Journal of Exercise Physiologyonline
(JEPonline)

Volume 8 Number 4 August 2005

Official Research Journal of The American Society of Exercise Physiologists (ASEP)

ISSN 1097-9751

Clinical Exercise Physiology

COMPARING METHODS FOR PRESCRIBING EXERCISE FOR INDIVIDUALS WITH CHRONIC HEART FAILURE

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ABSTRACT

Jeremy A. Patterson, Steve E. Selig, Deidre Toia, Ralph H. Geerling, Voramont Bamroongsuk, David L. Hare. Comparing Methods For Prescribing Exercise For Individuals With Chronic Heart Failure. ***JEP**online* 2005;8(4):9-19. This study examined the accuracy of current recommended guidelines for prescribing exercise intensity using the methods of percentage of heart rate reserve (%HRR), percentage of VO_2 peak (%VO_2peak) and percentage of VO_2 reserve (%VO_2R) in a clinical population of chronic heart failure (CHF) patients. The precision of prescription of exercise intensity for 45 patients with stable CHF (39:6 M:F, 65±9 yrs (mean±SD)) was investigated. VO_2peak testing is relatively common among patients with cardiac disease, but the assessment of VO_2rest is not common practice and the accepted standard value of 3.5 mL/kg/min is assumed in the application of %VO2R (%$VO_2R_{3.5}$). In this study, VO_2rest was recorded for 3 min prior to the start of a symptom-limited exercise test on a cycle ergometer. Target exercise intensities were calculated using the VO_2 corresponding to 50 or 80 %HRR, VO_2peak and VO_2R. The VO_2 values were then converted into prescribed speeds on a treadmill in km/hr at 1 %grade using ACSM's metabolic equation for walking. Target intensities and prescribed treadmill speeds were also calculated with the %VO_2R method using the mean VO_2rest value of participants (3.9 mL/kg/min) (%$VO_2R_{3.9}$). This was then compared to the exercise intensities and prescribed treadmill speeds using patient's measured VO_2rest. Error in prescription correlates the difference between %$VO_2R_{3.5}$ and %$VO_2R_{3.9}$ compared to %VO_2R with measured VO_2rest. Prescription of exercise intensity through the %HRR method is imprecise for patients on medications that blunt the HR response to exercise. %VO_2R method offers a significant improvement in exercise prescription compared to %VO_2peak. However, a disparity of 10 % still exists in the %VO_2R method using the standard 3.5 mL/kg/min for VO_2rest in the %VO_2R equation. The mean measured VO_2rest in the 45 CHF patients was 11 % higher (3.9±0.8 mL/kg/min) than the standard value provided by ACSM. Applying the mean measured VO_2rest value of 3.9 mL/kg/min rather than the standard assumed value of 3.5 mL/kg/min proved to be closer to the prescribed intensity determined by the actual measured resting VO_2. These results suggest that the %HRR method should not be used to prescribe exercise intensity for CHF patients. Instead, VO_2 should be used to prescribe exercise intensity and be expressed as %VO_2R with measured variables (VO_2rest and VO_2peak).

Key Words: Metabolic equations, Chronic Heart Failure, %VO_2R, Resting VO_2

INTRODUCTION

Physiological benefits gained from exercise training rely primarily on the intensity of the training stimulus. The prescribed intensity fraction can be alternatively applied using an absolute or relative approach. Absolute intensity is to prescribe a workload, such as 80 Watts on a cycle ergometer or a set caloric expenditure in a set time period (1). In this approach to intensity prescription, each person performing the set workload is under different physiological stress, *relative* to that person. Alternatively, exercise intensity is often prescribed by the relative physiological stress placed upon the body. The relative intensity is usually determined as a percentage of a maximum capacity, such as maximal heart rate, maximum oxygen capacity (VO_2peak), or maximum exercise capacity (1). Subsequently, the target exercise intensity is prescribed by assigning a calculated value, which corresponds to a percentage of the particular maximum.

