Examination of the constructs of the Transtheoretical model in patients with heart failure: a focus on physical activity readiness

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EXAMINATION OF THE CONSTRUCTS OF THE TRANSTHEORETICAL MODEL IN PATIENTS WITH HEART FAILURE: A FOCUS ON PHYSICAL ACTIVITY READINESS

A Dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
In partial fulfillment of the
Requirement for the degree of
Doctor of Philosophy

In

The Department of Kinesiology

By
Tracie Rena Parish
B.S., University of Southern Mississippi, 1994
M.Ed., Mississippi College, 1997
May 2006
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The goal of this research was to gain greater understanding about the management of heart failure patients. A particular focus was to evaluate exercise tolerance and behavior. The major findings of the first study included: (1) evidence that few heart failure patients receive adequate information regarding physical activity; (2) performance on a six-minute walk test were ~42% lower, and SF-36 scores were also lower in heart failure patients compared to controls; (3) stability in hemodynamic measures and distance walked on the 6-minute walk test were adequate, and (4) home exercise resulted in 19% improvement in maximum walking distance and 30% improvement in physical function score on the SF-36. The second study showed the feasibility to implement a care-managed program for heart failure patients in a family practice setting. However, a significant barrier was recruitment. Despite this failure, patients improved ~24% on the maximum walking distance and 29%, 46%, and 13% on the physical function, vitality, and mental health scores on the SF-36. The third study examined the motivation and readiness of heart failure patients to engage in planned physical activity. The findings revealed 22 patients in precontemplation, 33 in contemplation, 41 in preparation, 23 in action, and 29 in maintenance. In regards to the Transtheoretical model constructs (self-efficacy, pros and cons of decisional balance, and experiential processes) the data revealed that self-efficacy scores were lowest in the precontemplation and increased in linear fashion to maintenance. Decisional balance changed from greater perceived cons and lower perceived pros in precontemplation and contemplation to lower perceived cons and higher perceived pros in action and maintenance. Experiential processes were used predominantly in precontemplation and contemplation, whereas behavioral processes were more prominently used in action and maintenance. The most important predictors of physical activity stages of change were the behavioral processes ($r^2 = .78$).
followed by perceived self-efficacy ($r^2 = .66$). Finally, this study indicated that patients in pre-action stages of readiness to exercise have significant lower exercise tolerance then those in action and maintenance. These data suggest greater clinical emphasis should be placed on strategies to move patients toward the preparation and action stages of readiness.
CHAPTER 1. INTRODUCTION

1.1 Introduction

Heart failure is defined as the pathophysiological state in which an abnormality of cardiac function is responsible for failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues, or to do so only from an elevated filling pressure\(^1\). Heart failure is not a homogenous disease. Rather, it is the final common pathway of several disorders that impair the heart’s pumping ability.

An estimated 5.0 million Americans have heart failure, a chronic condition associated with frequent hospitalizations, widespread functional impairment, and a high mortality rate. Each year, approximately 550,000 new cases are diagnosed and nearly 300,000 patients die of heart failure as a primary or contributory cause\(^2\). During the last 10 years, the annual number of hospitalizations has increased from approximately 550,000 to nearly 900,000 for heart failure as a primary and from 1.7 to 2.6 million for heart failure as a secondary diagnosis.\(^3\)

In addition to the substantial morbidity and mortality associated with this condition, there is a significant financial impact on our society. In fact, heart failure is now the single most costly cardiovascular illness in the United States, with total treatment costs estimated at $24.3 billion.\(^1\) The cost to society is expected to increase due to an aging population and prolonged survival rates of individuals with cardiovascular disease, therefore imposing a large burden on individuals and the healthcare system.

Because heart failure is not a homogenous disease, management of the patient is extremely challenging with constant need for close monitoring and follow-up care. Primary goals of heart failure management include a reduction in the frequency of heart failure exacerbations, extending life, and improving quality of life. Additional goals include maximizing independence,
improving exercise capacity, enhancing emotional well-being, and reducing resource use and cost of care\textsuperscript{5-7}.

As a result of the increasing incidence of heart failure and the complex nature of the syndrome, the management of patients has become increasingly multidisciplinary in nature. Moreover, the composition of the team and relative importance of its members must constantly change depending on the status of the patient. Recent studies have shown the significant value of the use of a multidisciplinary approach in the management of the heart failure patient\textsuperscript{5-7}. These programs emphasize the importance of close monitoring and patient education. Despite positive outcomes from these programs, including fewer readmissions and hospital days, decreased costs, and improved functional status and quality of life, patient participation and adherence remain suboptimal\textsuperscript{5-7}. In fact, a major criticism of many large-scale therapeutic trials in heart failure is that the characteristics of the heart failure population at large are quite different from those being studied. This suggests there are a tremendous number of patients with heart failure who are currently not being reached.

A major component of the management of the heart failure patient is planned physical activity. Such programs have shown great promise as studies have revealed dramatic improvements in functional ability and quality of life and a reduction in healthcare costs and mortality in patients engaged in exercise programs\textsuperscript{8}. Consequently, current recommendations on the management of heart failure patients strongly emphasize an active lifestyle, and if possible, participation in a moderate exercise training regimen\textsuperscript{9}. However, despite the benefits of physical activity for patients with heart failure, research indicates that few individuals with heart failure actually engage in regular physical activity\textsuperscript{10}. Numerous studies have revealed that traditional methods of promoting physical activity have been only marginally successful in patients with
heart failure, citing failure to adhere to recommendations as a predominant factor\textsuperscript{11,12}. For example, our experience indicates that from a pool of approximately 350 heart failure patients, we were only able to recruit 20 patients for a 6 month intervention program. This was particularly disappointing given the fact we had an active recruiting program in place, which was coordinated by a dedicated nurse clinician. It has been suggested that these failures are in part due to the educational rather than behavior and motivational focus of many campaigns\textsuperscript{13}. Furthermore, many exercise programs are designed for people who have decided to begin exercise, yet a large proportion of individuals are simply not interested or ready to engage in physical activity programs\textsuperscript{14}. Thus, in an effort to provide patients with the greatest opportunities to help manage the heart failure syndrome, it is critical to understand the underlying reasons that may prevent a patient from participation as well as patient readiness to engage in physical activity behaviors. Appreciation of “barriers” to treatment will ultimately contribute to the development of improved strategies for inclusion of all patients with this disease.

The current document presents three research projects conducted at Louisiana State University designed to focus on the management of individuals diagnosed with heart failure. The focus of Chapter 2 was to evaluate physical function and perceived quality of life in patients with heart failure. Specifically, this project (1) examined written evidence regarding exercise recommendations to heart failure patients by their providers, (2) determined the construct validity of the 6-min walking test and a quality of life survey between patients with heart failure and age-matched controls; (3) examined the stability of the 6-min walking test, and (4) evaluated the effects of a care-managed exercise program. A unique contribution of this project was the fact it took place in a family practice clinic. Arguably it is this setting where the greatest numbers
of heart failure patients are managed, yet very little research concerning the management of these patients in this setting has been conducted. The first project led to the development of a grant proposal, which was ultimately funded through the Centers for Disease Control and Prevention. Consequently, the focus of Chapter 3 was to examine the influence of individualized, intensive education on measures of exercise tolerance and quality of life in patients with heart failure in a family practice setting. An important aspect of this study was the development and implementation of a tailored education handbook, as outlined by published guidelines for the evaluation and care of patients with heart failure by the Agency for Health Care Policy and Research (AHCPR)\textsuperscript{15}. These guidelines include recommended topics for patient and family education and counseling, such as diet, medications, physical activity, compliance, and recognition of worsening symptoms. The study was powered on recruiting approximately 60 patients from a pool of about 350 patients. A dedicated nurse clinician was coordinating recruiting efforts among approximately 6 physicians who were aware and for the most supportive of the study efforts. Despite this coordinated effort, the study failed to reach the targeted sample size. This failure is certainly not unprecedented in clinical trials and suggests two important problems. First, it suggests that data from many interventional trials with a focus on behavior modification may be biased to certain individuals. Second, it indicates there are a tremendous number of patients with heart failure who are currently not adequately reached and even managed. Recognizing this, it is not realistic to expect patients to make changes that they are not prepared to make that resulted in the development of the final project. In so, the focus of Chapter 4 was to assess the motivation and readiness of patients with heart failure to make necessary behavioral changes to aid in the management of their condition. No such studies are currently available for this patient population, despite strong suggestions that clinicians examine
theoretically based and practically important behavioral strategies that might be useful for encouraging and supporting a healthy behavior (such as exercise initiation) among individuals with chronic heart failure. Consequently, the final project aimed to (1) examine the associations of the constructs of the Transtheoretical model of behavior change and stage of change for planned regular physical activity; (2) determine the most important predictors of physical activity stages of change utilizing the constructs of the Transtheoretical model; and (3) examine the association of the stage of change construct for physical activity with maximum walking distance achieved on a 6 minute walk test among individuals with chronic heart failure.

A summary of the unique findings and the potential relevance of each project are presented in Chapter 5. In addition, Chapter 5 outlines some future recommendations regarding subsequent research in this and other disease populations.

Finally, the appendices include an extensive literature review on the heart failure syndrome, the educational workbook used in the second project, and the informed consent for project 3.

1.2 References


CHAPTER 2. EVALUATION OF PHYSICAL FUNCTION AND PERCEIVED QUALITY OF LIFE IN PATIENTS WITH HEART FAILURE IN A FAMILY PRACTICE SETTING

2.1 Introduction

An estimated 4.9 million Americans have heart failure, a chronic condition associated with frequent hospitalizations, widespread functional impairment, and a high mortality rate\(^1\). Each year, approximately 550,000 new cases are diagnosed and nearly 300,000 patients die of heart failure as a primary or contributory cause\(^1\). The syndrome is the underlying reason for 12 to 15 million office visits and 6.5 million hospital days each year\(^2\). Furthermore, during the last 10 years, the annual number of hospitalizations has increased from approximately 550,000 to nearly 900,000 for HF as a primary diagnosis and from 1.7 to 2.6 million for HF as a secondary diagnosis\(^3\). In addition to the substantial morbidity and mortality associated with this condition, there is a significant financial impact on our society. In fact, heart failure is now the single most costly cardiovascular illness in the United States, with total treatment costs estimated at $24.3 billion\(^1\).

Despite traditional pharmacologic treatment, the clinical phase of HF includes a marked decline in functional state, as defined by exercise tolerance and capacity with a subsequent decrease in quality of life. Furthermore, hospitalization rates remain high, owing in large part to a multitude of psychosocial, behavioral, and financial factors that serve as barriers to effective compliance with prescribed treatment. To deal with these issues, many centers have adopted a multidisciplinary approach to HF disease management\(^4\)-\(^7\). Comprehensive care programs for HF patients have been shown to be beneficial, but have largely been conducted in tertiary care settings. The fact the majority of patients are managed by primary care physicians warrants
further investigation to determine whether benefits of a comprehensive HF program, observed in tertiary settings, can be replicated in the primary care environment.

The purpose of this study was 3-fold: (1) to examine written evidence regarding exercise recommendations to heart failure patients by their providers, (2) to determine the construct validity of the 6-min walking test and a quality of life survey between patients with heart failure and age-matched controls; (3) to examine the stability of the 6-min walking test, and (4) to evaluate the effects of a care-managed exercise program on functional status and perceived quality of life in patients with heart failure in a family practice.

2.2 Methods

• Participants

All patients were recruited from the Family Medicine Residency Program/ Baton Rouge General Medical Center. Men and women over the age of 18 years with diagnoses of heart failure (regardless of etiology) were eligible for the study. The duration of heart failure in all patients was no less than 4 months and patients were optimally managed as deemed by the participant’s primary care physician. Those patients with acute unstable myocardial ischemia and/or angina, other non-cardiac diseases that would interfere with the completion of the study (uncontrolled hypertension, severe chronic obstructive pulmonary disease, or severe arthritis), and those recovering from a recent medical emergency resulting in hospitalization (e.g. acute myocardial infarction, coronary bypass graft surgery, radiation therapy, etc.) are excluded from participation. Participants without heart failure were selected and matched with the patients for age, gender, height, and weight.

• Study Design
This study included a retrospective analysis of medical records to evaluate the dissemination of physical activity information for the heart failure patient. This study also included a prospective comparison component to determine the construct validity of the two major dependent measures (i.e. the 6-minute walk distance and SF-36 scores). The short-term stability of the 6-min walking test was determined using a simple test-retest design. Finally, the study also included a prospective, randomized design aimed at measuring the potential benefit of a carefully managed exercise program for patients with chronic heart failure in a family practice setting.

- **Experimental Measurements**

  All tests were conducted over the course of 1 visit at the Family Medicine Residency Program/ Baton Rouge General Medical Center under the supervision of qualified clinicians as well as support staff from the Department of Kinesiology at Louisiana State University. Prior to testing a medical evaluation was performed by a qualified physician. The medical evaluation included a medical history, review of symptoms, and routine examination of the major organ systems.

  Prior to testing, each patient’s medical records were carefully examined for evidence regarding recommendations or guidance toward incorporating physical activity into the patient’s medical management. A simple scoring system was implemented based on the following evidence. If no evidence of physical activity information was noted over the last year, a score of “0” was given. In the case of simple advise to “exercise as tolerated”, a score of “1” was given. A score of “2” was given to more specific information about physical activity, and a “3” was given for specific exercise prescriptions according to the AHA guidelines.

  Following the medical examination exercise tolerance was assessed using a 6-minute walking test on a motor driven treadmill. The grade of the treadmill was set at 0%. Patients
controlled the treadmill speed by themselves and were allowed to change it at any time. The speed could be altered in increments of 0.1 km/hr, allowing precise measurement of walking distance. During the testing, blood pressure and heart rate were continuously monitored. Prior to testing the patients were instructed to walk as far as possible, avoiding chest pain or marked dyspnea. To standardize the protocol, subjects were not be coached during testing but all subjects were made aware of the time remaining to completion. The maximum walking distance during the 6-minute walk test was considered the dependent measure.

After the exercise tolerance test, the patients' perceived quality of life, defined for the present study as the subjective appraisal of general physical and emotional well-being, was assessed with the Short Form 36 (SF-36) questionnaire. The SF-36 was designed to measure the generic health concepts relevant across age, disease, and treatment groups. The SF-36 was constructed to represent 8 of the most important health concepts included in the medical outcomes study and other widely used health surveys. The SF-36 is comprised of 36 items that describe health related physical and psychosocial dysfunction in 8 areas to include physical function, social function, role-limitation-physical, role limitation-emotional, mental health, vitality, bodily pain, and general health. A single item evaluates the patient’s perception of change in health over the past year. Scores range from 0% to 100% with higher scores consistent with better health status. To examine the stability of the maximum walking distance achieved on the 6 minute walking test, and SF-36, both tests were repeated one week after the initial test.

- **Intervention**

  Participants were randomly assigned to one of 2 groups: home-exercise training or control. Exercise training consisted of aerobic activities of progressive duration and intensity performed on a daily basis for 16 weeks. All participants received extensive follow-up through weekly
telephone contact with members of the research team. In addition, all participant’s were scheduled for monthly clinic visits aimed at patient education, compliance to medication, identification of recurrent symptoms, and evaluation of exercise logs and modification of exercise prescription (only in those participants randomized to the exercise training group).

- **Statistical Analysis**

All statistical analyses were conducted using the latest version of the SPSS statistical package for windows. To examine the written evidence regarding exercise recommendations simple ranking statistics were applied. To determine the construct validity of the 6-min walking test and a quality of life survey between patients with heart failure and age-matched controls, independent sample t-tests were conducted. The stability of the 6-min walking test was examined using an ANOVA with repeated measures, and intraclass correlation coefficients. Finally, the effects of the exercise program on exercise tolerance and perceived quality of life were evaluated using a paired sample t-test. Alpha levels were set at 0.10.

2.3 Results

- **Patient Characteristics**

The patient demographics in this study were characteristic of the wide range of individuals who present to the clinic (see Table 2.1). Of the 16 patients enrolled 14 were African-American and 2 Caucasian. There were 12 women and 4 men with a mean age of 61±14 years. Approximately 55% of the participants had systolic dysfunction as defined by a left ventricular ejection fraction below 45%. Thirty percent of the participants had been diagnosed with diastolic dysfunction and the etiology of heart failure in the remaining patients was unclear. In regards to the patients’ pharmacotherapy, 12 patients were on ACE-inhibitors, all patients were on diuretics, 5 on beta-blockers, and 6 on digitalis glycosides. Comorbidities included hypertension
(80%), diabetes mellitus (53%) and depression (32%). The age-matched controls did not have any evidence of overt disease.

### Table 2.1. Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Race</th>
<th>Gender</th>
<th>Age (yr.)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
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<td></td>
<td></td>
<td>B</td>
<td>W</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart Failure</td>
<td>16</td>
<td>14</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>61±14</td>
<td>84.6±13</td>
</tr>
<tr>
<td>Age-Matched</td>
<td>13</td>
<td>0</td>
<td>13</td>
<td>3</td>
<td>10</td>
<td>65±11</td>
<td>77.8±13</td>
</tr>
</tbody>
</table>

\[ p \]

- **Survey Results**

The survey results indicated very little written evidence that clinicians provided patients with information regarding physical activity. Of the 16 patients, only one had received some specific information regarding physical activity over the last year. In contrast, there were no notes indicating any physical activity guidance for the remaining 15 patients. No patients were provided specific guidelines for exercise as recommended by the American Heart Association.

- **Validity and Reproducibility of the 6-minute Walk Test**

A major end-point in this study concerned the maximum walking distance achieved on the 6-min walk test. Given a lack of information on the acute responses during the 6-min walk test in this population, a group of heart failure patients were matched with an age-matched control group. The age-matched control group (63±6 years) consisted of individuals who had no evidence of underlying disease as determined by previous clinical examination. As expected the healthy participants walked significantly faster compared to the patient group at every minute of the walk test (see Figure 2.1). Furthermore, the maximum distance walked for the healthy participants (552.03±73.80m) was much greater in comparison to the distance achieved by the patients with heart failure (242.35±86.35m) \( p<0.05 \). Thus, these data clearly show that the 6-minute walk test differentiates between healthy and heart failure populations.
Importantly test-retest data reveals adequate reproducibility for maximum walking distance and heart rate responses for the 6-minute walking test. Results revealed an ICC and CV of 0.97 and 8.9% for visit 1 and 2, respectively. Hemodynamic measurements prior to and during the walk test were not significantly different from visit 1 to visit 2. The ICC and CV for heart rate in the last minute of exercise was 0.99 and 2.0%, whereas the ICC for BP ranged from 0.694 to 0.772 with CV of 6.3 to 13.0%, respectively. The reproducibility of the measures is further detailed in figures 2.2 through 2.5.

![Graph showing comparison of Health vs. Disease: 6-minute Walk Test. *p<0.05 Healthy Controls vs. Heart Failure.](image)

**Figure 2.1. Comparison of Health vs. Disease: 6-minute Walk Test. *p<0.05 Healthy Controls vs. Heart Failure**

- **Validity of the SF-36**

  A second major end-point in this pilot-study was the perceived quality of life measured using the SF-36 Health Survey. The survey provides information about 8 specific concepts (i.e. physical functioning (PF), role-physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role-emotional (RE), and mental health (MH)) and 2 combined
Figure 2.2. Six minute Walk Distance

Figure 2.3. Heart Rate Responses before, during and after the 6-Minute Walk Test
scores (i.e. physical component score (PCS) and mental component score (MCS). Table 2.2 clearly shows that the scores are significantly lower for the heart failure patients suggesting greater decrements in functioning and well being than the age-matched controls.

Table 2.2. Comparison of Heart Failure and Age-matched Healthy Controls: SF-36 Scales

<table>
<thead>
<tr>
<th></th>
<th>PF</th>
<th>RP</th>
<th>BP</th>
<th>GH</th>
<th>VT</th>
<th>SF</th>
<th>RE</th>
<th>MH</th>
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<th>MCS</th>
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<td>HF</td>
<td>44.7</td>
<td>31.3</td>
<td>55.7</td>
<td>48.6</td>
<td>44.1</td>
<td>67.2</td>
<td>54.2</td>
<td>67.0</td>
<td>31.0</td>
<td>45.7</td>
</tr>
<tr>
<td>Controls</td>
<td>85.0*</td>
<td>100.0*</td>
<td>81.0*</td>
<td>84.3*</td>
<td>73.1*</td>
<td>100.0*</td>
<td>100.0*</td>
<td>90.5*</td>
<td>51.4*</td>
<td>59.1*</td>
</tr>
</tbody>
</table>

*p<0.05 Controls vs. HF
In addition, data in Table 2.3 compared the scores for our heart failure patients to the norms established by Ware. The data appear to indicate that despite the small sample size the scores are very similar to the national norms for congestive heart failure patients.

