (mmHg) | 90.1±18 | 96.2±17.7 | * |

* p>0.05.

**Table 3. Peak exercise parameters of the patients during the tests.**

| | During arm testing X±SD | During treadmill testing X±SD | |
|---|---|---|---|
| **Heart rate** (beats/min) | 124±22.2 | 139.9±20.1 | ** |
| **Systolic blood pressure** (mmHg) | 131.6±23.2 | 146±26.2 | ** |
| **Diastolic blood pressure** (mmHg) | 83±11.9 | 90.2±12.8 | ** |
| **Rate-pressure product** (mmHg) | 165.2±43.6 | 201±37.7 | ** |
| **Peak $O_2$ consumption** (ml/kg/min) | 15±4.1 | 21.1±6.3 | ** |
| **Peak exercise durations** (sec) | 384.8±173.3 | 615.4±219.2 | ** |
| **Respiratory exchange ratio** | 0.91±0.1 | 0.96±0.1 | ** |
| **Rating of perceived exertion** | 16.6±3.5 | 16.3±3.2 | * |

* p>0.05, **p<0.05.

test becomes a necessity in any situation, such as for exercise testing in a patient with HF who also has walking limitation; it may provide at least a little information about prognosis.

Peak $VO_2$ levels were significantly higher during treadmill exercising compared with arm exercising. The finding was not surprising. Muscle mass is one of the important determinants for peak $VO_2$.[8,18] The treadmill exercise test requires movements that utilize leg, arm, and trunk muscles, while the arm testing involves smaller muscle mass. This fact would seem to explain the differences in peak $VO_2$ levels between the two tests.

In the literature, no study has compared treadmill and arm ergometer test results in patients with HF. Keteyian and coworkers have evaluated responses to arm exercise and to leg exercise by arm and cycle ergometer in HF. Similar to our results, they observed that peak $VO_2$ levels and other testing parameters were lower during arm exercising than they were during leg exercising.[16] In addition, our results are consistent with the findings of studies in healthy subjects[16], and in patients with chronic obstructive pulmonary diseases.[6]

Respiratory exchange ratio is an important exercise parameter in cardiac patients. When it is greater than one, subjects reach adequate exercise level.[17] Our sample's mean respiratory exchange ratio came close to one during the two tests (0.91-0.96). When we compared the value between two tests, it was significantly higher during the arm test than during the treadmill test.

Despite the lower exercise duration in the arm test, ratings of the perceived exertion levels were similar (which were about 16) for both tests. Our results indicated that our HF patients were able to

motivate themselves and continue the arm test until irresistible fatigue. A rating of perceived exertion scale is a valid measurement of physiological exercise intensity during testing and training.[22] Borg demonstrated that heart rate and the rating of perceived exertion are linearly related.[23] Our patients' ratings of perceived exertion levels were similar, but heart rate responses were different during the two tests. Higher heart rates were reported during the treadmill test. Research indicates that individuals with cardiac disease or other medical problems have discrepancies in the relationship between heart rate and rating of perceived exertion relationship,[24-25] that do not occur in healthy people. Lee at al study evaluated the responses of arm exercise alone in patients with HF and they found lower that peak heart rate during arm test than during leg exercises. Our results were in accordance with the literature.[17]

It must be noted that our study has several limitations. Because of small sample size, our results may not characterize the general HF patients. In addition, our study did not include a healthy control group. Unfortunately, these limitations do not allow to distinguish clearly the responses of the "arm ergometer testing" from the "treadmill exercise testing" in patients with HF.

In conclusion, our sample's peak $VO_2$ and peak heart rate values were significantly higher during treadmill than during arm ergometer testing in patients with HF. These data suggest that exercise capacity of arms was lower than exercise capacity of legs in patients with HF. Most patients do not perform exercises for upper extremities but they use them in everyday activities. In addition to leg exercise test, to use arm ergometer test may be helpful for assessing the patient's exertion intolerance in daily and occupational activities involving the arms and upper body. Exercise testing modalities and protocols must be chosen to according each patient's specific limitations, and a number of factors including disease severity, symptoms of dyspnea and fatigue, individual needs and possibilities. There is a need for further research, which will be carried out with larger sample groups, to compare the different exercise testing modalities in patients with HF.

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