This leads to two questions that should be addressed in order to establish optimal exercise training intensity for individuals with chronic heart failure (CHF):

1. What is the optimal target range of exercise intensity for this population?
2. How is the optimal target range of exercise intensity best determined?

Individuals that are at high risk, such as those with cardiac, pulmonary, and other chronic diseases, who develop signs of exertional intolerance such as ischemia or hypoxemia at specific workloads, need an accurately computed and prescribed exercise intensity (2). Reference measures that have been used to computed and prescribe exercise in these patient populations include percentage of heart rate max (%HRmax), heart rate reserve (HRR), VO_2peak, and more recently VO_2 reserve (VO_2R). The %HRmax method is often used with the general population by estimating HRmax as 220 - age and establishing the target heart as a percentage of HRmax (2). %HRR refers to a percentage of the difference between resting HR and maximum HR (i.e., heart rate range).

The formula used to calculate target HR by the %HRR method is:
Target HR = (intensity fraction%)(HRmax – HRrest) + HRrest (3).

This approach to calculating a target training heart rate gives a higher value compared to the heart rate computed as the percentage of HRmax, if both were calculated using the same percentage (e.g., 70 %). Furthermore, the %HRR method more closely corresponds to a prescribed VO_2 than does a set percentage of HRmax (4). For a healthy person, HR is a useful approach to prescribing intensity, because it increases linearly with oxygen consumption and can be cross-referenced with other objective and subjective indices of exercise intensity (2).

VO_2peak describes the amount of oxygen a person uses per kilogram of body weight in one minute (mL/kg/min). The VO_2peak value is a reasonable reference point from which to estimate exercise intensity as a percentage of VO_2peak, in an analogous fashion to HRmax. In 1998, the American College of Sports Medicine (ACSM) proposed the use of a new reference for prescribing exercise, namely the oxygen consumption reserve indice (%VO_2R) and in 2000 revised its exercise guidelines (2). Similar to %HRR, %VO_2R represents a percentage of the difference between VO_2rest and VO_2peak.

The formula used to calculate the target workload as a percentage of VO_2R (%VO_2R) is:
Target work rate will correspond to the VO_2 = (intensity fraction%)(VO_2peak – VO_2rest) + VO_2rest (3).

Exercise intensities have been recommended by the ACSM corresponding to 40-85 % of oxygen uptake reserve (%VO_2R) or heart rate reserve (%HRR) for healthy adults and 40-50 % of VO_2R or HRR for patients with heart disease (3). However, recommendations for patients with CHF have not been well established. Prior to ACSM including %VO_2R as an alternative to exercise prescription, intensity for all people (healthy and patients) was prescribed as percentages of HRmax, HRR, and VO_2peak. The reason for now questioning the use of these other methods is not due to a problem of over-prescribing exercise, but the reverse: exercise prescriptions were often of too low intensities to be effective in these patients.

Studies show that using the %HRR method for exercise prescription will give intensities that are closer to the targeted intensity than by using the %HRmax method (2). That is assuming the resting HR, HRmax and rhythm are not affected by a person’s medical condition or medications. Most patients with CHF are on HR-modulating medications that modify the response to exercise. For instance, exercise prescription by HR is insensitive to patients taking prescribed medications that blunt the HR response to exercise (5) (e.g., Beta-blockers (3)). This could lead to errors and unsafe exercise prescription in this population (6).

Medication therapy in CHF can influence HR (Table 1) leading to difficulties in calculating target HR intensities. Heart rate target range is often very narrow (7) due to high resting HR and low peak HR (e.g., atrial fibrillation), or low resting HR and low peak HR (e.g., beta-blockade) making it difficult to use the %HRR method. Thus, exercise prescription for patients with CHF should be based on VO_2 rather than HR.

VO_2R vs. %VO_2peak Method

Recent studies have shown that a disparity exists between %HRR and VO_2peak with %HRR being more closely equivalent to %VO_2R (8; 9). Thus, when intensities are set to a percentage of VO_2R, the value is similar to the percent value for the HRR (8). However for the reasons already espoused above, %HRR is problematic in patients with heart failure.