Table 2.3. Comparison of Baton Rouge General Pilot Data and National Norms for Patients with Heart Failure: SF-36 Scales

<table>
<thead>
<tr>
<th></th>
<th>PF</th>
<th>RP</th>
<th>BP</th>
<th>GH</th>
<th>VT</th>
<th>SF</th>
<th>RE</th>
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<td>48.6</td>
<td>44.1</td>
<td>67.2</td>
<td>54.2</td>
<td>67.0</td>
<td>31.0</td>
<td>45.7</td>
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<td>Norms</td>
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<td>34.4</td>
<td>62.7</td>
<td>47.1</td>
<td>44.3</td>
<td>71.3</td>
<td>63.7</td>
<td>74.7</td>
<td>34.1</td>
<td>47.3</td>
</tr>
</tbody>
</table>
Effect of 4 Month of Care-Managed Exercise Program

The 6-minute Walk Test

The results of the study indicated modest yet statistically significant improvements in the maximum walking distance following the 16-week period. Patients consistently selected higher walking speeds at each minute during the test. The pattern of speed changes during the walking tests from start to finish for heart failure patients who completed a 16-week care management program are depicted in Figure 2.6.

As can be seen from these data, patients selected higher speeds in the first minute of the test and were able to maintain these speeds throughout the 6-min walk test following the intervention period. Consequently, the maximum walk distance improved by 19%, $241.43 \pm 88.06$ m to $285.65 \pm 99.69$ m ($p=0.06$).
The SF-36 Health Survey

The preliminary findings on the effects of the 16-week Care-Managed Heart Failure Program are shown in Table 2.4. The data indicate a significantly higher score on the physical functioning (PF) component of the SF-36 in those subjects who completed the exercise arm of the pilot-study.

Table 2.4. Preliminary Data on the Effect of a 4 Month Care-Managed Heart Failure Program: SF-36 Scales

<table>
<thead>
<tr>
<th></th>
<th>PF</th>
<th>RP</th>
<th>BP</th>
<th>GH</th>
<th>VT</th>
<th>SF</th>
<th>RE</th>
<th>MH</th>
<th>PCS</th>
<th>MCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>45</td>
<td>29.167</td>
<td>53</td>
<td>49.33</td>
<td>50</td>
<td>64.58</td>
<td>27.78</td>
<td>62.67</td>
<td>35.83</td>
<td>43.2</td>
</tr>
<tr>
<td>Post</td>
<td>58*</td>
<td>25</td>
<td>63.17</td>
<td>44.33</td>
<td>60</td>
<td>50</td>
<td>27.78</td>
<td>68.67</td>
<td>38.17</td>
<td>42.53</td>
</tr>
</tbody>
</table>

*p<0.05 Pre vs. Post

Relationship of the 6-minute Walk Test and SF-36 Health Survey

Figure 2.7a depicts the relationship of the 6-minute walk test and the physical functioning score on the SF-36 Health Survey. The graph shows that as the physical functioning scores on the SF-36 decline so does the maximum walking distance on the 6-minute walking test ($r^2=0.72; p<0.05$). Furthermore, as shown in Figure 2.7b these preliminary data also reveal that as maximum walking distance improved (observed measures of physical function), scores on the physical functioning scale of the SF-36 health survey also improved (subjective measures of physical function), indicating a positive correlation between the change in maximum walking distance following the care-managed program and the physical functioning score on the SF-36 ($r=0.59; p=0.06$).

2.4 Discussion

The major findings of this study are as follows: (1) despite the overwhelming evidence of the benefits of exercise for patients with heart failure, there appears to be a lack of evidence to suggest that these patients are receiving adequate information regarding physical activity, (2) both the maximum walking distance on a 6-min walking test and the SF-36, a quality of life
Figure 2.7a and b Relationship of the 6-minute Walk Test and SF-36 Health Survey

survey, clearly differentiate between patients with heart failure and age-matched controls; (3) the one-week stability in the hemodynamic measures and the distance walked on the 6-minute
walking test on a treadmill were adequate, and (4) home exercise with frequent patient contact resulted in modest improvements in exercise tolerance and perceived quality of life.

- **Survey**

  It is not clear why the patients are apparently not receiving adequate information regarding physical activity. However, several factors may play into this dilemma. For example, the lack of physical activity recommendations may be secondary to a lack of appreciation of the importance of physical activity by the primary care physician, a lack of knowledge about the current guidelines on exercise in heart failure, an inability to discuss the subject matter effectively, a lack of time to discuss the subject matter, fear of precipitating further health or physical problems, a lack of confidence by the physician that the information may be put to use, and/or a lack of knowledge about available resources for these patients. In all fairness to the clinicians, the data from this study only suggest a lack of adequate information about physical activity. The data were collected directly from the medical records of the patients rather than examining the clinicians in action (i.e. the actual patient contact time). In some cases the clinician may in fact have discussed the role of physical activity with the patient but failed to note this in the medical records. Regardless of the barrier future research should aim to provide the clinicians with adequate strategies and the patients with the right opportunities to gather all the necessary information that may aid in improved management of the disease.

- **Validity and Reproducibility of the 6-minute Walk Test**

  The present study clearly shows that the 6-minute walking test differentiates between a healthy and heart failure population. In fact, the reported maximum walking distance for the heart failure patients in this study was quite consistent with previous reports. Guyatt et al. (1985) were one of the first to study the potential value of the 6-minute walk as an objective
measure of exercise capacity in patients with chronic heart failure\textsuperscript{10}. They administered the 6-minute walking test six times over 12 weeks in 18 patients with chronic heart failure and 25 with chronic lung disease. The subjects also underwent cycle ergometer testing, and their functional status was evaluated by means of conventional measures. The walking test proved highly acceptable to the patients, and stable, reproducible results were achieved after the first two walks\textsuperscript{10}. The results correlated with the conventional measures of functional status and exercise capacity. The authors concluded that the 6-minute walk is a useful measure of functional exercise capacity and a suitable measure of outcome for clinical trials in patients with chronic heart failure\textsuperscript{10}. The present study is somewhat unique in that the stability of the measures was found using a treadmill test rather than the traditional hallway test. Recognizing the importance of using the same approach when conducting repeat measures the present data clearly show the usability of a treadmill for the purpose of obtaining the maximum walking distance on the 6-minute walking test. The present data do support research by Guyatt et al.\textsuperscript{10}, who recommends a practice walk be performed. If the difference between the first and second walk is greater than 10\% a third walk should be undertaken and used as the baseline measure. In this study the magnitude of the difference did not exceed 10\% in any of the participants.

Uniquely, this is the first study to examine the stability of the hemodynamic responses to the 6-minute walking test. Interestingly, the hemodynamic measurements prior to and during the walk test were not significantly different from visit 1 to visit 2. Blood pressure responses during the 6-minute walking test were not significantly different from pre-test values. Moreover, test-retest comparison for blood pressure in the last minute of the 6-minute walking test revealed Interclass Correlation Coefficients ranging from -0.63 for systolic blood pressure to 0.77 for mean arterial blood pressure, suggesting much lower stability of the blood pressure responses. In
contrast, heart rate increased significantly from rest by the first minute of the 6-minute walking test, and returned to pre-test levels in the second minute of recovery. The Interclass Correlation Coefficients and Coefficient of Variation for heart rate in the last minute of exercise was 0.99 and 2.0%, respectively. The stability of the heart rate response in the last minute of exercise suggests the potential of this parameter as an outcome measure.

In contrast, reports of symptoms and ratings of perceived exertion were inconsistent from visit 1 to visit 2 indicating these measures may not be sensitive in this population. Although the mean values appear similar between tests, within subject variability was high. The reason for the variability may be the subjective nature of these measures. Furthermore, pre-test instructions emphasize the importance to achieve a perceived exertion rating of 12 to 14 toward the end of the test. The fact that not all patients achieved this goal possibly indicates lack of knowledge of proper use of the scales, and/or stress or uncertainty about the test. This is an important consideration when examining the effects of interventions.

Importantly, the average walking distance in this study was 242.35±86.35m. In light of recent work an average walking distance below 300 meters carries a rather ominous prognosis11. Roul et al. (1998)11 prospectively evaluated the potential of the 6-minute walk test compared with peak VO₂ in predicting outcome of patients with New York Heart Association (NYHA) class II or III heart failure. Death or hospitalization for heart failure was used as the judgment criterion. Patients who walked less than or equal to 300 m had a worse prognosis than those walking farther (p=0.013). Furthermore, the investigators found a significant correlation between distance covered and peak VO₂ (r=0.65, p=0.011). Thus, it appears that a distance walked in 6 minutes less than or equal to 300 m can predict outcome in patients with heart failure11. Moreover, in these cases there is a significant correlation between the 6-minute walk test and
peak VO₂ demonstrating the potential of this simple procedure as a first-line screening test for this subset of patients.

The precise mechanism for the low exercise tolerance is not fully known but involves a series of pathophysiological abnormalities that accompany the disease. In addition, the low maximum walking distance achieved by the patients confirms previous reports indicating the six-minute walk test is a simple objective guide to disability in patients with chronic heart failure.

• **Validity of the SF-36**

According to McHorney et al. the widespread use of standardized health surveys is predicated on the largely untested assumption that scales constructed from those surveys will satisfy minimum psychometric requirements across diverse population groups. McHorney et al. used data from the Medical Outcomes Study (MOS) to evaluate data completeness and quality, test scaling assumptions, and estimate internal-consistency reliability for the eight scales constructed from the MOS SF-36 Health Survey. Analyses were conducted among 3,445 patients and were replicated across 24 subgroups differing in sociodemographic characteristics, diagnosis, and disease severity. For each scale, item-completion rates were high across all groups (88% to 95%), but tended to be somewhat lower among the elderly, those with less than a high school education, and those in poverty. On average, surveys were complete enough to compute scales scores for more than 96% of the sample. Across patient groups, all scales passed tests for item-internal consistency (97% passed) and item-discriminant validity (92% passed). Reliability coefficients ranged from a low of 0.65 to a high of 0.94 across scales (median = 0.85) and varied somewhat across patient subgroups. Floor effects were negligible except for the two role disability scales. Noteworthy ceiling effects were observed for both role disability scales and the
social functioning scale. The authors conclude that their findings support the use of the SF-36 survey across the diverse populations studied\textsuperscript{15}.

Normative data for individuals with various disease conditions, including heart failure, have been estimated from the general US population and M.O.S. patient population. We recognize that the relatively small sample size (n=216) for heart failure and the fact that the norms are not adjusted for sociodemographics and comorbid conditions. However, it is clear from the currently available data that patients with heart failure exhibit markedly worse physical, role, and social functioning; mental health; health perceptions; and/or bodily pain compared with individuals with no chronic conditions.

In the present study the SF-36 scores for each specific concept are significantly lower for the patients compared to age-matched controls. This indicates reduced perception of quality of life. Despite our small sample size, these results are very similar to the national norms established by Ware\textsuperscript{9}. Furthermore, these data reveal a direct relationship between maximum walking distance and quality of life scores. These results confirm previous reports by Havranek et al.\textsuperscript{16}, suggesting the meaningfulness of these measures for the evaluation of heart failure interventions.

- **Effect of 4 Month of Care-Managed Exercise Program**

The pattern of speed changes during the walking tests from start to finish for the heart failure patients who completed a 4 month care management program are depicted in Figure 2. As can be seen from these data patients selected higher speeds in the first minute of the test and were able to maintain these speeds throughout the 6-min walk test following the intervention period. Consequently, the maximum walk distance improved by 19%, from 241.43±88.06m to 285.65±99.69m, $p=0.06$. The observed improvements in maximum walking distance in our pilot study are less than previously reported following a 3-week exercise training program\textsuperscript{17}. However, our
findings are similar to Rector et al. (1996) who showed increases in maximum walking distances (390±91 versus 422±86 m, \(p<0.05\)) in a study to determine whether supplemental oral L-arginine augment peripheral blood flow and improve functional status in patients with moderate to severe heart failure\textsuperscript{18}. Recognizing the limitations of a pilot study, these data do support the idea that a carefully managed program for heart failure patients may contribute to improvements in 6-minute walk test performance.

The preliminary findings on the effects of the 16-week Care-Managed Heart Failure Program on quality of life indicate a significantly higher score on the physical functioning (PF) component of the SF-36 in those subjects who completed the exercise arm of the pilot-study.

2.5. Conclusion

In conclusion, this study indicates that despite the overwhelming evidence of the benefits of exercise for patients with heart failure, there appears to be a lack of evidence to suggest that these patients are receiving adequate information regarding physical activity. Second, both the maximum walking distance on a 6-min walking test and the SF-36, a quality of life survey, clearly differentiate between patients with heart failure and age-matched controls. Third, the one-week stability in the hemodynamic measures and the distance walked on the 6-minute walking test on a treadmill were adequate. Finally, home exercise with frequent patient contact resulted in modest improvements in exercise tolerance and perceived quality of life.

2.6. References


9. Ware JE and Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36). Medical Care (1992); 30: 473-483.


CHAPTER 3. IMPROVED EXERCISE TOLERANCE AND QUALITY OF LIFE FOLLOWING A HEART FAILURE PROGRAM IN FAMILY PRACTICE

3.1 Introduction

Heart failure is defined as "the pathophysiological state in which an abnormality of cardiac function is responsible for failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues and/or to be able to do so only from an elevated filling pressure" \(^1\). The alteration in the normal physiological pumping capacity of the heart is principally due to three distinct etiologies: (1) intrinsic myocardial disease including coronary heart disease, cardiomyopathy, and infiltrative disease; (2) excess work load due to increased resistance to ejection (pressure load) secondary to hypertension and hypertrophic cardiomyopathy or increased stroke volume (volume load) secondary to aortic and/or valvular insufficiency; (3) iatrogenic myocardial damage from drugs or radiation therapy \(^2\).

The National Health and Nutrition Examination Survey reports an estimated 4.8 million Americans have heart failure. Each year approximately 400,000 new cases are diagnosed, and 36,387 Americans died from heart failure in 1992 \(^3\). This represents a significant rise in the number of deaths from heart failure since 1968. In addition to the cost of human life, heart failure poses an enormous financial burden on American society. The management of heart failure generally exceeds $5 billion \(^4\). It is expected that this cost to society will only rise in the future, as it is estimated that by the year 2020, the number of persons over 65 years of age population will represent over 20% of the general populous. This will undoubtedly result in a significant increase in the number of people with chronic conditions including heart failure.

The treatment of heart failure is aimed at correcting the underlying cause and/or controlling the heart failure state. The management of the heart failure patient generally includes a combination of pharmacological compounds aimed to relieve clinical symptoms and prolong life.
Numerous pharmacological agents are available which help improve central hemodynamics by reducing cardiac afterload or enhancing myocardial contractility. Additional pharmacological agents are used to reduce excessive fluid retention. Following initiation of such therapy mortality is reduced, and many patients experience resolution of their symptoms at rest. However, most patients continue to experience activity-related symptoms, including shortness of breath, muscle fatigue, and weakness. As a result, patients with heart failure often complain of chronic fatigue and are unable to perform many of their normal activities of daily living. Thus, despite traditional pharmacological treatment, the clinical phase of heart failure includes a marked decline in functional status, as defined by exercise tolerance with a subsequent decrease in quality of life.

Modifications of lifestyle can be helpful in controlling the symptoms of heart failure and maintaining clinical stability. For example, it has been suggested that basic habits of moderate sodium restriction, weight monitoring, exercise, and adherence to medication schedules may aid in avoiding fluid retention or alerting the patient to its presence. Multiple studies have shown that patients who are educated and knowledgeable about their disease process and understand how their medications work and the importance of compliance have fewer hospital readmissions and experience an increase in exercise tolerance and quality of life. For example, in a review of the literature from 1966 to 1993, counseling and health education increased life expectancy and quality of life, and reduced hospitalization of patients with heart disease.

In an effort to address this major public health concern, the Agency for Healthcare Policy and Research (AHCPR) published guidelines for the evaluation and care of patients with HF. These guidelines include recommendations for patient and family education and counseling, diet, physical activity, nursing and social services intervention, support groups, and specific measures.
to improve compliance. It is noteworthy that the vast majority of patients with heart failure are managed in the primary care setting, yet few studies have examined the efficacy of comprehensive care as outlined by the AHCPR in this setting. In fact, one of the key areas for future research suggested by the AHCPR is to determine the efficacy of their guidelines in different practice environments and with diverse populations (i.e. gender, race, socioeconomic status, level of education and etiology of heart failure). Consequently, the purpose of the second study was to determine whether a tailored heart failure educational program as outlined by the Agency of Health Care Policy and Research (AHCPR) could be effectively implemented in a primary care setting. Specifically, this study examined the effects of a 3-month care-managed program on exercise tolerance and measures of perceived quality of life in patients with heart failure in a family practice setting.

3.2 Methods

- **Participants**

  All patients were recruited from the Family Medicine Residency Program/ Baton Rouge General Medical Center. Men and women over the age of 18 years with diagnoses of heart failure (regardless of etiology) were eligible for the study. In addition, participants had to have the ability to read and write English. The duration of heart failure in all patients was no less than 4 months and patients were optimally managed as deemed by the participant’s primary care physician. Participants were not excluded on the basis of gender, race, and/or etiology of heart failure. However, those patients with acute unstable myocardial ischemia and/or angina, other non-cardiac diseases that would interfere with the completion of the study (uncontrolled hypertension, severe chronic obstructive pulmonary disease, or severe arthritis), and those recovering from a recent medical emergency resulting in hospitalization (e.g. acute myocardial
infarction, coronary bypass graft surgery, radiation therapy, etc.) were excluded from participation.

- **Recruitment Strategies**

  In an effort to maximize the ability to recruit from a pool of approximately 350 patients, a dedicated nurse clinician was hired. A major portion of the nurse clinician’s job responsibilities was to identify all potential candidates and contact both patients and physicians in terms of their potential participation. The first strategy involved identification of the candidates through medical and computer records. The second strategy involved telephone contact and subsequently a direct meeting when the patient was scheduled for an appointment. Finally, each physician (a total of 6) was constantly reminded about the program to help in remind them about the study.

- **Study Design and Experimental Measures**

  This study was a prospective, randomized controlled trial aimed at examining the effects of a multifaceted, care-managed program as outlined by the AHCPR in patients with heart failure in a family practice setting. Changes in exercise tolerance and perceived quality of life were followed over a 3-month period and patients were randomly assigned to one of two groups: Usual Care and Care-managed. Exercise tolerance was measured as the maximum distance (MWD) achieved on a six-minute walk test. Perceived quality of life (QOL) was evaluated using the short-form 36 health survey (SF-36). Patients in both the usual care and care-managed groups received an initial education session including general information about heart failure, followed by weekly telephone calls to monitor compliance and clinical status.

  Additionally, patients randomized to the care-managed group received education guided by an extensive heart failure patient workbook. The workbook included recommendations about
physical activity, medications, nutrition, and other pertinent issues as outlined by the AHCPR guidelines. Figure 3.1 displays an example of chapter outlines from the patient workbook.

**Figure 3.1. Heart Failure Disease Management Patient Workbook Sample**

Table 3.1 provides an overview of the specific topics that were addressed and monitored throughout the course of the study. These topics were specifically recommended by the AHCPR for patient and family education and counseling. Furthermore the decision to use these topics was based on the available literature which indicates the use of these strategies to be effective in heart failure patients in tertiary settings.

- **Baseline Visit One**

  Upon arrival to the clinic all participants received a comprehensive explanation of the proposed study, its benefits, inherent risks and expected commitments with regard to time and
patient responsibilities. Each individual was required to complete an informed consent
document approved by the Baton Rouge General and Louisiana State University Institutional
Review Board prior to any testing procedures. All patients underwent a medical evaluation
performed by the Medical Director of the study, which included a medical history, review of
symptoms, and routine examination of the major organ systems.