Findings from the Henry Ford Heart & Vascular Institute showed that when prescribing exercise to patients with heart disease based on VO_2, relative intensity should be given as %VO_2R (10). Target intensity using this method is calculated by the VO_2R formula: Target VO_2 = (intensity fraction)(VO_2peak – VO_2rest) + VO_2rest.

Measured Resting VO_2 vs. Predicted Resting VO_2

The next step in accurate and valid exercise prescriptions for these patients is to accurately measure resting VO_2 as well as VO_2peak. Average resting VO_2 is widely assumed to be 3.5 mL/min/kg and is recommended by ACSM to be used in the %VO_2R formula (3). Although research has shown that

%VO_2R is closer to %HRR than %VO_2peak in a healthy population, it has been reported that there is a 6% discrepancy between %HRR and %VO_2R in heart failure (10). To examine this further, resting VO_2 was measured in patients in the present study.

Table 1. Effects of Medications on HR, BP, the ECG, and Exercise Capacity.

ledications	*HR*	*BP*	*ECG*	*Exercise Capacity*
-Blockers (including arvedilol, labetalol)	↓ (R and E)	↓ (R and E)	↓ HR (R) ↓ ischemia (E)	↑ in patients with angina ↓ or ↔ in patients without angina
litrates	↑ (R) ↑ or ↔ (E)	↓ (R) ↓ or ↔ (E)	↑ HR (R) ↑ or ↔ HR (E) ↓ ischemia (E)	↑ in patients with angina ↔ in patients without angina ↑ or ↔ in patients with CHF
igitalis	↓ in patients with AF and possibly CHF Not significantly altered in patients with SR	↔ (R and E)	May produce nonspecific ST-T wave changes (R) May produce ST segment depression (E)	Improved only in patients with AF or in patients with CHF
iuretics	↔ (R and E)	↔ or ↓ (R and E)	↔ or PVCs (R) May cause PVCs and “false positive” test results if hypokalemia occurs May cause PVCs if hypomagnesemia occurs (E)	↔, except possibly in patients with CHF
'asodilators, onadrenergic	↑ or ↔ (R and E)	↓ (R and E)	↑ or ↔ HR (R and E)	↔, except ↑ or ↔ in patients with CHF
CE Inhibitors	↔ (R and E)	↓ (R and E)	↔ (R and E)	↔, except ↑ or ↔ in patients with CHF

Adapted from ACSM 2000
↑ = increase; ↔ = no effect; ↓ = decrease; R = rest; E = exercise; HR = heart rate; PVCs = premature ventricular contractions; AF = atrial fibrillation; SR = sinus rhythm

METHODS

Participants

The cohort consisted of 45 patients with stable CHF (39:6 male:female) aged 65±9 years (mean±SD), left ventricular ejection fraction (LVEF%) 27±7%, and the number of patients with New York Heart Association functional classification II and III was 31 (69 %) and 14 (31 %), respectively. Twenty-nine patients had ischaemic cardiomyopathy, one had valvular disease, and the other 15 had dilated cardiomyopathy. Most were on an angiotensin converting enzyme inhibitor or angiotensin receptor blocker, and a diuretic. These and other medications that patients were taking at entry into the study are summarized in Table 2.

Exercise Testing

VO_2peak tests were conducted in a hospital exercise laboratory. After written, informed consent was obtained; all participants underwent a familiarization maximal bicycle exercise test one week prior to baseline testing to decrease effects of anxiety on VO_2rest. Patients were given several minutes to adapt to the mouth piece and two-way non-rebreathing valve, then resting VO_2 values were recorded for 3 min prior to the start of exercise in an upright position.