Table 3.1. Topics for Patient, Family, and Caregiver Education and Counseling

<table>
<thead>
<tr>
<th>General Counseling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation of Heart Failure and the Reason for Symptoms</strong></td>
</tr>
<tr>
<td>• Cause or probable cause of heart failure</td>
</tr>
<tr>
<td>• Expected symptoms</td>
</tr>
<tr>
<td>• Symptoms of worsening heart failure</td>
</tr>
<tr>
<td>• What to do if symptoms worsen</td>
</tr>
<tr>
<td>• Self-monitoring with daily weights</td>
</tr>
<tr>
<td>• Explanation of treatment/care plan</td>
</tr>
<tr>
<td>• Clarification of patient’s responsibilities</td>
</tr>
<tr>
<td>• Importance of cessation of tobacco use</td>
</tr>
<tr>
<td>• Role of family members or other caregivers in the treatment/care plan</td>
</tr>
<tr>
<td>• Availability and value of qualified local support group</td>
</tr>
<tr>
<td>• Importance of obtaining vaccinations against influenza and pneumococcal disease</td>
</tr>
<tr>
<td><strong>Prognosis</strong></td>
</tr>
<tr>
<td>• Life expectancy</td>
</tr>
<tr>
<td>• Advance directives</td>
</tr>
<tr>
<td>• Advice for family members in the event of sudden death</td>
</tr>
<tr>
<td><strong>Activity Recommendations</strong></td>
</tr>
<tr>
<td>• Recreation, leisure, and work activity</td>
</tr>
<tr>
<td>• Exercise</td>
</tr>
<tr>
<td>• Sex, sexual difficulties, and coping strategies</td>
</tr>
<tr>
<td><strong>Dietary Recommendations</strong></td>
</tr>
<tr>
<td>• Sodium restriction</td>
</tr>
<tr>
<td>• Avoidance of excessive fluid intake</td>
</tr>
<tr>
<td>• Fluid restriction (if required)</td>
</tr>
<tr>
<td>• Alcohol restriction</td>
</tr>
<tr>
<td><strong>Medications</strong></td>
</tr>
<tr>
<td>• Effects of medications on quality of life and survival</td>
</tr>
<tr>
<td>• Dosing</td>
</tr>
<tr>
<td>• Likely side effects and what to do if they occur</td>
</tr>
<tr>
<td>• Coping mechanisms for complicated medical regimens</td>
</tr>
<tr>
<td>• Availability of lower cost medications or financial assistance</td>
</tr>
<tr>
<td><strong>Importance of Compliance with the Treatment/Care Plan</strong></td>
</tr>
</tbody>
</table>
Exercise tolerance was assessed using a 6 minute walking test on a motor driven treadmill. Prior to testing the patients were instructed to walk at a self-selected speed, avoiding chest pain or marked dyspnea. The grade of the treadmill was set at 0%. Patients controlled the treadmill speed and were allowed to change it at any time. The speed could be altered in increments of 0.1 km/hr, allowing precise measurement of walking distance. Heart rate and blood pressure were monitored during the test. To standardize the protocol, participants were not coached during testing but all participants were made aware of the time remaining to completion.

Finally, patients' perceived quality of life, defined for the present study as the subjective appraisal of general physical and emotional well-being, was assessed with the Short-Form 36 (SF-36) questionnaire. The SF-36 is comprised of 36 items that describe health related physical and psychosocial dysfunction in 8 areas to include physical function, social function, role-limitation-physical, role limitation-emotional, mental health, vitality, bodily pain, and general health. A single item evaluates the patient’s perception of change in health. Scores range from 0% to 100% with higher scores consistent with better health status.

- **Baseline Visit Two**

To ensure stability of the measure, the six minute walk test was repeated one week after the initial test. Therefore, upon arrival to the clinic participants were prepared for assessment of exercise tolerance. After a 15 minutes rest period, resting heart rate and blood pressure were obtained from the dominant arm, using standard auscultation procedures and a Trimline mercury sphygmomanometer (Pymah Co., Somerville, NJ). Subsequently, exercise tolerance was again assessed using the 6 minute walking test on a motor driven treadmill as described in the previous section.
Following these procedures, all patients received a general educational session with the nurse educator. The purpose of this session was to educate the patient about the serious implications of their diagnosis, an explanation of what patients can expect to experience during activities of daily living, typical symptoms of worsening heart failure, and who to contact if such symptoms develop. Furthermore, the nurse educator discussed medication compliance, low salt-diet and encouraged regular physical activity. In addition, patients randomized to the care-managed group received an educational workbook that included information regarding physical activity, diet, medications, and other pertinent issues as recommended by the AHCPR.

- **Follow-up**

All patients received weekly telephone follow-up to monitor clinical status. Additionally, patients randomized to the care-managed group received intensive education regarding specific topics as outlined by the AHCPR and individualized program modification. Furthermore, these patients were scheduled for monthly group visits for additional education on selected topics.

- **Three Month Follow-up**

At the end of the 3 month period, all patients were scheduled to undergo the same series of assessments as described for the baseline visits (Physical examination, quality of life survey, and the 6-minute walking test). In order to control for the possible confounding effects of pharmacotherapy, circadian rhythms, and other external sources of variability the tests were performed by the same team of investigators at approximately the same time of day.

- **Statistical Analysis**

All statistical analyses were conducted using the latest version of the SPSS statistical package for windows. To examine the influence of the intervention on exercise tolerance and hemodynamic measures a 2 (intervention and usual care group) by 2 (Pre versus Post) ANOVA
was conducted. To examine the influence of the intervention on quality of life a 2 (intervention and usual care group) by 2 (Pre versus Post) ANOVA was conducted. The stability of the 6-min walking test was examined using an ANOVA with repeated measures, and intraclass correlation coefficients. Alpha levels were set at 0.10.

3.3 Results

• **Patient Characteristics**

Of a possible 350 patients, only 18 patients with HF (NYHA class II or III) were taken through the program. From the 18 patients, ten were randomized to the care managed group (n=10; age=57±13) and eight to the usual care group (n=8; age=53±14). The main etiology of heart failure for the patients was ischemic heart disease followed by hypertensive heart disease. There were no differences between the groups prior to the intervention for age, height, weight, BMI, or any hemodynamic measures (see Table 3.2).

<table>
<thead>
<tr>
<th>Table 3.2. Participant Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant Characteristics</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Intervention (n=10)</td>
</tr>
<tr>
<td>Age (yrs)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
</tr>
<tr>
<td>HR_{rest} (b/min)</td>
</tr>
<tr>
<td>SBP_{rest} (mmHg)</td>
</tr>
<tr>
<td>DBP_{rest} (mmHg)</td>
</tr>
<tr>
<td>Co-Morbidity</td>
</tr>
</tbody>
</table>

• **Six-minute Walk Test**

The test-retest values for the 6 minute walk test prior to training are presented in Figure 3.2. As previously reported the reproducibility and stability of the test is adequate. For the purpose of comparing the pre and post training values the second test was used as the true baseline value.
Six-minute walking distances at baseline and three months are depicted in Table 3.3. Patients in the care-managed group walked significantly farther at 3-months as compared to baseline for each minute of the test; consequently, maximum walking distance improved by 24% (199.7±26 to 247.1±92; p=0.014). Maximum walking distance did not significantly improve for patients in the usual care group.

Table 3.3. Six Minute Walking Distance at Baseline and 3 months

<table>
<thead>
<tr>
<th></th>
<th>Six-Minute Walk Test (Walking Distance)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention (n=10)</td>
<td>Usual Care (n=8)</td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>3-Months</td>
</tr>
<tr>
<td>Min 1 (m/min)</td>
<td>30.25±15.80</td>
<td>35.76±17.54*</td>
</tr>
<tr>
<td>Min 2 (m/min)</td>
<td>32.48±14.03</td>
<td>38.74±17.34*</td>
</tr>
<tr>
<td>Min 3 (m/min)</td>
<td>34.87±14.51</td>
<td>42.31±15.51*</td>
</tr>
<tr>
<td>Min 4 (m/min)</td>
<td>36.66±14.75</td>
<td>42.91±15.29*</td>
</tr>
<tr>
<td>Min 5 (m/min)</td>
<td>36.66±14.75</td>
<td>42.32±15.86+</td>
</tr>
<tr>
<td>Min 6 (m/min)</td>
<td>36.66±14.75</td>
<td>42.32±15.86+</td>
</tr>
<tr>
<td>MWD (m)</td>
<td>199.70±29.00</td>
<td>247.10±92.00*</td>
</tr>
</tbody>
</table>

Table 3.4 shows the hemodynamic measures immediately after the 6th minute on the walk test. No significant differences between the periods or the groups were noted.

Table 3.4 Hemodynamic and Perceived Exertion in the Last Minute of the Walk Test

<table>
<thead>
<tr>
<th></th>
<th>Six-Minute Walk Test (Hemodynamics and Perceived Exertion @ 6 min)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention (n=10)</td>
<td>Usual Care (n=8)</td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>3-Months</td>
</tr>
<tr>
<td>Heart Rate (Bts/min)</td>
<td>103±13</td>
<td>96±17</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mmHg)</td>
<td>144±23</td>
<td>165±12</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mmHg)</td>
<td>81±16</td>
<td>77±8</td>
</tr>
<tr>
<td>RPE</td>
<td>9.33±1.63</td>
<td>10.44±1.51</td>
</tr>
</tbody>
</table>

- Quality of Life

The results of the effects of the 3-month Care-Managed Heart Failure Program on the perceived quality of life measured using the SF-36 Health Survey are shown in Table 3.5.
Table 3.5. Perceived Quality of Life before and after the intervention

<table>
<thead>
<tr>
<th>Perceived Quality of Life(SF-36)</th>
<th>Intervention(n=10)</th>
<th>Usual Care (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>3-Months</td>
</tr>
<tr>
<td>Physical Function</td>
<td>50±27</td>
<td>65±25*</td>
</tr>
<tr>
<td>Role Physical</td>
<td>39±42</td>
<td>50±45</td>
</tr>
<tr>
<td>Bodily Pain</td>
<td>63±30</td>
<td>65±27</td>
</tr>
<tr>
<td>General Health</td>
<td>48±23</td>
<td>55±19</td>
</tr>
<tr>
<td>Vitality</td>
<td>42±23</td>
<td>62±24*</td>
</tr>
<tr>
<td>Social Function</td>
<td>67±38</td>
<td>64±31</td>
</tr>
<tr>
<td>Role Emotional</td>
<td>59±32</td>
<td>78±24</td>
</tr>
<tr>
<td>Mental Health</td>
<td>66±21</td>
<td>75±26*</td>
</tr>
<tr>
<td>Physical Component Score</td>
<td>37±11</td>
<td>40±9</td>
</tr>
<tr>
<td>Mental Component Score</td>
<td>46±12</td>
<td>50±10</td>
</tr>
</tbody>
</table>

*p<0.05 vs. Baseline; ^p<0.10 vs. intervention

The data indicate that following the 3-month intervention, physical function (PF), vitality (VT), and mental health (MH) scores improved by 29% (50±27 to 64.5±25), 46% (42±23 to 61.5±24), and 13% (66.4±21 to 75.2±26), respectively (p<0.10), in patients randomized to the care-managed group.

3.4. Discussion

The present study indicates it is feasible to implement a multifaceted, care-managed program for individuals with heart failure in a family practice setting. However, a significant barrier to its success was the inability to effectively recruit patients from the pool of candidates. Despite this failure, the present data indicate moderate improvements in exercise tolerance and perceived quality of life in heart failure patients following a care-managed program in a family practice setting.

- **Reproducibility of the 6-minute Walk Test**

The present study clearly shows that the 6-minute walking test differentiates between a healthy and heart failure population. In fact, the reported maximum walking distance for the
heart failure patients in this study was quite consistent with previous reports\textsuperscript{10}. Guyatt et al.\textsuperscript{16} were one of the first to study the potential value of the 6-minute walk as an objective measure of exercise capacity in patients with chronic heart failure. They administered the 6-minute walking test six times over 12 weeks in 18 patients with chronic heart failure and 25 with chronic lung disease. The subjects also underwent cycle ergometer testing, and their functional status was evaluated by means of conventional measures. The walking test proved highly acceptable to the patients, and stable, reproducible results were achieved after the first two walks\textsuperscript{16}. The results correlated with the conventional measures of functional status and exercise capacity. The authors concluded that the 6-minute walk is a useful measure of functional exercise capacity and a suitable measure of outcome for clinical trials in patients with chronic heart failure\textsuperscript{16}. The present study is somewhat unique in that the stability of the measures was found using a treadmill test rather than the traditional hallway test. Recognizing the importance of using the same approach when conducting repeat measures the present data clearly show the usability of a treadmill for the purpose of obtaining the maximum walking distance on the 6-minute walking test. The present data do support research by Guyatt et al.\textsuperscript{16}, who recommends at least a practice walks be performed. If the difference between the first and second walk is greater than 10\% a third walk should be undertaken and used as the baseline measure. In this study the magnitude of the difference did not exceed 10\% in any of the participants.

- **Effect of 3 Month Intervention**

  Exercise tolerance as defined by the maximum walking distance achieved on a six-minute walk test improved in the patients randomized to the care-managed group. The pattern of speed changes during the walking tests from start to finish indicated patients in the care-managed group selected higher speeds in the first minute of the test and were able to maintain these speeds
throughout the 6-min walk test following the 3-month intervention period. Consequently, the maximum walk distance improved by 24%, from 199.7±26 to 247.1±92 (p=0.014). The observed improvements in maximum walking distance in this study are slightly better than our pilot study (19%, 241.43±88.06m to 285.65±99.69m (p=0.06). These findings are also similar to Rector et al. 18 who showed increases in maximum walking distances (390±91 versus 422±86 m, p<0.05) in a study to determine whether supplemental oral L-arginine augment peripheral blood flow and improve functional status in patients with moderate to severe heart failure. Recognizing the limitations of this study, these data support the idea that a carefully managed program for heart failure patients may contribute to improvements in 6-minute walk test performance.

In addition, data from the present study indicate a significantly higher score on three components of the SF-36. These included physical function, vitality, and mental health scores, which improved by 29%, 46%, and 13%, respectively (p<0.10). These improvements were only evident in the patients randomized to the care-managed group. The improvements are somewhat modest in comparison to another study that reported significant improvements in energy (80%), physical mobility (74%), and emotional reactions (83%) in heart failure patients 3 months following cardiac transplantation 19. Obviously such changes are difficult to compare as the present study did not involve transplantation. The present changes are also less than those reported by Kavanagh et al. 20, although they reported their improvements after one year of training.

- Recruitment Failures

The greatest failure of this study was the inability to effectively recruit, despite a dedicated nurse clinician, a committed medical director, and a large enough candidate pool. It is certainly not easy to pin-point the reasons for the lack of success but a few barriers are presented in an
effort to aid future attempts to overcome these more quickly. A major reason appeared to be a
general lack of interest by many patients with heart failure. The reasons for the lack of interest
are unknown but it is not uncommon to see this problem in populations with similar
demographics. It has been suggested that some patients may be somewhat fearful, in greater
denial, or mistrusting of a particular program that is not directly associated with their physician.
Other issues could certainly include a lack of perceived benefits, transportation problems, a lack
of education or other socioeconomic factors. Many of these factors have previously been
identified and should become a greater part of the planning stages of these sorts of efforts \(^{21-23}\). Another issue that may have affected the recruitment was the fact that the clinic was undergoing
a major transition in leadership. It appeared the physicians were somewhat distracted by these
issues which may have affected their attention to this study.

A second issue that requires a lot more thought and planning is the fact that it appeared many
patients were just not ready to engage, regardless of a specific reason. Given this lack of
readiness, it is not realistic to expect such patients to make changes that they are not prepared to
make. Thus it would appear greater attention to assessing the motivation and readiness of
patients with heart failure could be an important factor prior to forcing or implementing
behavioral changes \(^{24}\). In fact clinicians have been encouraged to examine theoretically based and
practically important behavioral strategies that might be useful for encouraging and supporting
behavior changes (e.g. exercise initiation and/or maintenance) among individuals with chronic
heart failure \(^{13, 25, 26}\). Application of behavioral theories, such as the Transtheoretical model
(TTM) of behavior change may be useful in designing effective intervention programs for
patients with heart failure \(^{26}\). These approaches could be used to guide strategies that go beyond
traditional patient educational approaches \(^{27}\). For example, with the appropriate activities to meet
the patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes. Therefore, the TTM offers an opportunity to improve compliance with published guidelines by individualizing the change process to meet the needs of each patient.

- **Educational Workbook**

  A major effort of this study was the development of an educational workbook that was specifically tailored to the patients’ level of education and disease. The workbook was designed to allow patients gain a greater understanding of their condition and teach them the importance of adhering to their program and recognizing early warning signs that may lead to congestive heart failure. Perhaps somewhat surprising few patients had any awareness of their condition and the steps needed to protect them from deteriorating. The workbook appeared to raise the patients’ awareness about their condition, which according to other researchers is a necessary component in the successful management of the patient.

  Clearly more work is needed. On the basis of the data from this study it would be important to modify the workbook to include strategies that may help individuals become more motivated and prepared to engage in these important behavioral strategies such as exercise, weighing, and careful adherence to diet and medications.

3.5 **Conclusion**

  The present study indicates it is feasible to implement a multifaceted, care-managed program for individuals with heart failure in a family practice setting. The present data indicate moderate improvements in exercise tolerance and perceived quality of life in heart failure patients following a care-managed program in a family practice setting. A greater appreciation of factors
that may prevent patients from participation in these intervention programs is necessary. One such factor may include pre-intervention assessments of the motivation and readiness of patients with heart failure to make behavior changes.

3.6 References


17. Ware JE and Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36). Medical Care (1992); 30: 473-483.


CHAPTER 4. EXAMINATION OF THE CONSTRUCTS OF THE TRANSTHEORETICAL MODEL IN PATIENTS WITH HEART FAILURE: A FOCUS ON PHYSICAL ACTIVITY READINESS

4.1 Introduction

Chronic heart failure remains a significant health problem in the United States, with frequent hospitalizations, widespread functional impairment, and a high mortality rate. Recent studies have shown the significant value of the use of a multidisciplinary approach in the management of the heart failure patient. These programs emphasize the importance of close monitoring and patient education. Despite positive outcomes from these programs, including fewer readmissions and hospital days, decreased costs, and improved functional status and quality of life, patient participation and adherence remain suboptimal.

A major component of the management of the heart failure patient is planned physical activity. Such programs have shown great promise as studies have revealed dramatic improvements in functional ability and quality of life and a reduction in healthcare costs and mortality in patients engaged in exercise programs. Consequently, current recommendations on the management of heart failure patients strongly emphasize an active lifestyle, and if possible, participation in a moderate exercise training regimen. However, despite the benefits of physical activity for patients with heart failure, research indicates that few individuals with heart failure actually engage in regular physical activity. Numerous studies have revealed that traditional methods of promoting physical activity have been only marginally successful in heart failure patients, citing failure to adhere to recommendations as a predominant factor.

Given the importance of physical activity, and the high levels of inactivity among individuals with chronic heart failure, clinicians have been encouraged to examine theoretically based and practically important behavioral strategies that might be useful for encouraging and supporting
exercise initiation and/or maintenance among individuals with chronic heart failure\textsuperscript{5,10,11}. Literature suggests that it is not realistic to expect patients to make changes that they are not prepared to make and little attention has been given to assessing the motivation and readiness of patients with heart failure to make necessary behavioral changes\textsuperscript{7}. Application of behavioral theories, such as the Transtheoretical model (TTM) of behavior change may be useful in designing effective intervention programs for patients with heart failure\textsuperscript{10}. These approaches could be used to guide strategies that go beyond traditional patient educational approaches\textsuperscript{12}. For example, with the appropriate activities to meet the patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes\textsuperscript{10,13,14}. Therefore, the TTM offers an opportunity to improve compliance with published guidelines by individualizing the change process to meet the needs of each patient. To date, no studies have examined the full TTM among patients with heart failure. Therefore, the specific aims of this research were three-fold:

1. To examine the associations of TTM behavior change constructs (behavioral and cognitive processes of change, decisional balance, and self-efficacy) by stage of change for planned regular physical activity among individuals with chronic heart failure.
2. To determine the most important predictors of physical activity stages of change utilizing the constructs of the TTM among individuals with chronic heart failure.
3. To examine the association of the stage of change construct for daily physical activity and maximum walking distance achieved on a 6 minute walk test.

In regards to specific aim one, the following hypotheses were tested:
Hypothesis I: Self-efficacy will increase in linear fashion from precontemplation to maintenance.

Hypothesis II: Perceived pros will increase across the stages from precontemplation to maintenance; whereas, perceived cons will decrease across the stages. The crossover point in decisional balance scores will be observed in the preparation stage.

Hypothesis III: Experiential and behavioral processes will increase across the stages of change.

In regards to specific aim two:

The predictive power of the TTM constructs to the stage of change is unknown in patients with heart failure; therefore, no specific hypothesis is stated.