Peak total body oxygen consumption (VO_2peak) was determined during a symptom-limited graded exercise test (17) on an electronically-braked cycle ergometer (Ergomed, Siemens, Erlangen, Germany), commencing at 10 Watts and increasing by 10 Watts/min. Measurements were made each minute for VO_2 and VCO_2 (OM-11 Medical Oxygen Gas Analyser, and LB2 Medical Carbon Dioxide Gas Analyser; Beckman, Fullerton, CA, USA), minute ventilation (V_E (BTPS), 47304A respiratory flow transducer with Fleisch pneumotach, Hewlett Packard, USA), heart rate (EK43 Multiscriptor 12 lead ECG, Hellige, Belgium), arterial oxygen saturation (Biox 3700 Pulse Oximeter, Oxi-Radiometer, Boulder, Colorado, USA) and self-ratings of perceived exertion. Respiratory exchange ratio (RER) was measured each minute and RERpeak and HRpeak were used as indices of metabolic stress at the end of the VO_2peak test. All instrumentation used in the measurement of VO_2peak was calibrated using standard methods before and immediately after each test. Patients continued cycling until they were no longer able to maintain at least 60 rev/min, or cardiovascular signs or symptoms intervened.

Statistical Analyses

Exercise intensities of 50 and 80 % were used to match against the study by Brawner et al (10). Target rates were calculated by using $\%VO_2R$ in mL/kg/min and converting the values into prescribed speed on a treadmill in km/hr on a 1% grade. A grade of

Table 2. Descriptive characteristics of the 45 CHF Patients who underwent VO_2peak testing.

HF patients (n=45)	Characteristics
ge, yrs	65 ± 9
ale / Female	39 / 6
leight (cm)	170 ± 8
ody mass (kg)	81.5 ± 15
VEF%	27 ± 7
IYHA	2.3 ± 0.5
ody mass index (kg/m)	27.9 ± 5.6
eak VO_2 (mL/kg/min)	15.7 ± 4.3
eak heart rate (beats/min)	126 ± 25
esting heart rate (beats/min)	73 ± 15
PEpeak	16.7 ± 1.5
ERpeak	1.16 ± 0.15
HF diagnosis *N* (%)	
Ischemic heart disease	29 (64%)
Dilated cardiomyopathy	15 (33%)
Valvular	1 (2%)
hythm *N* (%)	
Sinus	35 (78%)
Atrial Fibrillation	7 (15%)
Paced	3 (7%)
ledications *N* (%)	
ACE inhibitor or angiotensin receptor blocker	35 (78%)
Diuretic	38 (84%)
Beta-blocker	21 (47%)
Digoxin	18 (40%)
Aspirin	27 (60%)
Warfarin	19 (42%)
Amiodarone	7 (16%)
Nitrates	8 (18%)
Calcium channel antagonist	4 (9%)

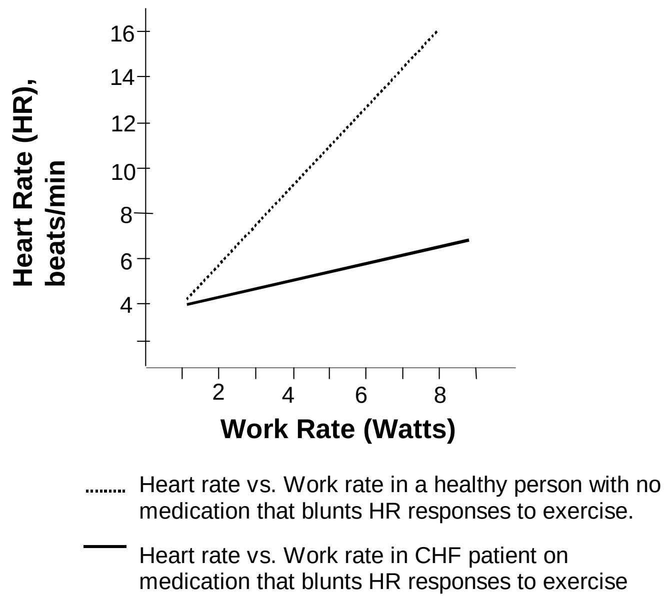
RPEpeak, peak self-rating of perceived exertion (Borg 6-20 point scale); RERpeak, (VCO_2/VO_2 ratio); LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