In regards to specific aim three, the following hypothesis was tested:

Hypothesis IV: Both maximum walking distance and daily physical activity scores will be higher in the action and maintenance stages as compared to the previous stages.

- **Background and Significance**

Heart failure is defined as the pathophysiological state in which an abnormality of cardiac function is responsible for failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues, or to do so only from an elevated filling pressure\textsuperscript{15}. Despite traditional pharmacological treatment, the clinical phase of heart failure includes a marked decline in functional status, defined by exercise tolerance and capacity with a subsequent decrease in quality of life.

An estimated 4.9 million Americans have heart failure, a chronic condition associated with frequent hospitalizations, widespread functional impairment, and a high mortality rate. Each year, approximately 550,000 new cases are diagnosed and nearly 300,000 patients die of heart
failure as a primary or contributory cause. Elderly individuals are particularly at risk for developing heart failure. In fact, heart failure is the most common hospital discharge diagnosis for patients over 65 years. The syndrome is the underlying reason for 12 to 15 million office visits and 6.5 million hospital days each year. Furthermore, during the last 10 years, the annual number of hospitalizations has increased from approximately 550,000 to nearly 900,000 for heart failure as a primary diagnosis and from 1.7 to 2.6 million for heart failure as a secondary diagnosis. In addition to the substantial morbidity and mortality associated with this condition, there is a significant financial impact on our society. In fact, heart failure is now the single most costly cardiovascular illness in the United States, with total treatment costs estimated at $24.3 billion. The cost to society is expected to increase due to an aging population and prolonged survival rates of individuals with cardiovascular disease, therefore imposing a large burden on individuals and the healthcare system.

Research indicates that a multidisciplinary approach to heart failure management may be associated with important clinical benefits, including fewer readmissions and hospital days, decreased costs, improved functional status and quality of life. An important component of such programs focuses on the promotion of behavior modification, including proper diet, adequate exercise and rest, and other lifestyle changes. Unfortunately, adherence to heart failure programs is generally low, and noncompliance remains a serious problem. In fact, failure to adhere to recommendations continues to be a primary reason for hospital readmission for patients with decompensated heart failure. The reasons behind the noncompliance are poorly understood. Clearly, a better understanding of factors that may contribute to noncompliance may lead to better strategies for the clinician to engage the patients in their disease management.
The use of appropriate and adequate physical activity may be of particular importance in the management of the heart failure patient. Arguably, there is no single intervention with greater promise than physical activity in the management of the heart failure syndrome\textsuperscript{20}. Not only does physical training improve measures of exercise tolerance and capacity, but exercise training also reverses a number of maladaptations in the vasculature, skeletal muscle, neuroendocrine systems, and metabolism in heart failure patients. Moreover, patients’ functional ability and quality of life improve dramatically. Lastly, a recent meta-analysis reveals a significant reduction in mortality in patients engaged in exercise programs\textsuperscript{4}. Consequently, the current recommendations on the management of heart failure patients strongly emphasizes an active lifestyle, and if possible, participation in a moderate exercise training regimen\textsuperscript{5,6}. However, as previously stated, few individuals with heart failure actually engage in regular physical activity\textsuperscript{7}. In fact, Sneed & Paul\textsuperscript{7} reported only 38% of patients with heart failure (age=56±12) exercise regularly (at least 3 days per week for at least 20-minute intervals).

Traditional strategies to alter behaviors such as physical activity patterns include educational classes, videos, and written materials. These materials are generally presented to all patients in the same manner. More recently, there is clear evidence that education will only work if the patient is willing to engage in the process\textsuperscript{14}. For example, despite the use of an individualized intervention focused on preventing exacerbations of heart failure through symptom recognition, medication, dietary education, and modification of poor health behavior, a 33% readmission rate was noted within the first 6 months after hospital discharge\textsuperscript{8}. The authors attributed the high readmission rates to lack of social support and individual motivation to learn and manage health behavior\textsuperscript{8}. 
The problems with motivating individuals to change health-related behaviors are similar in other populations. For example, Marcus et al. revealed that population-based interventions such as media-based campaigns, aimed at increasing the public’s interest in initiating physical activity have been ineffective in reaching large numbers of people. The authors speculate that the failures are in part due to the educational rather than behavior and motivational focus of many campaigns. Furthermore, many exercise programs are designed for people who have decided to begin exercise, yet a large proportion of individuals are simply not interested or ready to engage in physical activity programs. A general rule of thumb is that at any given moment, only about 20% of at-risk populations are ready to take meaningful action to change a health behavior and 40% of those with a problem are in a stage of change marked by denial and resistance. This reflects a mismatch between what is currently offered (action-oriented programs) and where individuals might be regarding their readiness to change (i.e., sedentary and not interested in exercise). Consequently, interventions should be tailored to the specific needs of the population of interest. The following section will describe a theoretical framework for understanding behavioral change.

- **The Transtheoretical Model of Health Behavior Change**

  The TTM provides a theoretical framework for assessing and addressing readiness for changes in behavior. A strength of the model is its focus on the dynamic nature of health behavior change, or understanding behavior change as a process rather than a single event. The use of the TTM originated in studies to treat addictive behaviors, but has since been offered as a coherent framework to help understand readiness to begin physical activity. Additionally, the TTM has been applied successfully to a wide variety of populations in the physical activity domain. Although only one study has utilized the TTM to assess readiness for behavior...
change in patients with heart failure, currently there are no studies that have specifically addressed physical activity behaviors using the TTM in patients with heart failure. Understanding how the model works in patients with heart failure may yield insight into why some patients are ready to engage in physical activity programs and others are not. Furthermore, once the correct stage of an individual is identified more appropriate interventions can be implemented to move a person along the continuum of physical activity behavior change.

The framework of the TTM consists of four core constructs (see Table 4.1): the stages of change, processes of change, decisional balance, and self-efficacy. It has been recommended that interventions to increase physical activity participation be designed utilizing these constructs. Each construct will be briefly discussed in the following sections. Particular attention will be given to the need to use these constructs in the heart failure population.

<table>
<thead>
<tr>
<th>Table 4.1. Transtheoretical Model: Core Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construct</strong></td>
</tr>
<tr>
<td>Stages of Change</td>
</tr>
<tr>
<td>Processes of Change</td>
</tr>
<tr>
<td>Decisional Balance</td>
</tr>
<tr>
<td>Self-efficacy</td>
</tr>
</tbody>
</table>

**Stages of Change**

The central construct of the TTM is the stages of change. The stage construct was developed to reflect the temporal dimension of health-behavior change. A change in behavior is viewed as a 5-stage process that may progress in a linear fashion, but most often progresses in a cyclical pattern, including relapse to previous stages, before the change becomes stable. Five stages that have been proposed within the TTM include: 1) Precontemplation; individuals in this stage are
not intending to take action in the foreseeable future, usually measured as the next 6 months; 2) Contemplation; reflects the intent to change within the next 6 months; 3) Preparation; indicates the intent to change in the immediate future, usually measured within the next 30 days; 4) Action; during which specific, overt modification in lifestyle has occurred within the past 6 months; and 5) Maintenance; maintenance of an overt behavior change for more than 6 months23.

Studies that have used the stage of change construct generally report greater success in terms of adopting targeted behaviors. More specifically, research suggests physical activity interventions targeted to stage of change are more effective than interventions not tailored to stage of change21, 30. Currently, clinicians typically provide generic health advice to patients with heart failure. Although literature suggests that it is not realistic to expect patients to make changes that they are not prepared to make, little attention has been given to assessing the motivation and readiness of patients with heart failure to make necessary behavioral changes7. Therefore, knowledge of a person’s stage of readiness to begin regular physical activity could be used to assist clinicians in developing targeted, effective behavior change interventions and to guide strategies that go beyond traditional patient educational approaches12.

Self-efficacy

The self-efficacy construct originated with Bandura’s theory that successful change is based on the degree of confidence an individual has in his/her ability to be physically active under a number of specific circumstances31. Self-efficacy is positively associated with physical activity behavior21 and motivational readiness for physical activity adoption27, 32. Additionally, many studies have found that self-efficacy is the best predictor of physical activity behavior, suggesting that improved self-efficacy leads to higher levels of physical activity26. Although there have been no studies that have addressed this construct in heart failure patients, Hellman13
utilized the TTM to determine that perceived self-efficacy was an important predictor of stage of change and exercise adherence in a cardiac rehabilitation population.

The self-efficacy construct may be particularly important in the heart failure patient. Many patients are somewhat fearful in engaging in activities that may bring on symptoms associated with their condition. Thus information about their perceived self-efficacy for regular physical activity may be particularly important for the clinician.

**Decisional Balance**

The decisional balance construct is based on the theoretical model of decision-making developed by Janis and Mann\(^{33}\) and reflects an individual’s relative weighing of the pros and cons, or benefits and costs, of changing behavior. The underlying assumption is that a person will not decide to change behavior to begin an activity unless the pros of changing exceed the costs of changing the behavior. Differences in decisional balance tend to correspond to different stages of motivational readiness\(^{23}\). People in precontemplation stage perceive more barriers (cons) than benefits (pros) to change, while those in the action stage perceive more benefits than barriers\(^{34}\). Prochaska and colleagues\(^{34}\) studied twelve problem behaviors and noticed that for all twelve behaviors, the cons of changing are more important than the pros for people in the precontemplation stage. The opposite is true for people in the action stage in eleven out of twelve behaviors. Additionally, across all twelve behaviors, the pros of changing always increase from precontemplation to contemplation, whereas, the cons of changing always decrease from contemplation to action\(^{35}\). Furthermore, the cross-over point for pros and cons for exercise behavior was observed in the preparation stage\(^{34}\), and this finding has been replicated in recent studies\(^{27, 28}\). Once more, there are currently no data available regarding decisional balance for any behavior (including physical activity) in the heart failure patient.
Processes of Change

Processes of change include strategies and techniques used to support efforts to progress through the stages of change. Ten distinct processes can be divided into 5 experiential processes that are internally focused on emotions, values, and cognitions; and 5 behavioral processes that are focused on behavioral changes. Experiential processes include consciousness-raising, dramatic relief, environmental reevaluation, social liberation, and self-reevaluation. Behavioral processes include counter-conditioning, helping relationships, reinforcement management, stimulus control, and self-liberation (Table 4.2).

Table 4.2. Process of Change Descriptions for Physical Activity Behaviors

<table>
<thead>
<tr>
<th>Experiential Processes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consciousness raising</td>
<td>Seek new information about exercise</td>
</tr>
<tr>
<td>Dramatic relief</td>
<td>Experience and express intense feelings about being inactive</td>
</tr>
<tr>
<td>Environmental re-evaluation</td>
<td>Assess how being inactive affects physical and social environment</td>
</tr>
<tr>
<td>Self re-evaluation</td>
<td>Re-appraise values regarding inactivity</td>
</tr>
<tr>
<td>Social-liberation</td>
<td>Develop awareness and acceptance of active lifestyle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behavioral Processes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter-conditioning</td>
<td>Substitute alternative behaviors for sedentary activities</td>
</tr>
<tr>
<td>Helping relationships</td>
<td>Use support from others to be more active</td>
</tr>
<tr>
<td>Reinforcement management</td>
<td>Changes contingencies; reward physical activity</td>
</tr>
<tr>
<td>Self-liberation</td>
<td>Choose and commit to being more active; believe that change is possible</td>
</tr>
<tr>
<td>Stimulus control</td>
<td>Control situations and cues that support inactivity</td>
</tr>
</tbody>
</table>

The TTM posits that the use of specific processes varies by stage of change. In general, sedentary individuals, those in the earlier stages of motivational readiness (precontemplation, contemplation), tend to place greater emphasis on cognitive processes, while regularly active individuals, those in later stages of physical activity adoption tend to endorse more behavioral processes. Moreover, use of behavioral processes of change has been shown to significantly predict physical activity behavior, and stage of motivational readiness for physical activity. Kosma and colleagues utilized the TTM constructs to examine the most important physical activity stage of change predictors for mostly inactive adults with physical disabilities. Results
revealed that the most important predictors were the behavioral \((r^2 = .88)\) and cognitive processes \((r^2 = .50)\), followed by self-efficacy \((r^2 = .33)\), and decisional balance \((r^2 = .13)\). These results are consistent with findings for other populations\(^{26}\).

Furthermore, research has demonstrated that an integration of the stages and processes of change can provide a useful guide for interventions\(^{21,32}\). Once an individual’s stage has been assessed, interventionists have a better idea of which processes to emphasize in order to facilitate progress to the next stage of change\(^{24}\).

**Table 4.3. Stages of Change in which Processes are most emphasized.**

<table>
<thead>
<tr>
<th>Stages of Change</th>
<th>Precontemplation</th>
<th>Contemplation</th>
<th>Preparation</th>
<th>Action</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processes</td>
<td>Consciousness Raising</td>
<td>Dramatic relief</td>
<td>Environmental reevaluation</td>
<td>Self-reevaluation</td>
<td>Contingency management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Helping relationships</td>
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<td></td>
<td></td>
<td>Counter-conditioning</td>
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<td></td>
<td></td>
<td></td>
<td>Stimulus control</td>
</tr>
</tbody>
</table>

With the appropriate activities to meet the heart failure patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes\(^{13}\).

**Summary of the Transtheoretical Model**

The TTM consists of 4 distinct constructs. Careful examination and appreciation of these constructs generally results in greater success in adoption of a targeted behavior, such as planned physical activity. In a meta-analysis of eighty studies using the TTM in the physical activity domain, no study was included that examined the TTM’s constructs among individuals with heart failure\(^{26}\). Interestingly the majority of the guidelines for management of the heart failure syndrome emphasize the need for using targeted behavioral strategies\(^{5,6,11}\). Therefore,
considering the lack of data regarding the full TTM in patients with heart failure, and given the success of the TTM for understanding physical activity behaviors in other populations, the TTM has been identified as a potentially useful model for understanding the exercise behavior of individuals with chronic heart failure\textsuperscript{10, 14}. However, before the TTM is widely used for intervention studies, its utility and relevance must first be examined within this population segment.

- **Measure of Physical Activity**

As stated above, a patient’s perception of his or her stage of readiness might not always match the patient’s actual behavior\textsuperscript{14}. Therefore, an actual assessment of physical activity should also be included in order to compare the results of such assessments with the individual’s stage of change\textsuperscript{27}. The measurement of actual physical activity or exercise tolerance is difficult in patients with heart failure. Numerous tools are available, for assessment of actual exercise behavior such as activity logs or journals, accelerometers, symptom limited graded exercise tests, and submaximal tests such as the 6-minute walk\textsuperscript{37}. Each of these assessments has limitations and flaws and may not be very representative of the patient’s actual physical activity behavior. One of the better predictors of a patient’s functional ability, exercise tolerance and physical activity behavior may be the maximum distance an individual can travel on a 6-min walk test\textsuperscript{37, 38}. Moreover, the 6-min walk test provides prognostic information about the heart failure patient and appears to be sensitive to interventions such as exercise training. A recent review\textsuperscript{37} revealed that the 6-min walk test is recommended as a useful, simple, noninvasive alternative for assessing physical activity in patients with heart failure. There currently are no studies that have examined the TTM constructs for physical activity behavior to an actual measure of exercise tolerance in
patients with heart failure. Such data could potentially provide a better understanding of the links between the TTM constructs and the patient’s physical activity behavior.

- **Clinical Relevance**

  There is clear evidence that implementation of a tailored heart failure educational program as outlined by the Agency of Health Care Policy and Research is effective in improving physiological and functional outcomes, as well as reduces hospitalization and associated health care costs\(^\text{39}\). Despite this evidence a significant number of patients with heart failure do not participate in such programs even when accessible. For example, our experience shows that from a pool of approximately 250 heart failure patients we were only able to recruit 20 patients. This is particularly disappointing given the fact we had an active recruiting program in place, which was coordinated by a dedicated nurse clinician. Moreover, a major criticism of many large-scale therapeutic trials in heart failure is that the characteristics of the heart failure population at large are quite different from those being studied. This suggests there is a tremendous number of patients with heart failure who are currently not being reached. Knowledge regarding factors that may provide a better understanding of reasons that may prevent a patient from participation will ultimately contribute to the development of improved strategies for inclusion.

### 4.2 Methods

- **Participants**

  One hundred and forty-eight patients with a diagnosis of heart failure were recruited from the Baton Rouge, LA and Jackson, MS areas. Participants had to be at least 18 years of age, and be on stable and optimal pharmacotherapy for their heart failure condition as determined by their physician. In addition, participants had to have the ability to read and write English. Participants were not excluded on the basis of gender, race, and/or etiology of heart failure. Exclusion criteria
included individuals with acute medical conditions related or independent of the primary
diagnosis (e.g. congestive heart failure requiring hospitalization, unstable angina, active
infections etc.). Prior to participation, each individual was required to complete an informed
consent approved by the area Institutional Review Board.

• **Study Design**

  The study was a cross-sectional design aimed at examining the application of the full TTM
for physical activity in a group of individuals with chronic heart failure. Upon arrival to a
scheduled Cardiology appointment, each participant was asked at check-in if they would mind
completing information regarding physical activity behaviors and beliefs. If willing to
participate, the individual was given a folder containing all questionnaires to be completed for
the study, including stage of change, decisional balance, processes of change, self-efficacy, and
Daily Activity in Heart Failure Questionnaire (DAIHFQ). Additionally, each participant
underwent a six minute walk (6MW) test and a review of medical history and demographics.
Data were collected in one visit.

• **Experimental Measurements**

  **Stage of Change**

  Each participant’s stage of change for physical activity adoption was assessed by the Stages
of Change for Physical Activity Questionnaire, using the algorithm recommended by Reed and
colleagues\(^{40}\). Specifically, participants were asked to indicate their present levels of physical
activity behavior. Regular physical activity or exercise was defined as “any *planned* physical
activity of moderate intensity (e.g., brisk walking, cycling, jogging, swimming, aerobics, etc.)
aimed at improving/maintaining your health. The activity does not have to be painful to be
effective but should be done at a level that increases your breathing rate and causes you to break
For activity to be **regular** it must add up to a total of 30 or more minutes per day, and be done **at least 5 days per week**. For example, you could take a 30 minute walk or take 3 ten minute walks each day.” Participants were asked to indicate whether they engage in planned regular physical activity, according to the above definition, by marking one out of five statements, each of which reflects one of the five stages: precontemplation: “I do NOT plan to start regular physical activity in the next 6 months”; contemplation (C): “I am planning to start regular physical activity in the next six months”; preparation (P): Not regularly, but I engage in such activities occasionally and plan to start on a regular basis within the next month; action (A): “I have been physically active for LESS than six months”; and, maintenance (M): I have been physically active for MORE than six months”. This staging measure is recommended as the most accurate estimate for adults⁴⁵, and the construct validity and test-retest reliability of this methodology has received strong support in previous research⁴¹.

**Processes of Change**

The processes of change were assessed using a 30-item, five-point Likert scale designed specifically for exercise⁶⁶. Fifteen items assessed the behavioral processes of change (i.e., counter-conditioning, contingency management, helping relationships, self-liberation, and stimulus control) and fifteen items assessed the cognitive processes of change (i.e., consciousness raising, dramatic relief, environmental reevaluation, self-reevaluation, and social liberation). An example of a behavioral process is “Instead of relaxing by watching TV or eating, I take a walk or do physical activity”; whereas, an example of a cognitive process is “I read articles to learn more about physical activity”⁵⁵.

**Self-efficacy**
Self-efficacy was assessed using a six-item survey designed to measure confidence in one’s ability to persist with exercising in various situations\textsuperscript{32}. A sample item is, “I am confident I can participate in regular physical activity when I am tired.” Participants responded to each item using a five-point Likert scale (1 = “not at all confident,” 2 = “somewhat confident,” 3 = “moderately confident,” 4 = “very confident”, and 5 = “completely confident”). Prior studies have shown an alpha coefficient of this scale is 0.82 and scores have been shown to significantly differentiate individuals at most stages of motivational readiness for physical activity adoption\textsuperscript{36,32}.

**Decisional Balance**

Decisional balance was measured using a 10-item inventory assessing five perceived benefits (pros) and five perceived barriers (cons) to physical activity participation\textsuperscript{42}. Items were rated using a five-point Likert scale with 1 being “not at all important” and 5 being “extremely important”. This measure has been shown to have good internal consistency for both pros and cons of physical activity participation, at .82 and .72, respectively\textsuperscript{42}. The actual decisional balance score was determined by subtracting the participant’s con score from the pro score (i.e. pros-cons).