1% was selected because it caused less musculo-skeletal and joint jarring than 0%, as many individuals with CHF also have arthritic hips and knees. Prescribed speeds for each patient were calculated using the methods of %HRR, $\%VO_2peak$, $\%VO_2R_{3.5}$ and $\%VO_2R$ using the mean VO_2rest value of the studies participants (3.9 mL/kg/min; $\%VO_2R_{3.9}$) and was then compared to each patient's measured resting VO_2. ANOVA's with repeated measures were applied with post-hoc analyses conducted using the LSD method to locate the means that were significantly different. All of these statistical analyses were performed using SPSS (version 13; Chicago, IL). The level of significance was set at $P<0.05$ for all variables. All data are reported as mean±SD.

RESULTS

Subject characteristics were described in Methods and Table 2. All 45 patients were able to complete the testing, although two had discomfort with the mouthpiece and were not included in the overall analysis.

To reveal the theoretical basis of the heart rate estimation method when using individuals with disease, Figure 1-3 present representative heart rat responses. Figure 1 presents heart rate response curves for a heart rate medicated individual with CHF and a non-diseased individual. Figures 2 and 3 compare the heart rate extrapolation for exercise prescription for a normal (Figure 2) and diseased and medicated (Figure 3) individual.



The disparities between the four methods of %HRR, $\%VO_2peak$, $\%VO_2R_{3.5}$, and $\%VO_2R_{3.9}$, compared to $\%VO_2R$ using a measured VO_2rest are shown collectively in Figure 4. Exercise prescription based on $\%VO_2R$ with resting VO_2 measured and $\%VO_2R_{3.9}$ were not significantly different from one another. In contrast, prescription using $\%VO_2R_{3.5}$, $\%VO_2peak$ and %HRR were all significantly different from the actual resting VO_2 measured value.

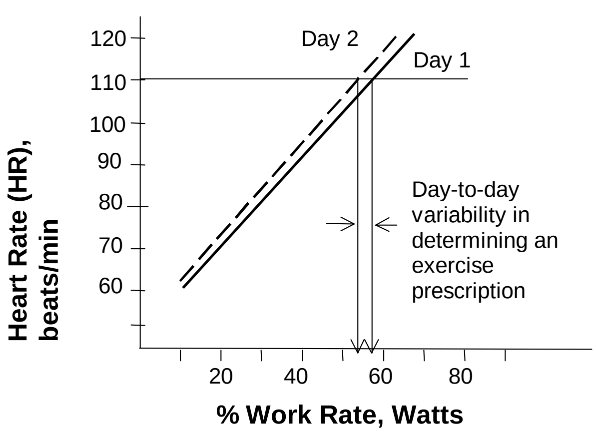


Figure 2. Representation of a normal linear heart rate response to exercise in an adult on no medication and showing a small margin of error in prescribed exercise intensity when HR is used.

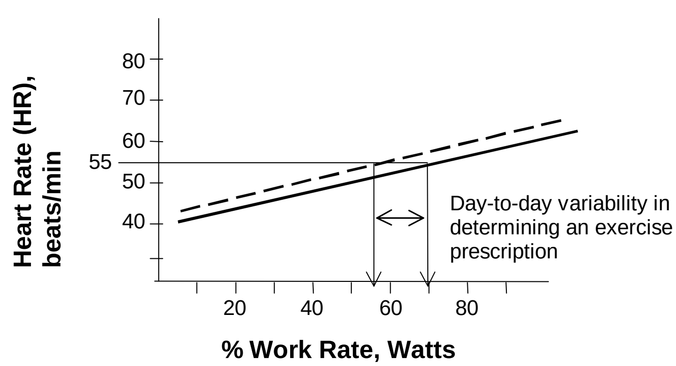


Figure 3. Representation of the HR response to exercise in a patient with CHF caused by prescribed medication and how it magnifies the error in exercise prescription when HR is used.

Table 3 presents results of the statistical analyses for pair-wise comparisons of the data of Figure 4.