**Six-Minute Walk Test**

Exercise intolerance is defined as the reduced ability to perform activities that involve dynamic movement of large skeletal muscles because of dyspnea or fatigue\textsuperscript{38}. Exercise tolerance was measured as the maximum walking distance achieved on a 6-min-walk test\textsuperscript{38}. The six-minute walk test is recommended as a useful, simple, noninvasive alternative for assessing physical activity in patients with heart failure. The test was performed in a corridor and participants were instructed to walk as far as possible in 6 minutes, avoiding chest pain, marked
dyspnea, or other symptoms\textsuperscript{44}. To standardize the protocol, the participants were not coached during the test, but made aware of time remaining to completion. The use of the six-minute walk test has received a lot of attention recently, due to its relative ease of administration. The test is also thought to reflect a realistic effort as performed in daily life, and appears highly acceptable to patients\textsuperscript{38}. Furthermore, several studies have reported the prognostic significance of the 6-minute walk test in patients with heart failure\textsuperscript{43,44}.

**Physical Activity Questionnaire**

Garet et al. (2004) recently published a detailed self-administered questionnaire of daily energy expenditure dealing with 7 dimensions of everyday life to better reflect habitual activities in patients with heart failure\textsuperscript{45}. To validate this questionnaire the investigators\textsuperscript{45} measured actual VO\textsubscript{2}\textsubscript{peak}s and found it to be a valid and reliable reflection of physical activity status. The original questionnaire was in French; therefore, in the present study a translation of the French questionnaire was used. The translation was made with help of the original investigators of the questionnaire. The questionnaire considers seven main areas including sleeping and resting, basic everyday activities (e.g. eating and washing), housework activities, leisure time physical activities, physical activity in salaried or voluntary work, moving about, and miscellaneous activities. Subsequently, activities could be classified in terms of intensity, i.e. activities below 3 METs, between 3 and 5 METs, and above 5 METs, as well as duration (minutes performed)\textsuperscript{45}. Three response models were applied depending on the item. For example, participants reported information pertaining to time spent on each activity, quantifying the number of times the activity is done per week or day, and reported whether help or interruption was needed systematically, sometimes, or never during an activity\textsuperscript{45}. Detailed scoring instructions are provided elsewhere\textsuperscript{64}. 
• **Statistical Analysis**

The Statistical Package for the Social Sciences (SPSS version 12.0, SPSS Inc., Chicago, IL) was used for all data analysis. Descriptive statistics were performed to provide demographic characteristics of the study participants. The first specific aim and respective hypotheses were examined using a one-way MANOVA with Univariate F-tests to describe the general trend of the associations among the constructs of the Transtheoretical model. Specifically, this includes the associations between the stages of change (independent variable) and the other constructs of the TTM (i.e., self-efficacy, decisional balance, and the cognitive and behavioral processes), which serve as the dependent variables.

In terms of the second specific aim, a direct discriminant function analysis (DDF) was conducted from which a classification matrix was generated\(^{46}\) to identify the most influential predictors of exercise stage of change as well as overall prediction accuracy. Criterion for a significant relationship between predictors and discriminant functions is \(> .33\)^{46}. Finally, the hypothesis associated with the final aim was tested using a univariate general linear model with the maximum walking distance as the dependent measure and the stage of change constructs as the independent measures. In addition, to examine the concurrent and construct validity between the physical activity questionnaire and the six-minute walk test, simple correlation coefficients and a multivariate general linear model with the categories of activity as the dependent measures and stages of change as the fixed factor were used.

4.3 **Results**

• **Patient Characteristics**

Patient characteristics are presented in Table 4.5 through 4.9. A total of 148 patients were studied. Ninety eight participants were men, and fifty women. The mean age for the total group
was 52±13 (years), the average left ventricular ejection fraction (LVEF) for the group was 31±11%. Etiology of heart failure included: ischemic heart disease (18.5%), non-ischemic cardiomyopathy (20.0%), hypertensive heart disease (16.9%), pregnancy induced heart failure (3.1%), viral induced heart failure (3.1%), heart failure related to cancer treatments (1.5%), idiopathic cardiomyopathies (32.3%), and congenital heart failure (4.6%). The duration of heart failure averaged just over 6 years, ranging from 2 months to 35 years. The majority of patients were classified as New York Heart Association (NYHA) Class II (61%) and III (38%). One patient was considered between a Class III and IV, and was included in the analyses. Forty-six percent of the patients were married, 26% were separated/divorced or widowed, and the remaining 28% of the participants were single or engaged. Sixty-five percent of the participants were Caucasian, 34% were African-American, and 1% Hispanic. In regards to the level of education 26% of participants did not have a high-school diploma, 57% did have at least a high school diploma or equivalent, 13% had an earned bachelor’s degree, and 4% had an earned post-baccalaureate degree.

The majority of participants reported being in the preparation stage of change (n = 41, 27.7%), followed by contemplation (n = 33, 22.3%), maintenance (n = 29, 19.6%), action (n = 23, 15.5%), and precontemplation (n = 22, 14.9%). In regards to the stage of change classification, no significant differences were noted for age, LVEF and heart failure duration (see Table 4.5 and 4.6). Furthermore, as depicted in Tables 4.7 and 4.8, no differences in the stage classifications for race, employment status, income level, education level, heart failure diagnosis, number of co-morbidities and medications were observed. Therefore, these demographic variables were not treated as moderators in subsequent analyses. However, there was a tendency
for a greater percentage of women (75%) than men (60%) to be in the precontemplation and contemplation stages of readiness (p=0.06).

Table 4.5 Descriptive Statistics (Age, Height, Weight, BMI)

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>Age (yrs) Mean</th>
<th>Age (yrs) SD</th>
<th>Height (m) Mean</th>
<th>Height (m) SD</th>
<th>Weight (kg) Mean</th>
<th>Weight (kg) SD</th>
<th>BMI (kg/m²) Mean</th>
<th>BMI (kg/m²) SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>55</td>
<td>13</td>
<td>1.72</td>
<td>0.10</td>
<td>98.49</td>
<td>33.56</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>Contemplation</td>
<td>52</td>
<td>16</td>
<td>1.72</td>
<td>0.08</td>
<td>88.52</td>
<td>27.38</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Preparation</td>
<td>50</td>
<td>13</td>
<td>1.74</td>
<td>0.09</td>
<td>105.14</td>
<td>32.99</td>
<td>35</td>
<td>11</td>
</tr>
<tr>
<td>Action</td>
<td>55</td>
<td>9</td>
<td>1.77</td>
<td>0.09</td>
<td>93.13</td>
<td>13.65</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>Maintenance</td>
<td>50</td>
<td>15</td>
<td>1.76</td>
<td>0.08</td>
<td>91.96</td>
<td>16.64</td>
<td>31</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>13</td>
<td>1.75</td>
<td>0.10</td>
<td>95.28</td>
<td>26.43</td>
<td>31</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4.6 Descriptive Statistics (Hemodynamics)

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>LVEF (%) Mean</th>
<th>LVEF (%) SD</th>
<th>HR (bts/min) Mean</th>
<th>HR (bts/min) SD</th>
<th>SBP (mmHg) Mean</th>
<th>SBP (mmHg) SD</th>
<th>DBP (mmHg) Mean</th>
<th>DBP (mmHg) SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>35.58</td>
<td>12.83</td>
<td>74</td>
<td>12.74</td>
<td>130</td>
<td>22.91</td>
<td>73</td>
<td>14.93</td>
</tr>
<tr>
<td>Preparation</td>
<td>29.16</td>
<td>10.26</td>
<td>78</td>
<td>13.99</td>
<td>117</td>
<td>18.50</td>
<td>68</td>
<td>10.17</td>
</tr>
<tr>
<td>Action</td>
<td>31.35</td>
<td>7.07</td>
<td>74</td>
<td>11.70</td>
<td>110</td>
<td>15.90</td>
<td>70</td>
<td>6.85</td>
</tr>
<tr>
<td>Maintenance</td>
<td>29.84</td>
<td>11.79</td>
<td>76</td>
<td>11.42</td>
<td>121</td>
<td>8.51</td>
<td>69</td>
<td>6.69</td>
</tr>
<tr>
<td>Total</td>
<td>30.70</td>
<td>11.03</td>
<td>76</td>
<td>13.98</td>
<td>118</td>
<td>19.59</td>
<td>70</td>
<td>12.09</td>
</tr>
</tbody>
</table>
Table 4.7 Test for Differences between Stages of Change: One Way ANOVA

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>435.585</td>
<td>4</td>
<td>108.896</td>
<td>.597</td>
<td>.665</td>
</tr>
<tr>
<td>Height (m)</td>
<td>.039</td>
<td>4</td>
<td>.010</td>
<td>1.96</td>
<td>.318</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>3646.859</td>
<td>4</td>
<td>911.715</td>
<td>1.324</td>
<td>.267</td>
</tr>
<tr>
<td>BMI</td>
<td>476.563</td>
<td>4</td>
<td>119.141</td>
<td>1.690</td>
<td>.267</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>377.627</td>
<td>4</td>
<td>94.407</td>
<td>1.769</td>
<td>.548</td>
</tr>
<tr>
<td>RHR (b/min)</td>
<td>122.191</td>
<td>4</td>
<td>30.548</td>
<td>.146</td>
<td>.964</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>1774.276</td>
<td>4</td>
<td>443.569</td>
<td>1.171</td>
<td>.335</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>133.878</td>
<td>4</td>
<td>33.469</td>
<td>.215</td>
<td>.929</td>
</tr>
</tbody>
</table>

Table 4.8 Test for Differences between Stages of Change: Kruskal Wallis Test

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Race</th>
<th>NYHA</th>
<th>Employ Status</th>
<th>Income level</th>
<th>Educ. Level</th>
<th>CHF Diagnosis</th>
<th>Comorbidities (#)</th>
<th>Med (#)</th>
</tr>
</thead>
<tbody>
<tr>
<td>df</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Sig</td>
<td>.060</td>
<td>.707</td>
<td>.267</td>
<td>.990</td>
<td>.831</td>
<td>.872</td>
<td>.054</td>
<td>.488</td>
<td>.866</td>
</tr>
</tbody>
</table>

Grouping Variable: Stage of Change

- **Hypotheses I-III**

  The MANOVA, used to examine the associations between the stages of change and the TTM constructs, revealed a statistically significant relationship ($F(20, 461) = 26.4; p < .001, \eta^2 = .47$) between the stages of change (independent variable) and other constructs of the TTM (self-efficacy, decisional balance, behavioral and experiential processes) that served as the dependent variables. The means, standard deviations, $F$-tests, variance explained ($\eta^2$), and Tukey post hoc contrasts of the follow-up ANOVAs for self-efficacy, decisional balance, and the cognitive and behavioral processes of change across the five stages are shown in Table 4.9. Based on these results, the behavioral processes of change explained most of the variance ($\eta^2 = .83$), followed by self-efficacy ($\eta^2 = .77$), perceived pros ($\eta^2 = .62$), perceived cons ($\eta^2 = .54$), and experiential processes ($\eta^2 = .53$).
Table 4.9 Descriptive Associations between the Constructs of the Transtheoretical Model across the Stages of Change

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stage of Change</th>
<th>N=148</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>Perceived Pros M</td>
<td>12.77</td>
<td>17.09</td>
</tr>
<tr>
<td>SD</td>
<td>2.29</td>
<td>3.24</td>
</tr>
<tr>
<td>Perceived Cons M</td>
<td>13.95</td>
<td>12.30</td>
</tr>
<tr>
<td>SD</td>
<td>3.40</td>
<td>2.94</td>
</tr>
<tr>
<td>Experiential Processes M</td>
<td>30.91</td>
<td>42.06</td>
</tr>
<tr>
<td>SD</td>
<td>7.83</td>
<td>8.51</td>
</tr>
<tr>
<td>Behavioral Processes M</td>
<td>22.32</td>
<td>30.91</td>
</tr>
<tr>
<td>SD</td>
<td>5.07</td>
<td>7.18</td>
</tr>
<tr>
<td>Self-Efficacy M</td>
<td>8.50</td>
<td>11.55</td>
</tr>
<tr>
<td>SD</td>
<td>2.55</td>
<td>3.42</td>
</tr>
</tbody>
</table>

1PC = precontemplation, C = contemplation, PR = preparation, A = Action, M = maintenance
*p < .001

As depicted in Table 4.9, the general trend of the scores for the dependent variables illustrates an increase from the lower to the higher stages in all variables except for perceived cons. Specifically, individuals in the precontemplation stage had the lowest scores for self-efficacy, showed minimal use of the behavioral and experiential processes of change, and perceived relatively fewer pros and higher cons than any other stage. Whereas, the participants in the contemplation stage reported higher self-efficacy scores as compared to those in precontemplation, were clearly using some experiential strategies, yet continued to report relatively high perceived cons for exercise. In the preparation stage, individuals reported using the behavioral processes of change more so than in the previous stages, along with advances in
the use of the experiential processes of change, higher self-efficacy scores, the perception of more pros to exercise, along with significantly fewer perceived cons to exercise as compared to previous stages. Those individuals in the action stage reported higher self-efficacy scores and extensive use of behavioral processes, whereas, the scores for experiential processes were similar to those in the preparation stage. Decisional balance clearly favored the pros, with higher pros as compared to previous stages and the cons diminishing to a lower level than any previous stage. In the maintenance stage, participants continued to use the behavioral processes extensively, self-efficacy scores and perceived pros also remained high, experiential processes remained similar to those in preparation and action stages, and perceived cons remained low and were similar to those in the action stage.

In summary, based on the results of the general linear model multivariate procedure, the hypotheses were generally supported. First, self-efficacy scores were lowest in the Precontemplation stage and increased in linear fashion to maintenance (PC<C<PR<A, M). Secondly, decisional balance shifted from greater perceived cons and lower perceived pros in the precontemplation and contemplation stages to lower perceived cons and higher perceived pros in the action and maintenance stages (Cons: PC,C>PR>A,M; Pros: PC<C<PR<A,M). Furthermore, although both experiential and behavioral processes increased from lower to the higher stages, it should be noted that scores for experiential processes were higher than behavioral processes in precontemplation, contemplation, and preparation stages; whereas, the opposite was true for the action and maintenance stages.

- **Predictors of the Stage of Change**

  A direct discriminant function analysis (DDF) was conducted to identify the most important stage-of-change predictors based on the TTM constructs (perceived pros and cons, self-efficacy,
and behavioral and experiential processes of change), which served as the independent variables. The structure matrix for each discriminant function, along with canonical correlations, eigenvalues, and % variance are shown in Table 4.11. Of the four discriminant functions produced in the DDF analysis, the predictor variables were found to differentiate the stages of change with two significant functions, which accounted for 95.0% (Wilks’ $\lambda = .080, X^2(20) = 358.76, p<.001$) and 4.8% (Wilks’ $\lambda = .705, X^2(12) = 49.62, p<.001$), respectively, of the between-group (stage of change) variability. The a priori criterion for an accepted canonical correlation was $\geq .33$ 46. Thus, the third and fourth functions were neither statistically ($p=.87$ and $p=.72$) nor practically ($r^2=.11$ and $r^2=.07$) significant, respectively. Therefore, the focus was on the first two discriminant function analyses and the other two were discounted.

As depicted in Table 4.10, the structure coefficients (i.e., correlation between each predictor and the first discriminant function) revealed that the most important stage of change predictors were the behavioral processes ($r^2=.78$) and perceived self-efficacy ($r^2=.66$), followed by pros ($r^2=.44$), cons ($r^2=-.38$), and experiential processes ($r^2=.33$). According to the functions at group centroids (mean discriminant scores for each stage of change) (see Table 4.11 and Figure 4.1), these predictors contributed mostly in the discrimination between precontemplation and the other four stages, as well as in discriminating contemplation and preparation from action and maintenance. Furthermore, the second function revealed that the experiential process of change ($r^2=.80$) and the pros of decisional balance ($r^2=.48$) distinguished those in the precontemplation stage from contemplation and preparation, as well as those in the preparation stage from action and maintenance.

The number & corresponding percentages of correctly classified cases within the five stages, on the basis of predictors, and after weighing for different group sizes are shown in Table 4.14.
Table 4.11 Discriminant Function Structure Matrix

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Function 1</th>
<th>Function 2</th>
<th>Function 3</th>
<th>Function 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Processes</td>
<td>.781*</td>
<td>.010</td>
<td>.245</td>
<td>-.444</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.657*</td>
<td>-.143</td>
<td>.234</td>
<td>-.138</td>
</tr>
<tr>
<td>Experiential Processes</td>
<td>.334</td>
<td>.800*</td>
<td>.417</td>
<td>-.255</td>
</tr>
<tr>
<td>Cons</td>
<td>-.384</td>
<td>-.002</td>
<td>.861*</td>
<td>.290</td>
</tr>
<tr>
<td>Pros</td>
<td>.439</td>
<td>.476</td>
<td>.098</td>
<td>.740*</td>
</tr>
</tbody>
</table>

| Eigenvalue               | .78        | .39        | .01        | .01        |
| % Variance               | 95.0       | 4.8        | .20        | .10        |
| Cumulative %             | 95.0       | 99.8       | 99.9       | 100        |
| Canonical correlation     | .94        | .53        | .11        | .07        |
| $P$                      | .000       | .000       | .87        | .72        |

* Largest absolute correlation between each variable and any discriminant function.

Table 4.12 Functions at Group Centroids

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>-3.98</td>
<td>-.97</td>
</tr>
<tr>
<td>Contemplation</td>
<td>-2.19</td>
<td>.17</td>
</tr>
<tr>
<td>Preparation</td>
<td>-.42</td>
<td>.82</td>
</tr>
<tr>
<td>Action</td>
<td>3.13</td>
<td>-.52</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3.62</td>
<td>-.20</td>
</tr>
</tbody>
</table>

Figure 4.1 Canonical Discriminant Functions
Table 4.13 Correlation Matrix among the Predictor Variables for the Discriminant Function Analysis

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
<th>Experiential Processes</th>
<th>Behavioral Processes</th>
<th>Self-efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pros</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cons</td>
<td>.15</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiential Processes</td>
<td>.39</td>
<td>.17</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral Processes</td>
<td>.09</td>
<td>-.16</td>
<td>.52</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Self Efficacy</td>
<td>.04</td>
<td>-.20</td>
<td>.17</td>
<td>.38</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Results revealed that 34 individuals (82.9%) were correctly classified in preparation, 18 (81.8%) in precontemplation, and 25 (75.8%) in contemplation, followed by 18 (62.1%) in maintenance and 11 (47.8%) in the action stage. Overall, the probability of correct stage classification was 71.6%.

Table 4.14. Classification Results

<table>
<thead>
<tr>
<th>SOC</th>
<th>Predicted Group Membership</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Count</td>
<td>Precontemplation</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>0</td>
</tr>
<tr>
<td>%</td>
<td>Precontemplation</td>
<td>81.8</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>.0</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>.0</td>
</tr>
</tbody>
</table>

a 71.6% of original grouped cases correctly classified.

- **Hypothesis IV**

A total of 111 subjects were available to examine if the 6 minute walk distance is capable of distinguishing the action and maintenance stages from the previous stages of readiness. No significant differences were noted between the groups according to age, height, weight, and LVEF. As indicated in Table 4.15, the average walking distance for the entire group was 349±118 meters. The walking distance appears to increase dependent on the stage of change.
category. Indeed, as indicated in Table 4.16, the univariate general linear model analyses with the 6 minute walk distance as the dependent measure and stages of change as the fixed factor, revealed a significant main effect. Post hoc examination, using a Tukey test, indicates the following differences (see Figure 4.2): The 6-minute walk distance for individuals in precontemplation, contemplation and preparation stages appear to be similar, whereas the 6-minute walk distance for the action and maintenance groups are significantly higher. Finally, there does not appear to be a significant difference between the action and maintenance groups. These findings suggest the 6-minute walk distance is capable of distinguishing the action and maintenance stages from the previous stages of readiness and is in support of the stated hypothesis.