Table 3. Comparison of disparities between prescribed exercise intensities based on %VO_2R with measured VO_2rest, using the methods of %HRR, %VO_2peak, %$VO_2R_{3.5}$, and %$VO_2R_{3.9}$.

CHF Patients (N = 43)	
lethod (at 50 and 80%)	**P value**
6HRR	0.997
6VO_2peak	0.969
6VO_2R (3.5 mL/kg/min)	0.489
6VO_2R (3.9 mL/kg/min)	0.034*

* P<0.05

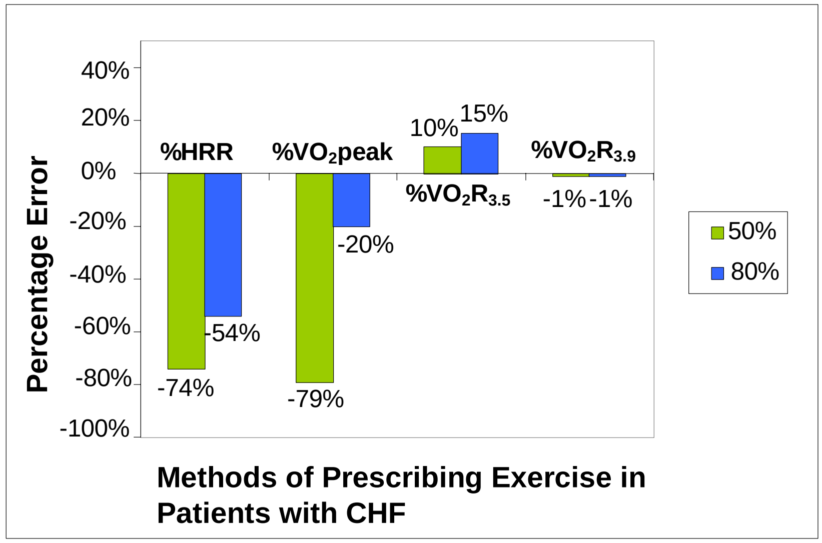


Figure 4. Errors for four methods of prescribing exercise in patients with CHF. For each, the error represents the % difference between the exercise intensity predicted by the method (%HRR, %VO_2peak, %$VO_2R_{3.5}$, %$VO_2R_{3.9}$), compared to the actual measurement during the symptom-limited graded exercise test.

DISCUSSION

Heart rate is widely used for exercise prescription in the general community, and in most situations involving exercise, serves as a parameter of metabolic rate. In laboratory-based exercise testing, metabolic rate is often indexed by oxygen consumption (VO_2). However, in most non-laboratory situations, VO_2 testing is impractical. To overcome this, the assumption that there is a linear relationship between heart rate and oxygen consumption during exercise has traditionally been used. The exercising heart rate or percentage of heart rate has been used to estimate exercise intensity. The use of %HRR method of prescribing target heart rates, which uses the difference between maximum heart rate and resting heart rate, has been commonly applied, based on the assumption that %HRR will yield the same exercise intensity as the equivalent percentage of VO_2peak. However, %HRR is the difference between resting heart rate and maximum heart rate and is thought to correspond very closely to the difference between resting oxygen consumption and maximum oxygen consumption (VO_2 Reserve) (3), not gross oxygen consumption (VO_2peak).

Precise prescription of exercise intensity should be established for CHF in order to gain maximum benefit from training regimes. Although numerous trials concerning the effects of exercise in CHF have been completed, the range of intensities that have been prescribed to patients varies from 40% (11) to 75% (12) VO_2peak, 50% (13) to 85% (14) of maximum HR, 70% to 80% (15) of peak capacity, 60% of HR Reserve (16), and a Rate of Perceived Exertion of 12-14 (17). The exercise-training program should be patient-specific, tailored to any limitations or desired activity level. Intensity levels of 50%, 70%, and 80% of maximal exertion during aerobic interval training have shown to be beneficial and cause positive physiological responses in individuals with CHF (18). Target heart rate (THR) derived by the heart rate reserve (%HRR) method, rating of perceived exertion (RPE), and/or a percentage of functional capacity are often used for cardiac rehabilitation programs (19). However, in a recent study, 52 patients with left ventricular dysfunction were tested to assess methods of prescribing exercise intensity (19). Exercising at high intensities can cause negative physiological responses in this population such as ventricular arrhythmias, thrombus formation, decreased left ventricular function, and excessive fatigue (20) thus, the target intensity used in the study was ±10% of the heart rate measured at ventilatory threshold (VT) (VT-HR ± 10%). Patients underwent an exercise test reaching VT to determine exercise prescription as VT-HR ± 10% and compare it to the %HRR method set at intensities of 60 %, 70 %, and 80 % and rate of perceived exertion (RPE) level 11 and 13. Results showed that there was no significant correlation between VT-HR ± 10% and RPE level 11-13. Only 50 % of the patients fell into the correct intensity level using this method and less than 40 % when using the %HRR method were below the VT. These findings of common errors in exercise prescription are similar to the results shown in this study, however, the use of VT-HR ± 10% does not take into account the everyday disparities in HR that are found in this population due to medications that blunt the HR response to exercise. In individuals with CHF, prescribed medications, such as beta-blockers, alter resting and/or maximum heart rate. A large disparity occurs between increases in heart rate to work rate ratio when compared to the healthy population resulting in an inappropriate prescription of intensity even when matching against VT. Other researchers have also suggested the use of VT as an alternative (21,22). In a study by Oka et al., only 69% of the heart failure patients had a measurable VT, showing how difficult and unreliable detecting VT in this population is (22). Since using HR for exercise prescription in these individuals is unreliable, a VO_2 method should be considered. Results show a significant error when prescribing exercise intensity with %VO_2peak method (Figure 4 and Table 3). This suggests that individuals with CHF should have prescribed exercise intensities determined by the method of %VO_2R rather than by %HRR or %VO_2peak.

To provide the required variables of the %VO_2R equation, resting VO_2 must be measured or otherwise assumed. When exercise intensity is determined from %VO_2R method with a measured resting VO_2 there is little error in the prescription. However, in most cases resting VO_2 is not measured and a standard value of 3.5 mL/kg/min provided by the ACSM is inserted. This study showed that patients with CHF have an increased resting VO_2 compared to healthy volunteers. When the %VO_2R method is used to prescribe exercise intensity for individuals with CHF a disparity exists when the standard resting VO_2 value of 3.5 mL/kg/min is used (+10%). Although this disparity is substantially less than observed with the %VO_2peak method, it is still different compared to the prescribed exercise intensity using the patients measured resting VO_2. Exercise prescription based on %VO_2R using 3.9 mL/kg/min as resting VO_2 is more closely related to %VO_2R with a measured resting $VO_{2.}$ This is a significant finding because, endurance and strength training can be used safely in rehabilitation programs (23) and is a recommended intervention for people with cardiovascular disease (24), and recently including individuals with CHF (25).

Although, %VO_2R has been shown to be closely related to %HRR in the healthy population, a discrepancy between the two still occur (10). Brawner et al. (10) reported an 8 % disparity in CHF patients that are on beta-blockers, while there was only a 0.9% difference in patients with myocardial infarctions on beta-blockers (10). Their findings on individuals with CHF are relatively similar to the 10% disparity observed in this study. Patients with myocardial infarctions in the Brawner et al. (10) study were without a history of coronary revascularization and no left ventricular dysfunction, whereas the individuals with CHF had a resting left ventricular ejection fraction ≤ 35%. Thus, beta-blockade may have been more heavily prescribed in the CHF group, although this data was not provided. Furthermore, the average age in their HF group was 53 years with an average peak heart rate of 135±23 beats/min (average resting heart rate was not provided). The age is significant because it is related to a higher average in HRmax than is commonly seen in this population. As therapy has improved in the past decade the average age has increased. The average HRmax measured by Brawner et al. (10) is 9 beats/min higher than the group used in this study which had an average age of 65±9 years. Thus, the older the age group the greater the disparity. This may explain the greater disparity reported in this study (10 %) compared to Brawner et al. (10) (8 %). Other studies have included a measured VO_2rest (8), but in each case this data was not reported. Brawner et al. (10)