Table 4.15 Descriptive Statistics: Maximum Walking Distance (Meters) on the 6-minute Walk Test

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>297</td>
<td>137</td>
<td>12</td>
</tr>
<tr>
<td>Contemplation</td>
<td>276</td>
<td>108</td>
<td>29</td>
</tr>
<tr>
<td>Preparation</td>
<td>323</td>
<td>80</td>
<td>30</td>
</tr>
<tr>
<td>Action</td>
<td>401</td>
<td>87</td>
<td>20</td>
</tr>
<tr>
<td>Maintenance</td>
<td>472</td>
<td>73</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>349</td>
<td>118</td>
<td>111</td>
</tr>
</tbody>
</table>

- Validity of the 6-minute walking distance

  **Stage of Change according to Estimated Exercise Capacity**

To further examine the influence of the stage of change categories on exercise tolerance/capacity, an estimated VO$_2$peak was calculated from the 6-minute walking distance, using a regression equation$^{47}$. The equation: VO$_2$peak = 0.03 * 6-minute walking distance + 3.98 ($r^2 = 0.42$ vs. actual VO$_2$peak measures) was validated against actual VO$_2$peak measures and is based on the fact that the 6-minute walking distance is the best predictor of VO$_2$peak$^{47}$.
Table 4.16 Tests of Between-Subjects Effects: Dependent Variable: 6-minute Walk Distance

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncentral Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>567212</td>
<td>4</td>
<td>141803</td>
<td>16</td>
<td>0.0001</td>
<td>0.371</td>
<td>63</td>
<td>1.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>12450284</td>
<td>1</td>
<td>12450285</td>
<td>1374</td>
<td>0.0001</td>
<td>0.928</td>
<td>1374</td>
<td>1.000</td>
</tr>
<tr>
<td>Stage of Change</td>
<td>567212</td>
<td>4</td>
<td>141803</td>
<td>16</td>
<td>0.0001</td>
<td>0.371</td>
<td>63</td>
<td>1.000</td>
</tr>
<tr>
<td>Error</td>
<td>960766</td>
<td>10</td>
<td>9064</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>15016475</td>
<td>11</td>
<td>9064</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>1527978</td>
<td>11</td>
<td>9064</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Computed using alpha = .05; $b r^2 = 0.371$ (Adjusted $r^2 = 0.347$)

Figure 4.2 Six-Minute Walk Distance per Category

Figure 4.2 Six-Minute Walk Distance per Category

Means and standard deviations for the estimated VO$_2$peak are presented in Table 4.17 and depicted in figure 4.3. Consistent with the analysis for the 6-minute walk distance there was a
significant main effect for stage of change category (p=0.0004), and significant differences in the means for VO$_2$peak between the Action and Maintenance categories vs. the remaining three categories. Importantly, the average estimated VO$_2$peak for the Action and Maintenance groups is above the prognostically relevant 14 ml/kg/min threshold (as indicated by the dashed line on figure 4.3).

<table>
<thead>
<tr>
<th>Stage of Change</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>12.90</td>
<td>4.11</td>
<td>12</td>
</tr>
<tr>
<td>Contemplation</td>
<td>12.24</td>
<td>3.22</td>
<td>29</td>
</tr>
<tr>
<td>Preparation</td>
<td>13.66</td>
<td>2.40</td>
<td>30</td>
</tr>
<tr>
<td>Action</td>
<td>16.01</td>
<td>2.60</td>
<td>20</td>
</tr>
<tr>
<td>Maintenance</td>
<td>18.15</td>
<td>2.199</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>14.44</td>
<td>3.54</td>
<td>111</td>
</tr>
</tbody>
</table>

**Stage of Change according to Daily Physical Activity**

To examine the criterion validity between the physical activity questionnaire and the six-minute walk test, 78 data sets were available which allowed for simple correlation coefficients and a multivariate general linear model with the categories of activity as the dependent measures and stages of change as the fixed factor.

![Figure 4.3 Estimated VO$_2$peak per Category](image)
Figure 4.4 Estimated Minutes of Physical Activity above 5 METs vs. 6-minute Walk Distance

Simple correlation coefficients revealed significant associations between the 6-minute walk test and self-reported amount of minutes spent at rest ($r = -0.27$, $p = 0.02$), performing activities between 3 and 5 METs ($r = 0.52$, $p = 0.0009$), and activities over 5 METs ($r = 0.56$, $p = 0.0001$). A significant association was also seen between total minutes of daily physical activity and the 6-minute walk test ($r = 0.32$, $p = 0.005$). Interestingly, it appears from the scatterplot (see figure 4.4), that the amount of activity may be dependent on the patients stage of change.

On the basis of a multivariate general linear model with the categories of activity as the dependent measures and stages of change as the fixed factor, a significant main effect was found ($p = 0.0005$). Subsequent univariate tests revealed no differences between minutes at rest and stage of change category, but significant differences for the other measures as indicated in Table 4.18 and 4.19. Figures 4.5a and b further highlight the observed differences between the stages of change categories.
### Table 4.18 Minutes of Rest and Various Intensities of Physical Activity per Day

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stage of Change</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>Precontemplation</td>
<td>613</td>
<td>108</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>604</td>
<td>111</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>531</td>
<td>137</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>573</td>
<td>126</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>551</td>
<td>192</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>572</td>
<td>137</td>
<td>91</td>
</tr>
<tr>
<td>Total Activity (min)</td>
<td>Precontemplation</td>
<td>820</td>
<td>224</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>995</td>
<td>223</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>1030</td>
<td>339</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>1133</td>
<td>341</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>1041</td>
<td>393</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1008</td>
<td>315</td>
<td>91</td>
</tr>
<tr>
<td>Minutes up to 3 METs</td>
<td>Precontemplation</td>
<td>684</td>
<td>230</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>879</td>
<td>201</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>907</td>
<td>277</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>927</td>
<td>312</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>824</td>
<td>299</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>855</td>
<td>269</td>
<td>91</td>
</tr>
<tr>
<td>Minutes between 3 to 5 METs</td>
<td>Precontemplation</td>
<td>73</td>
<td>86</td>
<td>14</td>
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<tr>
<td></td>
<td>Contemplation</td>
<td>107</td>
<td>61</td>
<td>23</td>
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<tr>
<td></td>
<td>Preparation</td>
<td>111</td>
<td>101</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>186</td>
<td>86</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>180</td>
<td>121</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>128</td>
<td>99</td>
<td>91</td>
</tr>
<tr>
<td>Minutes above 5 METs</td>
<td>Precontemplation</td>
<td>2</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Contemplation</td>
<td>8</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>13</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Action</td>
<td>20</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>37</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>15</td>
<td>19</td>
<td>91</td>
</tr>
</tbody>
</table>

### Table 4.19: Univariate Tests for Activity categories and Stage of Change

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>95549</td>
<td>4</td>
<td>23887</td>
<td>1.29</td>
<td>0.281</td>
<td>0.057</td>
<td>5.155</td>
<td>0.387</td>
</tr>
<tr>
<td>Total Activity (min)</td>
<td>763952</td>
<td>4</td>
<td>190988</td>
<td>2.01</td>
<td>0.100</td>
<td>0.086</td>
<td>8.041</td>
<td>0.580</td>
</tr>
<tr>
<td>Minutes up to 3 METs</td>
<td>579684</td>
<td>4</td>
<td>144921</td>
<td>2.09</td>
<td>0.089</td>
<td>0.089</td>
<td>8.374</td>
<td>0.600</td>
</tr>
<tr>
<td>Minutes between 3 to 5 METs</td>
<td>150391</td>
<td>4</td>
<td>37598</td>
<td>4.47</td>
<td>0.003</td>
<td>0.172</td>
<td>17.872</td>
<td>0.928</td>
</tr>
<tr>
<td>Minutes above 5 METs</td>
<td>11267</td>
<td>4</td>
<td>2817</td>
<td>11.12</td>
<td>0.000</td>
<td>0.341</td>
<td>44.461</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Figure 4.5a Estimated Minutes of Physical Activity above 5 METs according to Stage of Change
*p < 0.05 vs precontemplation, contemplation, preparation, and action; †p < 0.05 vs. precontemplation, contemplation, and maintenance; ‡p < 0.10 vs. precontemplation

Figure 4.5b Estimated Minutes of Physical Activity between 3 and 5 METs according to Stage of Change. *p < 0.05 vs. precontemplation, contemplation, and preparation
• **Summary Section 4**

In summary, these data indicate that the 6-minute walking distance is capable of distinguishing individuals in the action and maintenance stages from the pre-action stages of readiness. Furthermore, the data clearly indicate differences in the means for estimated VO₂peak between the action and maintenance categories vs. the remaining three categories. Uniquely, the average estimated VO₂peak for the action and maintenance groups is above 14 ml/kg/min, and perhaps more importantly the estimated VO₂peak is below this powerful prognostic indicator for the pre-action stages. These data reveal significant associations between self-reported physical activity and the 6-minute walk distance. Finally, the number of minutes at higher intensities of physical activity is greater in individuals in the action and maintenance stages compared to the pre-action stages of readiness.

4.4 Discussion

• **Patients Characteristics**

Review of the available literature reveals very few studies, which have attempted to examine the readiness for behavioral changes in patients with heart failure\(^7,14\). Consequently, it is difficult to compare the patient characteristics in the present study to other studies. Perhaps the only study of comparison is by Sneed and Paul (2003). In this study a mail survey was sent to patients with heart failure\(^7\). Respondents were asked to select the stage of readiness for change in 6 lifestyle behaviors important in management of the heart failure syndrome. Unfortunately, Sneed and Paul (2003) did not examine the full TTM model among individuals with heart failure\(^7\). Despite that, it is interesting to note the patient population in that study was remarkably similar to the present study\(^7\). In general, their subjects were also relatively young (mean 55.6 years vs. 52±13yrs). Fifty-nine percent of the participants were Caucasian and 40% were African-
American as compared to 65% Caucasian, 34% African American, and 1% Hispanic in our study. Sixty-two percent were men and 38% women compared to sixty-six percent men and 34% women in the present study. Fifty-nine percent of the patients were married and most had a high school education; whereas, in the present study forty-six percent of the patients were married and 57% did have at least a high school diploma or equivalent. The duration of heart failure was virtually the same as the present study (mean 6.5 years, range: 6 months to 35 years vs. 6 years, range: 2 months to 35 years in our study).

Unfortunately the authors did not report the patients LVEF, etiology of heart failure, or NYHA class, although it appears from a Specific Activity Scale that the patients ranged from a Class I to IV, which appears to be a little more diverse than the patients in the present study. However, it is not known how the Specific Activity Scale compares to the more widely used NYHA classification.

Considering the present study also examined the association of the stage of change construct for physical activity with actual measures of exercise tolerance (six minute walk test), and self-reported daily physical activity, a second comparison study is offered by Garet et al. (2004)45. These investigators assessed the reproducibility, sensitivity, and concurrent validity of self-reported daily energy expenditure in a population of stable patients with heart failure. Their population consisted of 105 Caucasian participants (mean age: 55.8±12.4 yr, range 31–80 years). Mean left ventricular ejection fraction was nearly exactly as reported in the present study (LVEF: 33.2±6.1%). Interestingly the majority of the patients in the comparison study suffered from dilated cardiomyopathy (66 patients) and ischemic cardiomyopathy (39 patients), which is somewhat higher than the major etiology in the present study45.
In summary, although few comparison studies are available, the present population characteristics appear to be similar to published studies. Moreover, based on the available guidelines for the management of heart failure, it would appear that the participants in this study would be excellent candidates for heart failure intervention programs including exercise training.

Classification according to the TTM for stage of change reveals the majority of participants in this study were in the preparation stage of change (n = 41, 27.7%), followed by contemplation (n = 33, 22.3%), maintenance (n = 29, 19.6%), action (n = 23, 15.5%), and precontemplation (n = 22, 14.9%). These findings are somewhat similar to a previous which examined the predictors of exercise adherence and the validity of the Stages model among older adults (N = 349) with a cardiac diagnosis (not heart failure) after discharge from a cardiac rehabilitation inpatient program\textsuperscript{13}. In that study, 16% of the patients were in precontemplation, 16% in contemplation, 22% in preparation, and 23% in both the action and maintenance stage\textsuperscript{13}. In yet another study, the theorized associations of the TTM of behavior change constructs were examined along with exercise barriers, by stage of change for exercise behavior among individuals with physical disabilities\textsuperscript{27}. In that study the majority of participants reported being in the maintenance stage of change (53.7%), followed by precontemplation (18.9%), action (11.8%), contemplation (9.0%), and preparation (6.5%)\textsuperscript{27}. One possible explanation for the greater number of individuals classified in the maintenance stage in this comparison study\textsuperscript{27} is the passive recruitment method used by the authors, which tends to over-represent those individuals with an interest in the subject matter. Other than differences in recruiting strategies, it is difficult to reconcile the differences among studies, given the vast differences in terms of populations, geographical location, and overall subject number. However, it is important to appreciate that in the current study 65% of patients were in the pre-action stages of readiness to engage in a
treatment strategy known to be critical in the management of their disease. In fact, the present data falls very much in line with the study by Sneed & Paul\(^7\) who reported only 38% of patients with heart failure exercised regularly.

- **Hypotheses I-III**

  This study was unique in that it was the first study to examine the full TTM among individuals with chronic heart failure. The first purpose of this study was to examine the associations of TTM behavior change constructs (behavioral and cognitive processes of change, decisional balance, and self-efficacy) and stage of change for planned regular physical activity among individuals with chronic heart failure. It was hypothesized that 1) self-efficacy would increase in linear fashion from precontemplation to maintenance; 2) the crossover point in decisional balance scores would be observed in the preparation stage; and 3) experiential processes would be utilized in the earlier stages; whereas, behavioral processes would be utilized in the latter stages of change.

  Based on the results of the one-way MANOVA, the hypotheses were generally supported. First, self-efficacy increased across the stages of change in linear sequence, although differences were not significant between the action and maintenance groups. These results suggest that confidence to be active increases with advances in stage of change, as proposed by the TTM\(^26\). Similar findings have been reported among individuals with a cardiac diagnosis\(^13\), and those with\(^27\) and without\(^26\) disabilities. Thus, the conclusion from various studies and narrative reviews that self-efficacy differentiates between individuals at most stages appears supported\(^13, 24, 48, 49\). This is an important finding because the self-efficacy construct may be particularly relevant in the heart failure patient. Many patients are somewhat fearful in engaging in activities that may bring on symptoms associated with their condition. Thus, information about a patient’s perceived
self-efficacy for regular physical activity may be particularly important for the clinician to guide strategies for physical activity adoption.

Secondly, decisional balance shifted from greater perceived cons and lower perceived pros in the precontemplation and contemplation stages to lower perceived cons and higher perceived pros in the action and maintenance stage, which is consistent with TTM theory\textsuperscript{34} and previous research\textsuperscript{49}. Once again, this research is unique in that prior to this study there was no data available regarding decisional balance for any behavior (including physical activity) in the heart failure population. The underlying assumption of TTM theory is that a person will not decide to change behavior unless the benefits (pros) of change exceed the costs (cons)\textsuperscript{23}. Differences in decisional balance tend to correspond to different stages of motivational readiness\textsuperscript{23, 34}. Results of this study support previous research which suggests that people in the precontemplation stage perceive more barriers (cons) than benefits (pros) to change, while those in the action stage perceive more benefits than barriers\textsuperscript{34}. For example, patients in the early stages (precontemplation and contemplation) endorsed such items as “I am too tired to get regular physical activity because of my other daily responsibilities.” Additionally, these patients perceived physical activity would take too much time, cost too much, or they would worry about looking awkward. In contrast, patients in the advanced stages (action and maintenance) indicated that physical activity would help them have a more positive outlook, control their weight, sleep better, reduce tension or manage stress, and feel more confident about their health. These findings are in line with Prochaska and colleagues\textsuperscript{34} who studied twelve problem behaviors and noticed that for all twelve behaviors, the cons of changing were more important for people in the precontemplation stage than the pros. The authors\textsuperscript{34} concluded the opposite was true for people in the action stage in eleven out of twelve behaviors. These findings suggest that progress from
precontemplation to contemplation involves an increase in the perceived pros (perceived benefits) of physical activity; whereas, progressing from contemplation to action involves a decrease in the perceived cons (barriers). This implies the increase in the pros followed by a decrease in the cons should lead to a crossover in decisional balance across the stages of change. Consequently, it was hypothesized that the cross-over point (or “balance point”) for pros and cons for physical activity behavior would be observed in the preparation stage, because this finding has been observed in recent studies. Interestingly, results of this study revealed the crossover occurred in the contemplation stage. It has been suggested that the stage in which the crossover occurs is a function of how much and when the pros increase and how much and when the cons decrease. This implies that the strategies for moving patients from precontemplation to contemplation, or toward thinking about physical activity must focus on increasing perceived benefits; whereas, to move someone from contemplation to action, would require a decrease in perceived barriers.

Another possible explanation could be the manner in which the preparation stage was defined in the present study. The studies in which the crossover occurred in preparation, defined the preparation stage with an intention to change behavior only. Based on recommendations from previous research, we defined the preparation stage as currently participating in planned physical activity but less than the recommended guidelines AND an intention to engage in planned physical activity at the target level within the next month. Therefore, the present data reveal individuals in the preparation stage were engaging in some physical activity and consistent with theory, these individuals exhibited more pros and fewer cons than those in previous stages. Consequently, consistent with the literature, the present data reveal the crossover prior to the preparation stage.
The clinical relevance of these findings suggests a systematic approach for changing the pros and cons to facilitate progress from precontemplation to action. For example, initially the intervention should first target increasing the perceived pros (benefits) of physical activity, which should lead to progression from precontemplation to contemplation. Once progression to the contemplation stage has occurred, the intervention should focus on decreasing the perceived cons (barriers) to physical activity, while continuing to increase perceived pros. This should lead to further progress from the contemplation to the action stage.

Lastly, as hypothesized, the experiential processes were used predominantly in the precontemplation and contemplation stages, whereas behavioral processes were more prominently used in the action and maintenance stages of change. Specifically, scores for the experiential processes of change increased in linear sequence from precontemplation to preparation, before leveling off between preparation, action, and maintenance. The behavioral processes increased linearly from precontemplation to action, and leveled off between action and maintenance. This is consistent with theoretical predictions, previous studies, and narrative reviews which indicate that behavioral processes peak during action and then level off during maintenance. The lack of significance between action and maintenance suggests that efforts to maintain physical activity habits do not require additional changes in behavioral and experiential strategies. Additionally, these data support previous research which reveals sedentary individuals, those in the earlier stages of motivational readiness (precontemplation, contemplation), tend to place greater emphasis on experiential processes, while regularly active individuals, those in later stages of physical activity adoption tend to endorse more behavioral processes.
These results support previous studies which have demonstrated that an integration of the stages and processes of change can provide a useful guide for interventions\textsuperscript{21, 32}. The clinical relevance of this work is that once an individual’s stage has been assessed, interventionists may have a better idea of which processes to emphasize in order to facilitate progress to the next stage of change\textsuperscript{24}. Moreover, with the appropriate activities to meet the heart failure patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes\textsuperscript{13}.

- **Predictors of the Stage of Change**

The objective of specific aim two was to determine the most important predictors of physical activity stages of change utilizing the constructs of the TTM among individuals with chronic heart failure. This study is unique in that it is the first to have examined this in patients with chronic heart failure. These data may provide clinicians with a greater understanding how to ‘move’ patients toward the action stages of behavior change. The results of this study are similar to other studies that have used the full TTM to investigate the most important psychosocial predictors of the exercise stages of change. For example, Cardinal et al. (2004) have used the full TTM to investigate the most important predictors of the exercise stages of change among mainly active adults with physical disabilities\textsuperscript{27}. In descending order of significance, the most important predictors were behavioral processes of change, self-efficacy, cognitive (experiential) processes of change, perceived pros, and perceived cons. In a similar study focusing on inactive adults with disabilities\textsuperscript{28}, the behavioral processes of change also contributed mostly to the physical activity stage of change distinction followed by the cognitive (experiential) processes of change, self-efficacy, and decisional balance. Further confirmation of this finding was found amongst
university students where behavioral processes of change contributed to the stage-of-change classification in the first function; whereas, the experiential processes of change and perceived pros mostly contributed to the stage of change differences in the second function. Likewise, in the present study, behavioral processes ($r^2 = .78$) were the most significant predictors, followed by self efficacy ($r^2 = .66$), pros ($r^2 = .44$), cons ($r^2 = -.38$), and experiential processes ($r^2 = .33$). These predictors contributed to the first discriminant function and were important in the discrimination between precontemplation and the other four stages, as well as in distinguishing individuals in contemplation and preparation from those in action and maintenance stages. Furthermore, similar to previous results, the second function revealed that the experiential process of change ($r^2 = .80$) and the pros of decisional balance ($r^2 = .48$) distinguished those in the precontemplation stage from contemplation and preparation, as well as those in the preparation stage from action and maintenance.

In contrast, in a study among older cardiac rehabilitation patients, slightly different results were reported. In that study the authors concluded that self-efficacy was the most important predictor, followed by perceived benefits of exercise (pros), perceived barriers to exercise (cons), and interpersonal support for exercise. A possible reason for the differences in said study is that predictors of stage of change in exercise adherence were examined in patients who were recently discharged following a cardiac event. It could be argued these patients were more concerned with issues of self-efficacy due to their recent events. Interestingly, other patients in that study had, in fact, enrolled in cardiac rehabilitation. It could be argued that self-efficacy scores would be higher for that subset of patients’ as well.

In summary, the behavioral processes of change appear to be the most important predictors of physical activity stages of change among patients with chronic heart failure. Such results have
been reported for individuals with\textsuperscript{27,28} and without disabilities\textsuperscript{50}, and university students\textsuperscript{3}. These results suggest that the behavioral processes as predictors may be similar across diverse populations and conditions. In this study, self efficacy also contributed significantly for stage prediction, followed by pros, cons, and experiential processes, reinforcing the use of all TTM constructs for physical activity behavior change. It has been suggested that the experiential (cognitive) processes of change were more important to inactive individuals than active individuals, whereas, self-efficacy contributed more to active participants than inactive participants. Clearly, more work needs to go into further understanding these constructs. However, the clinical relevance of this work is that once an individual’s stage has been assessed, interventionists may have a better idea of which processes to emphasize in order to facilitate progress to the next stage of change. Moreover, with the appropriate activities to meet the heart failure patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes.

- **Classification Accuracy**

Using the behavioral and experiential processes of change, self-efficacy, and the perceived pros and cons to classify participants into their respective stage of change for physical activity, the most reliably predicted stages were preparation (82.9%), precontemplation (81.8%), contemplation (75.8%), followed by maintenance (62.1%), and action (47.8%). Overall, the probability of correct stage classification was 71.6%. Relative to previous studies employing the full TTM among different population segments, and using similar multivariate statistical techniques, the overall prediction accuracy was similar to that reported by Cardinal and colleagues\textsuperscript{27} in adults with physical disabilities (69.6%) but was slightly higher than other studies.
involving college students, older adults, and older adults with a cardiac diagnosis, which range from 50% to 64%. The enhanced classification accuracy observed in the present study could be due to the fairly even distribution of individuals among the stages of change in this study as compared to previous studies, the various methods of recruiting, or simply the relevance of TTM for this population segment.

- **Hypothesis IV**

  A unique contribution of these data are the findings that the 6-minute walking distance is capable of distinguishing individuals in the action and maintenance stages from the early stages of readiness (precontemplation, contemplation). Moreover, using the 6-minute walking distance to estimate VO_{2\text{peak}} reveals that a greater majority of those individuals above 14 ml/kg/min are in the action and maintenance categories. Perhaps more importantly these data suggest that the majority of patients with heart failure in the early stages of readiness are below the 14 ml/kg/min threshold, a powerful prognostic indicator of an increased likelihood of death or hospitalization within 3 months to a year. Finally, these data suggest that individuals in the action and maintenance stages perform a greater amount of physical activity, especially at higher intensities, compared to those in the early stages of readiness (precontemplation, contemplation).

  The 6-minute walk test has been used as an outcome measure in clinical trials since 1988. The test is a self-paced walk test, simple to administer, and because of the familiarity of the activity is a measure of overall mobility and physical function. Importantly, the test carries important prognostic information. The total group average for the maximum walking distance (349±118 meters) in this study appears to be quite typical for patients with heart failure, with a NYHA Class II and III. For example, Opasich et al (2001) reported a maximum walking distance of 396±92 meters in 315 chronic heart failure patients (age: 53±9 years, NYHA class: II (182), III
More importantly, based on the literature indicating that a maximum walking distance less than 300 meters is associated with an increased likelihood of early mortality\cite{47,56-58}, the results of the present study suggest many of the patients are at elevated risk for complications. In fact, 36\% of all the participants in this study scored below the 300 meter threshold. Interestingly, patients who scored below 300m on the 6-minute walk test were not different from the patients scoring above 300m, in terms of age, BMI, LVEF, resting blood pressure and heart rate. In addition, no differences were noted for race, employment status and income, etiology, and length of heart failure, comorbidities, or number of medications. One interesting observation in the present study is that a greater percentage of women scored below the 300 meter threshold. Given the evidence that the distance of < 300 m also identifies women at high risk of death\cite{58}, this requires further examination and focus from a clinical perspective. A further important observation is that the average age for the women in this study was significantly lower than the men, yet their average maximum walking distance (MWD) was much lower as well. Unfortunately, these findings can not be explained by the available information concerning the clinical status of the patients in this study, but this should certainly receive greater attention in future studies.

Generally, the validity of the 6-minute walk test has been investigated through the comparison against a “gold-standard” functional capacity test\cite{59}. Usually the “gold-standard” test for this comparison has been a maximal exercise test with or without gas analyses on a treadmill or cycle ergometer. To date 28 such studies are available, and are extensively reviewed elsewhere\cite{59}. For the most the comparison studies reveal moderate to strong correlations between the 6-minute walk test and VO\textsubscript{2}\text{peak} obtained through exercise ergometry (treadmill or cycle)\cite{56}. The consistent findings that the 6-minute walk test is a good estimate of functional
capacity have led to several multivariate equations that allow estimation of the VO₂peak. In the present study, the equation developed by Cahalin et al. (1996) was used to estimate the VO₂peak of this cohort. The rationale for this selection was that the present study population was similar to those in the aforementioned study, and the fact that the simple equation: VO₂peak = 0.03 (MWD) + 3.98, was able to account for nearly 45% of the variance in that study. In this study the average VO₂peak was 14.42±3.52 ml/kg/min. The average estimated VO₂peak in this study are similar to many studies that have examined NYHA Class II and III heart failure patients. This average is particularly relevant given the evidence in the literature that individuals below 14 ml/kg/min have a much poorer prognosis in terms of survival compared to those above this threshold. In fact, even today the threshold is an important factor, considered clinically, when evaluating heart transplant candidates. In other words those individuals that drop below the threshold of 14 ml/kg/min are immediately moved up on the transplant lists, as their immediate risk for mortality increases exponentially. In the present study 50% of patients are below the threshold score. Again the data indicate a gender difference in that approximately 62% of the women and 47% of the men are below 14 ml/kg/min.

In recent publications by a group of French investigators, a detailed self-administered questionnaire, specifically for the heart failure patient, was used to examine daily energy expenditure. The questionnaire deals with 7 dimensions of everyday life to provide a picture of habitual activities. The questionnaire was compared against actual VO₂peak measures and it was found it to be valid and reliable. In the present study a translation of the French questionnaire was used. The translation was made with help of the original investigators of the questionnaire and with some modifications was implemented in the study. Most of the modifications dealt with exchanging activities that were more appropriate choices for the present
study population. Recognizing that this approach may require further modifications and improvements, the data did allow further comparison to the functional scores. The findings revealed significant associations between the 6-minute walk test and the self-reported amount of minutes spent at rest ($r = -0.27, p = 0.02$), performing activities between 3 and 5 METs ($r = 0.52, p = 0.0009$), activities over 5 METs ($r = 0.56, p = 0.0001$). Moreover, a significant association was apparent between the total minutes of physical activity performed throughout the day, and the 6-minute walk test ($r = 0.32, p = 0.005$). This is the first study to report these associations using a submaximal performance test. In comparison to previous work the reported associations are somewhat lower. The discrepancy may in part be a consequence of the questionnaire modifications, or the fact that the 6-minute walk test was used. Irrespective of those possibilities, the findings are intriguing and suggest the questionnaire is able to differentiate between patients who score high or low on the 6-minute walk test. Interestingly, the patients in the present study had lower estimated VO$_2$peak values, then their French counterparts. In addition, the patients in this study performed fewer activities above 5 METs and had slightly lower overall energy expenditures over the course of the day. It is difficult to reconcile these differences as the American patients were similar in terms of age, gender, LVEF, NYHA class, and etiology of disease. However, there are apparent differences in terms of weight and BMI, with the American cohort heavier (American Cohort: 95.28±26.43; French Cohort: 74.80±15.00) and with a greater average BMI (American Cohort: 31.68±8.53; French Cohort: 25.08±4.00). Unfortunately, failure to show an association between weight and BMI and the 6-minute walk test and estimated energy expenditures, in the present study, does not allow for a real appreciation of these apparent differences compared to previous studies.
In summary, the present data compare favorably to a number of studies which have used the 6-minute walk test to examine functional capacity in patients with heart failure. In addition to the risks associated with the heart failure diagnosis, a large number of patients appear to be at even greater risk for hospitalization and mortality, secondary to their low scores on the 6-minute walk test, and subsequent estimated VO₂peak. In addition, these data reveal significant associations between measures of functional ability and a valid physical activity questionnaire for patients with heart failure. Finally, patients in this study appear to spend fewer minutes performing activities above 5 METs and overall physical activity throughout the day compared to a similar study by others.

In regards to Hypothesis IV, it was predicted that the maximum walking distance would be capable of distinguishing the action and maintenance stages from the precontemplation and contemplation stages of readiness. As indicated in Table II, the univariate General Linear Model analyses with the 6 minute walk distance as the dependent measure and stages of change as the fixed factor, a significant main effect was revealed. Figure 1 shows that indeed the action and maintenance stages were different from the precontemplation and contemplation stages of readiness. Closer observation of these data reveal that the majority of patients in the action and maintenance stages were in fact above the 300meter, and 14 ml/kg/min threshold, compared to the majority of patients in the early stages (i.e., precontemplation, contemplation) who were below these clinically important cut-offs. More specifically, 51% and 71% of patients in the precontemplation stages were below the 300meter, and 14 ml/kg/min threshold compared to only 7.5% and early stages were in NYHA class III (precontemplation, contemplation, preparation) 47% vs. action/maintenance: 25% (p < 0.05), were women (early stage: 40% vs. Action/Maintenance: 21%, p < 0.05), and had LVEFs below 30% (Pre-contemplation,
contemplation, preparation: 56% vs. Action/Maintenance: 45%). Finally, those in the pre-action stages reported fewer minutes of daily activity (Pre-action: 977±288min vs. Action/Maintenance: 1087±365min, p < 0.10), and activities above 5 METs (Pre-action: 11±23min vs. Action/Maintenance: 29±23min, p < 0.05), then the patients in the Action and Maintenance stages.

These data suggest that those in the early stages are clinically more fragile, are less involved in daily physical activities and are women. The importance of this information obviously lies in the fact that specific strategies need to be developed to move patients in these pre-action stages toward the Action stage. This study is the first to identify individuals who may need more specific behavioral strategies as part of their disease management. Clearly future studies should continue to identify these patients and develop these strategies in clinical practice.

- **Clinical Relevance**

  Careful examination and appreciation of the TTM constructs generally results in greater success in adoption of a targeted behavior, such as planned physical activity. In a meta-analysis of eighty studies using the TTM in the physical activity domain, no study was included that examined the TTM’s constructs among individuals with heart failure\(^{26}\). Interestingly the majority of the guidelines for management of the heart failure syndrome emphasize the need for using targeted behavioral strategies\(^{5,6,11}\). Therefore, considering the lack of data regarding the full TTM in patients with heart failure, and given the success of the TTM for understanding physical activity behaviors in other populations, the TTM has been identified as a potentially useful model for understanding the exercise behavior of individuals with chronic heart failure\(^{10,14}\). However, before the TTM is widely used for intervention studies, its utility and relevance must first be examined within this population segment.
This study is unique in that the full TTM was evaluated in a group of patients with chronic heart failure. It is anticipated that this information will greatly facilitate the further development of even more effective heart failure programs. For example, research has demonstrated that an integration of the stages and processes of change can provide a useful guide for interventions. More specifically, knowledge of an individual’s self efficacy, decisional balance, and stage of readiness to begin regular physical activity could be used to assist clinicians in developing targeted, effective physical activity interventions and to guide strategies that go beyond traditional educational approaches for individuals with chronic heart failure. Furthermore, knowledge regarding factors that prevent a patient from participation may ultimately contribute to a better understanding of the reasons for noncompliance and to the development of improved strategies for physical activity promotion in patients with heart failure.

Finally, this study suggests that the stage of change algorithm aids in the identification of patients with heart failure at increased risk for complications and early mortality. Consequently, ‘moving’ patients toward the action stages may ultimately contribute to the well-being of the patient and perhaps have an impact on health-care costs associated with this disease.

**Limitations**

In considering the findings of this study, it is important to keep the following limitations in mind. First, as mentioned previously, this was a cross-sectional design and therefore developmental trends in stage of change cannot be observed. Future studies should include longitudinal designs in order to examine the stability of various physical activity predictors across time. Secondly, although the defined level of physical activity appears appropriate for patients in this study, the exercise prescription must be something that is feasible for the population and the best prescription for physical activity in patients with heart failure has yet to
be determined. Additional research may be warranted to determine the most appropriate activity levels for more diverse groups of patients.

4.5 Conclusion

In conclusion, this is the first study to examine stage of change for physical activity in patients with heart failure on the basis of the full TTM. The data reveal that despite the fact that participants in the study would be excellent candidates for heart failure intervention programs including exercise training, only 35% of patients are actively engaged in planned physical activity as recommended by the AHA. Thus, 65% of patients were in the pre-action stages of readiness to engage in a treatment strategy known to be critical in the management of their disease.

The stage of change algorithm revealed 22 patients in precontemplation, 33 in contemplation, 41 in preparation, 23 in action, and 29 in maintenance. In regards to the TTM constructs (self-efficacy, pros and cons of decisional balance, and experiential processes) the data revealed that self-efficacy scores were lowest in the precontemplation stage and increased in linear fashion to maintenance. Decisional balance changed from greater perceived cons and lower perceived pros in the precontemplation and contemplation stages to lower perceived cons and higher perceived pros in the action and maintenance stage. Experiential processes were used predominantly in the precontemplation and contemplation stages, whereas behavioral processes were more prominently used in the action and maintenance stages. These findings are similar to available literature among patients with a cardiac diagnosis (not heart failure), and those with and without disabilities. Therefore, these data support the external validation of TTM to a unique and understudied population segment.
In addition, this study aimed to determine the most important predictors of physical activity stages of change utilizing the constructs of the TTM. Findings revealed that the most important stage of change predictors were the behavioral processes \( (r^2 = .78) \) and perceived self-efficacy \( (r^2 = .66) \), followed by pros \( (r^2 = .44) \), cons \( (r^2 = -.38) \), and experiential processes \( (r^2 = .33) \).

The clinical relevance of this work is that once an individual’s stage has been assessed, interventionists may have a better idea of which processes to emphasize in order to facilitate progress to the next stage of change. Moreover, with the appropriate activities to meet the heart failure patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes.

Finally, data from this study indicate that patients in pre-action stages of readiness to exercise have significant lower exercise tolerance/capacity than those in the action and maintenance stages. In fact, over 50% of patients in pre-action may be at even greater risk for complications and early mortality secondary to scoring <300 meters on the six-minute walk test and having an est\(\text{VO}_2\text{peak}\) of <14 ml/kg/min. Moreover, patients in the pre-action stages have significant lower daily energy expenditures. These data suggest greater clinical emphasis should be placed on strategies to move patients toward the action and maintenance stages of readiness.

### 4.6 References


CHAPTER 5. SUMMARY

5.1 Summary

The overall goal of the research conducted was to gain a greater understanding regarding the management of patients with heart failure. A particular focus of the research projects was to evaluate exercise tolerance and to examine exercise behavior. The rationale for this focus is evidence that the clinical phase of heart failure includes a marked decline in functional state, as defined by exercise tolerance and capacity with a subsequent decrease in quality of life. Moreover, there is growing evidence that exercise training reverses many of the peripheral abnormalities present in the heart failure patient. These improvements translate in an increased exercise tolerance, reduction in activity-related symptoms, and improved quality of life. Perhaps most importantly, exercise training improves survival, reduces health care costs and re-hospitalization in patients with chronic heart failure. Unfortunately, despite this evidence patient participation and adherence in these types of programs remain suboptimal.

Chapter 2 indicated that despite the overwhelming evidence of the benefits of exercise for patients with heart failure, patients are not receiving adequate information regarding physical activity. Furthermore, Chapter 2 also showed that measures of exercise tolerance and quality of life were significantly lower for the patients with heart failure compared to age-matched controls. Finally, some preliminary data indicated that a very basic home exercise program with frequent patient contact resulted in modest improvements in exercise tolerance and perceived quality of life.

Chapter 4, in part, evolved from failure to adequately recruit from the available heart failure pool for projects 1 and 2. In fact, it appeared that many patients just did not want to make behavior changes. Thus, Chapter 4 assessed the motivation and readiness of patients with heart
failure to make necessary behavioral changes to aid in the management of their condition. The findings revealed that only 35% of patients were actively engaged in planned physical activity as recommended by the American Heart Association. Thus, 65% of patients were in the pre-action stages of readiness to engage in a treatment strategy known to be critical in the management of their disease. More specifically, the stage of change algorithm revealed 22 patients in precontemplation, 33 in contemplation, 41 in preparation, 23 in action, and 29 in maintenance. Further analyses revealed that self-efficacy scores were lowest in the precontemplation stage and increased in linear fashion to maintenance. Decisional balance changed from greater perceived cons and lower perceived pros in the precontemplation and contemplation stages to lower perceived cons and higher perceived pros in the action and maintenance stage. Experiential processes were used predominantly in the precontemplation and contemplation stages, whereas behavioral processes were more prominently used in the action and maintenance stages. These findings are similar to available literature among patients with a cardiac diagnosis (not heart failure), and those with and without disabilities3-5. Therefore, these data support the external validation of the Transtheoretical model to a unique and understudied population segment.

In addition, this study aimed to determine the most important predictors of physical activity stages of change utilizing the constructs of the Transtheoretical model. Findings revealed that the most important stage of change predictors were the behavioral processes and perceived self-efficacy.

Finally, data from this study indicated that patients in pre-action stages of readiness to exercise have significant lower exercise tolerance/capacity than those in the action and maintenance stages. In fact, over 50% of patients in pre-action may be at even greater risk for complications and early mortality secondary to scoring <300 meters on the six-minute walk test
and having an estVO₂peak of <14 ml/kg/min⁶,⁷. Moreover, patients in the pre-action stages have significant lower daily energy expenditures. These data suggest greater clinical emphasis should be placed on strategies to move patients toward the preparation and action stages of readiness.

The clinical relevance of this work is that once an individual’s stage has been assessed, interventionists may have a better idea of which processes to emphasize in order to facilitate progress to the next stage of change. Moreover, with the appropriate activities to meet the heart failure patient’s stage of readiness for change, healthcare providers may facilitate a patient’s movement along the continuum of change to alter lifestyle behaviors, such as physical activity, that can result in improved outcomes. In a meta-analysis of eighty studies using the Transtheoretical model in the physical activity domain, no study was included that examined the Transtheoretical model constructs among individuals with heart failure⁴. Interestingly the majority of the guidelines for management of the heart failure syndrome emphasize the need for using targeted behavioral strategies⁸-¹⁰. Considering this is the first study to have examined the full Transtheoretical model in patients with heart failure, this study is unique and its findings could greatly facilitate the further development of even more effective heart failure programs.

For example, research has demonstrated that an integration of the stages and processes of change can provide a useful guide for interventions¹¹,¹². More specifically, knowledge of an individual’s self efficacy, decisional balance, and stage of readiness to begin regular physical activity could be used to assist clinicians in developing targeted, effective physical activity interventions and to guide strategies that go beyond traditional educational approaches for individuals with chronic heart failure. Furthermore, knowledge regarding factors that prevent a patient from participation may ultimately contribute to a better understanding of the reasons for noncompliance and to the development of improved strategies for physical activity promotion in
patients with heart failure. Finally, this study suggests that the stage of change algorithm aids in the identification of patients with heart failure at increased risk for complications and early mortality. Consequently, ‘moving’ patients toward the action stages may ultimately contribute to the well-being of the patient and perhaps have an impact on health-care costs associated with this disease.

5.2 References


APPENDIX A. INFORMED CONSENT

CONSENT TO PARTICIPATE IN RESEARCH

The University of Mississippi Medical Center

Study Title:
Examination of the Constructs of the Transtheoretical Model in Patients with Heart failure: A Focus on Physical Activity Readiness

Principal Investigator: Charles K. Moore, M.D.
Co-investigators: Michael A. Welsch, Ph.D., Tracie Parish, M.Ed., ATC/L

Introduction: Heart failure is a significant health problem in the United States. Patients with this condition are often hospitalized, and complain of chronic fatigue and can not perform many of the normal daily activities. You are being invited to be in this study, because you have been diagnosed with heart failure. Please ask us about anything in this document or that we tell you that you do not understand.