stated that a limitation to their study was the absence of a measured VO_2 at rest, they recalculated the regressions using 4.2 mL/kg/min (a value reported by (26), as resting VO_2 while standing) and reported less disparity than with 3.5 mL/kg/min. This elevated oxygen consumption is not surprising considering the characteristics observed in this patient population. Higher VO_2rest is probably due to increased ventilatory demand and/or reduced ventilatory metabolic efficiency at rest. Individuals with CHF have an exaggerated ventilatory requirement at rest and during exercise (27; 28). Deoxygenation of the accessory respiratory muscles (29), increased work of breathing (30), and decreased strength of the respiratory muscles (31) have been reported in this patient population. Together, these could be expected to exert influences on VO_2rest.

There are several significant implications from these data. First, exercise prescription through the %HRR method is insensitive to patients taking prescribed medications that blunt the HR response to exercise. In this group, prescribed medications alter resting and/or max heart rate. A large disparity occurs between increases in heart rate to work rate ratio when compared to the healthy population resulting in an inappropriate prescription of intensity. Second, using HR for exercise prescription in these individuals is unreliable, thus one of the VO_2 methods should be considered. Third, %VO_2R is significantly more accurate than %VO_2peak. When prescribing exercise intensity to patients with CHF, the %VO_2R method should be used. The results support Brawner et al.'s recent recommendations for the use of %VO_2R in patients with heart disease and now more specifically in the population of CHF. The final implication is that this method, although more accurate than %VO_2peak, over predicts prescription of exercise by as much as 10%. The introduction of 3.9 mL/kg/min as the standard VO_2rest value for individuals with CHF, at least for patients with the clinical backgrounds of the current cohort of 45, reduces much of the remaining disparity. Individuals with CHF exhibited a higher resting VO_2 than the standard given value provided by ACSM. The ACSM recommends an assumed value of 3.5 mL/kg/min to represent VO_2rest. This is used whether the ensuing exercise is cycling or ambulatory exercise such as stepping or treadmill exercise. The approach used in this study was to actually measure VO_2rest in each individual while sitting upright on the cycle erogometer, as one of the input variables in the calculation of VO_2R. This has two advantages over an assumed 3.5 mL/kg/min: (i) this accounts for upright, seated posture used in cycling exercise which has been the most common mode of exercise used in published studies, and (ii) the actual VO_2rest was measured, rather than an assumed value.

Many problems still remain with respect to the safe, yet effective, exercise prescription for individuals with CHF. It was recently demonstrated in a study of our own (32) that moderate exercise intensity (RPE 12-14 (which is equivalent to 40 to 60 %VO_2R)) is beneficial for these patients. Exercise training at a moderate intensity for three months increases exercise capacity, skeletal muscle strength and endurance, and improves peripheral blood flow. This study showed that exercise intensities should be calculated by the %VO_2R method and established the importance of exercise testing in the CHF population. It appears prudent that exercise testing should be recommended for individuals with CHF and resting oxygen consumption obtained when possible for an accurate prescription of exercise intensity.

CONCLUSIONS

This study demonstrates that individuals with CHF have a blunted heart rate response to exercise compared to the healthy population. The altered HR response is most likely a result of prescribed medication and has a significant effect on prescribed exercise intensities determined by %HRR method. Thus, %HRR should not be used to calculate intensity for this high-risk patient population. The use of oxygen consumption is more reliable in these patients. Using %VO_2R method for prescribing exercise intensity is more accurate than %VO_2peak. When prescribing exercise intensity to patients with CHF the %VO_2R method should be used with measured variables (VO_2rest and VO_2peak). In situations where VO_2rest cannot be established, 3.9 mL/kg/min should be used in place of 3.5 mL/kg/min.

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