Purpose: The purpose of the study is to learn about reasons why some patients with heart failure do not participate in certain behaviors known to help in controlling the heart condition.

Procedures: If you agree to participate in this study, you will be asked a series of Behavioral and Knowledge questions which will give us information about your current behaviors such as your daily physical activity. The questions will be given to you during one visit. In addition, you will be asked to perform a 6 minute walking test, at a pace that is comfortable to you. We expect that it will take approximately one hour to answer the questions and perform the walking test.

Risks: The risks associated with this study are very small and mostly involve risks during the 6-minute walk test. The risks associated with the walking test are muscle soreness, stiffness or tightness, or in some rare cases more severe problems such as chest pain, shortness of breath or cardiovascular complications.

Benefits: You may or may not receive a direct benefit from being in this research study. In identifying your readiness to participate in heart healthy behaviors, we may be able to provide you with more appropriate information that will help you understand how to stay healthy given your condition. We also hope to learn information that may help others in the future.

Alternatives: This is not a treatment study and the only alternative is to not participate in the study.

Costs: There will be no additional costs to your participation in this study. In the case of injury or illness resulting from your participation in this study, medical treatment is available to you at the University of Mississippi Medical Center. You will be charged the usual and customary charges for any such treatment you receive.

Compensation: You will not be paid for participating in this study.

Voluntary Participation and Withdrawal: Your participation is voluntary. If you decide not to participate in this study you will not suffer a penalty or loss of benefits to which you are otherwise entitled. If you decide to participate in this study you may discontinue your participation at any time, without penalty or loss of benefits and it will have no effect on the quality of your medical care, academic standing, job status, etc. (whatever phrase is appropriate).
Confidentiality: Every effort will be made to keep the information we learn about you private. Study personnel, the Food and Drug Administration (FDA), the Office for Human Research Protections (OHRP) and the University of Mississippi Medical Center’s Institutional Review Board (IRB) and Office of Compliance may review the study records. If study results are published your name will not be used.

Protected Health Information: Protected health information is any personal health information through which you can be identified. The data collected in this study include your medical history and information from the questionnaires and walking test. A decision to participate in this research means that you agree to the use of your health information for the study described in this form. This information will not be released beyond the purposes of conducting this study. The information collected for this study will be kept until the study is complete. While this study is ongoing you may not have access to the research information, but you may request it after the research is completed.

Number of Participants: We expect about 200 participants to enroll in this study.

Questions: If you have questions about this study you may discuss your rights as a research participant with the Chairman of the University of Mississippi Medical Center’s Institutional Review Board, 2500 North State Street, Jackson, Mississippi 39216; telephone, 601 984-2815; facsimile, 601 984-2961. The Institutional Review Board is a group of people not involved with this study who have reviewed the study to protect your rights.

Statement of Participation: Your signature indicates that you have decided to participate after having read the information provided above.

You will be given a copy of this consent document for your records.

SIGNATURES

By signing this form I am not waiving any legal rights I may have.

Participant’s Printed Name ____________________________ Date/Time

__________________________
Signature of Participant Date/Time

Printed Name of Person Obtaining Informed Consent ____________________________ Date/Time

__________________________
Signature of Person Obtaining Informed Consent Date/Time
I acknowledge that the participant identified above has been entered into this study, with properly obtained informed consent.

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Signature of Principal Investigator

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Date*

*Absent extenuating circumstances, the investigator’s signature should be obtained within 48 hours of the participant’s signature.
APPENDIX B. LITERATURE REVIEW

THE HEART FAILURE SYNDROME: THE IMPORTANCE OF MULTIDISCIPLINARY TREATMENT STRATEGIES

A Review of Literature
Submitted to the Graduate Faculty of
The Louisiana State University and Agricultural and Mechanical College
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INTRODUCTION

Heart failure (HF) is defined as the pathophysiological state in which an abnormality of cardiac function is responsible for failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues, or to do so only from an elevated filling pressure (Braunwald, 1988). Heart failure is not a homogenous disease. Rather, it is the final common pathway of several other disorders that impair the heart’s pumping ability (Pernenkil, Vinson, et al., 1997). Coronary artery disease is the cause of HF in about two thirds of patients with left ventricular systolic dysfunction (Gheorghiade, Bonow, 1998). Other causes of HF are associated with a nonischemic cardiomyopathy, which may result from long-standing hypertension, a toxin-related illness (e.g., alcohol), a systemic illness affecting the heart (e.g., thyroid disease), valvular disease, myocarditis, or idiopathic causes. Finally, heart failure could be the result of underlying pericardial disease (Hunt, Baker, Chin, et al., 2001).

The insult to the cardiovascular system is frequently met with a variety of compensatory adaptations with short- to long-time constants aimed to maintain cardiac output and arterial pressure to adequately perfuse the brain and the heart. These compensatory adaptations include (1) an increase in ventricular end-diastolic volume and pressure (ventricular dilatation); (2) sympathetic nervous system activation; (3) neurohumoral vasoconstriction; (4) renal sodium and water retention; (5) myocardial hypertrophy; (6) impaired vasodilatory capacity; and (7) intrinsic changes in skeletal muscle. Although, these compensatory adaptations may be remarkably effective under resting conditions, the capacity to sustain cardiac performance in the face of hemodynamic overload relative to myocardial contractility is finite and exacts a price (Zelis,
Sinoway, Leuenberger, et al., 1991). In fact, it is those compensatory mechanisms that ultimately contribute significantly to the clinical severity of the disease.

The purpose of this review is twofold: (1) to describe the compensatory adaptations to heart failure, with the focus on the morphological, biochemical, cellular, and neurohumoral changes characteristic of heart failure and how these relate to the exercise tolerance, a marker of the clinical severity of the disease, (2) to examine currently available strategies to manage the heart failure patient, with specific focus on the need for multidisciplinary programs.

**HEART FAILURE STATISTICS**

An estimated 4.9 million Americans have heart failure, a chronic condition associated with frequent hospitalizations, widespread functional impairment, and a high mortality rate. Each year, approximately 550,000 new cases are diagnosed and nearly 300,000 patients die of heart failure as a primary or contributory cause (AHA Heart & Stroke Facts, 2003). Elderly individuals are particularly at risk for developing heart failure. In fact, HF is the most common hospital discharge diagnosis for patients over 65 years. The syndrome is the underlying reason for 12 to 15 million office visits and 6.5 million hospital days each year (O’Connell & Bristow, 1993). Furthermore, during the last 10 years, the annual number of hospitalizations has increased from approximately 550,000 to nearly 900,000 for HF as a primary diagnosis and from 1.7 to 2.6 million for HF as a secondary diagnosis (Haldeman, Croft, et al., 1999). In addition to
the substantial morbidity and mortality associated with this condition, there is a significant financial impact on our society. In fact, heart failure is now the single most costly cardiovascular illness in the United States, with total treatment costs estimated at $24.3 billion (AHA Heart & Stroke Facts, 2003). The cost to society is expected to increase due to an aging population and prolonged survival rates of individuals with cardiovascular disease, therefore imposing a large burden on individuals and the healthcare system (Bourassa, Gurne, & Bangdiwala, et al., 1993).

**THE HEART IN HEART FAILURE**

Following partial destruction of the myocardium, and/or a pressure or volume overload, the heart uses a series of short- to long-term adaptive strategies to maintain cardiac output compatible with survival. Within seconds to minutes of a reduction in stroke volume, an increase in venous return and inotropic state can cause ventricular dilation and increased myocardial contractility (Ross, 1976).

**Ventricular dilatation and myocardial contractility**

Ventricular dilatation is the result of adaptive lengthening of the non-infarcted sarcomeres (Pfeffer, M.A., & Braunwald, E. 1987) or may develop secondary to expansion of an infarcted zone (Hutchins et al., 1978). This adaptive strategy aims to restore cardiac output through the Frank-Starling mechanism despite a loss in contractile function (Starling, 1895). If the preload reserve is inadequate to maintain cardiac output, activation of the sympathetic nervous system results in an increase in myocardial contractility. Sympathetic activation causes stimulation of beta-receptors and intracellular second messenger systems.

Unfortunately, stretching of the sarcomeres to a more optimal length is an adaptive strategy that is easily pushed to the maximum, increases wall stress (and therefore myocardial oxygen demand), and does not work well chronically (Zelis, Sinoway, Leuenberger, et al., 1991).
In fact, left ventricular dilation (in particular end-systolic volume) represents one of the most powerful prognostic indicators for cardiac failure and death (White, Norris, Brown, et al., 1987). Furthermore, down-regulation or decreased responsiveness of beta-receptors and gradual development of dysfunction of the stimulatory guanylate nucleotide binding protein, which couples the beta-receptor to the adenylate cyclase system, and contractile apparatus ultimately, renders catecholamine stimulation of the myocardium ineffective over the long-term (Longabaugh et al., 1988).

**Cardiac remodeling**

To cope with a chronic elevation of myocardial wall stress, the heart remodels and hypertrophies. Gradually, new sarcomeres (contractile units) are laid down to share the work load and reduce the wall stress. Patients with cardiomyopathies have shown that an increase in left ventricular end-diastolic volume and an almost doubling of left ventricular mass counter a reduction in ejection fraction (Holubarsch et al. 1991). Clearly, such an adaptation has a much longer time constant and is slow in onset and slow to regress. However, myocardial hypertrophy exacts a price. More sarcomeres means more muscle that needs to be oxygenated which results in an increase in myocardial oxygen demand. The increase in myocardial oxygen demand may subsequently result in myocardial ischemia due to an inability to raise coronary flow beyond the ceiling imposed by coronary artery atherosclerotic obstruction. Consequently the aim of treatment of overt heart failure is to control the vicious cycle of cardiac failure through restriction of physical activity, restriction of sodium intake, diuretics, vasodilators, digitalis glycosides, and/or other inotropes.

Unfortunately if the underlying cause of heart failure is not corrected, patients enter the next phase of the disease known as chronic heart failure defined by a gradual decline in physical
function with occasional exacerbations of their condition. Chronic heart failure is a complex clinical syndrome, or constellation of signs and symptoms, that may include fatigue and shortness of breath on exertion (progressing to symptoms at rest), peripheral edema, orthopnea, paroxysmal nocturnal dyspnea, nocturia, mental status changes, anorexia, and abdominal pain. The symptoms appear to be the consequence of a variety of compensatory adaptations with short- to long-time constants aimed to maintain cardiac output and arterial pressure to adequately perfuse the brain and the heart. These compensatory adaptations were described above and will be discussed in further detail in the next sections regarding the consequence of the heart failure syndrome on physical function, as defined by exercise tolerance. It is important to recognize that the compensatory adaptations are remarkably effective early on in the disease process and under resting conditions. However, the capacity to sustain cardiac performance in the face of the compensatory adaptations exacts a price (Zelis et al., 1991), as they ultimately contribute significantly to the clinical severity of the syndrome. In fact, the cardinal symptoms of HF include (1) dyspnea (2) significant intolerance to physical activity, and (3) chronic fatigue. Consequently, the long-term management of the chronic heart failure patient must focus on the control of the heart failure syndrome and the need to manage the compensatory changes associated with the disease. It is clear from the present literature that clinicians and therefore patients struggle tremendously with the long-term management of the syndrome, despite evidence of available efficacious strategies.

THE PERIPHERY IN CHRONIC HEART FAILURE
Intuitively, one would hypothesize that the clinical severity of heart failure is directly related to the degree of cardiac dysfunction. Yet, most clinical measures of cardiac function (e.g. cardiothoracic ratio; left ventricular ejection fraction) correlate poorly with the clinical severity of heart failure, as defined by exercise capacity or tolerance (see Figures 2a and b) (Coats, 2001; Parish, Alomari, Wood, et al., 2002). This discordance has led to the identification of multiple compensatory mechanisms with short- to long-time constants, which may contribute to the marked exercise intolerance in heart failure. These compensatory mechanisms include: (1) "hyper"-activation of neurohumoral factors, e.g. increased catecholamines and fluid-regulatory hormones and a decrease in endothelium-mediated dilators, (2) alterations in skeletal muscle blood flow, metabolism and function, and (3) structural vascular and skeletal muscle changes (Drexler, 1991).
Although, the purpose of the compensatory adaptations in heart failure is thought to be an attempt to maintain a cardiac output and arterial pressure that adequately perfuse the brain and the heart, it is the magnitude of these compensatory adaptations that eventually sows the seed for a series of maladaptive processes which lead to a decompensated state or even end-stage heart failure (Zelis, Sinoway, Leuenberger, et al., 1991). Yet, to date, it is not clear to what degree the compensatory adaptations in heart failure are inherent to the disease or to other contributing factors such as physical deconditioning and/or malnutrition. The peripheral alterations in heart failure are thought to be, in part, protective as they prevent blood pressure from decreasing when the failing heart cannot adequately increase cardiac output (Zelis, Sinoway, Leuenberger, et al., 1991). Others suggest that the peripheral alterations in heart failure in part mimic the deconditioning process seen with prolonged physical inactivity (Adamopoulos & Coats, 1991; Stratton, Dunn, Adamopoulos, et al., 1994). Thus, it is presently not clear to what degree the exercise intolerance in heart failure is inherent to the disease itself, level of inactivity, or one or more unidentified contributing factors.

**Circulatory Compensatory Adaptations**

In patients with low cardiac output, arterial pressure is supported by a rise in systemic
vascular resistance. Therefore, in addition to the cardiac compensatory mechanisms discussed above, heart failure is characterized by a complex series of circulatory adaptations which aim to maintain arterial blood pressure. These circulatory adaptations include (1) neural vasoconstriction, (2) humoral vasoconstriction, and (3) local impairment of vasodilatory capacity. The compensatory mechanisms often act in concert to maintain arterial pressure, but each has its own time-constant and ultimately contributes to the development of the "Heart Failure Syndrome".

Alterations in cardiovascular reflexes

In the acute phase of low-output heart failure, arterial and cardiopulmonary baroreflexes are activated to help maintain blood pressure. However, sensitivity of both receptors diminishes contributing to blunted reflexes (Dibner-Dunlap & Thames, 1992; Eckberg, Drabinsky, & Braunwald, 1971; Ellenbogen, Mohanty, Szentpetery, et al., 1989). It is thought that the marked desensitization of the reflexes contributes to abnormal neurohumoral stimulation. Although the precise mechanisms involved are not entirely understood, it is proposed that in patients with heart failure the abnormalities in the cardiovascular reflexes could lead to a reduced restraining influence on the sympathetic nervous system, thereby removing the restraining or "braking" influence on the heart and circulation. In time, this would favor the development of a neurohumoral excitatory state with tachycardia and sympathetically mediated vasoconstriction.

Alterations in the autonomic nervous system

A rise in systemic vascular resistance is accomplished initially, by activation of the sympathetic nervous system. The effect of systemic activation on the heart was described above. Activation of the sympathetic nervous system is very effective over the short term to maintain blood pressure (Zelis & Flaim, 1982). Plasma norepinephrine concentrations, an index of the
activity of this system, are generally two or three times higher in patients with heart failure in comparison to healthy controls (Cohn, Levine, Olivari, et al., 1984). The magnitude of elevation of plasma norepinephrine is related to the degree of left ventricular dysfunction and carries an ominous prognosis (Cohn, Levine, Olivari, et al., 1984). The purpose of the increase in sympathetic activation is to maintain cardiac output and arterial pressure through stimulation of myocardial contractility and α1-adrenoreceptors in the vascular wall. Stimulation of the α1-adrenoreceptors causes an increase in vasomotor tone and systemic vascular resistance. However, any supportive effect of the increased sympathetic nervous system activity on arterial blood pressure is, in time, superseded by a number of organ-specific consequences. The potential adverse effects of sympathetic activation on cardiac muscle (see figure 4a and b), the kidneys, and the vasculature is numerous and contributes to the clinical manifestations of heart failure (Hackenthal, Paul, Genten, et al, 1990).

**Humoral activation**

Humoral activation is one of the hallmarks of the heart failure syndrome (Drexler, 1991).
blood volume. The increased volume also assists the failing heart by increasing the preload which subsequently stretches the sarcomeres in the myocardium to a more optimal length during the early phases of heart failure until myocardial hypertrophy develops. However, as a result of chronic humoral activation two vicious cycles develop: (1) vasoconstriction and (2) sodium and water retention. Arterial vasoconstriction causes an increase in systemic vascular resistance and inevitably an increase in afterload and systolic wall stress. The sodium and water retention causes an increase in circulating volume, which may be beneficial at first, but ultimately results in an increased ventricular filling pressure and diastolic wall stress. Together, these vicious cycles may eventually lead to progressive myocardial and vascular dysfunction, peripheral tissue abnormalities, fluid accumulation, and finally the clinical picture of heart failure (Remme, 1994).

Activation of the renin-angiotensin-aldosterone axis is attributed to low renal perfusion and sympathetic stimulation. The formation of angiotensin II, which is catalyzed by angiotensin converting enzyme, located in the endothelium of the vascular tree, contributes to a rise in peripheral vascular resistance, enhances renal sodium reabsorption, facilitates catecholamine release from sympathetic nerve endings, and stimulates mineralcorticoid production in the adrenal gland (Hackenthal, Paul, Genten, et al., 1990). Angiotensin II has also been implicated as a growth factor or growth modulator in the cardiovascular system. The renin-angiotensin-aldosterone axis is markedly activated in patients with decompensated heart failure.

With the discovery that the renin-angiotensin-aldosterone system is markedly activated in heart failure, it is not surprising that a significant number of investigators have focused on the role of angiotensin-converting-enzyme (ACE) inhibitors as a strategy to treat patients with heart failure. Results from subsequent clinical trials have shown convincingly that cardiovascular morbidity and mortality can be reduced in patients with left ventricular dysfunction (ejection
fraction ≤ 40%) secondary to ischemic heart disease following long-term use of ACE-inhibitors (SOLVD Investigators, 1991; SOLVD Investigators, 1992; Pfeffer, Braunwald, Moye, et al., 1992). Interestingly, the precise mechanism(s) of action of ACE-inhibitors are still not fully understood. It is thought that the mechanism of action is in part cardioprotective and vasculoprotective. A reduction in systemic vascular resistance secondary to inhibition of angiotensin II generation may reduce afterload and myocardial work. Mechanisms for the vasculoprotective properties include a reduction in angiotensin II production, decreased bradykinin degradation, antagonism of macrophage function and migration as well as inhibition of sympathetic nervous system and thrombotic activity (Pepine, 1996). All of these could result in plaque stabilization, and may contribute to reversal of vascular dysfunction.

Arginine vasopressin is also elevated in heart failure (Schrier & Abraham, 1999). The mechanism for the release of arginine vasopressin in heart failure is not well understood but is believed to be due to non-osmotic causes. Perhaps a decreased sensitivity of atrial stretch receptors, which normally serve to inhibit arginine vasopressin release with atrial distention, contributes to the elevation of circulating arginine vasopressin. Non-osmotic stimulation of arginine vasopressin has been linked to low stroke volume and cardiac output. Improvement in cardiac performance by afterload reduction in patients with heart failure decreases arginine vasopressin levels and enhances water excretion. A potential unfavorable consequence of elevated arginine vasopressin is hyponatremia. Hyponatremia is a common manifestation of severe heart failure and occurs when water is retained in excess of sodium. It has been shown to be a powerful independent predictor of cardiovascular mortality (Lee & Packer, 1986).

Circulating atrial natriuretic peptide levels are reportedly increased in patients with heart failure. The elevation in plasma atrial natriuretic peptide in heart failure patients is thought to be
due to increased cardiac volume and/or pressure overload. Several studies have demonstrated that atrial natriuretic peptide correlates with the functional class of patients with heart failure, plasma renin activity, plasma norepinephrine concentrations, and mortality. As a result atrial natriuretic peptide has emerged as an important diagnostic and prognostic marker in heart failure (Gottlieb, Kukin, Ahern, et al., 1989).

More recent evidence suggests that there is a diminished response to and a gradual impairment in the capacity to release atrial natriuretic peptide in heart failure (Volpe, Tritto, De Luca, 1991). The mechanism for the hyporesponsiveness to atrial natriuretic peptide is thought to be multifactorial and include (1) a reduction in renal perfusion, (2) increased renal sympathetic nerve activity, (3) increased circulating catecholamines, (4) atrial natriuretic peptide receptor downregulation, (5) enhanced atrial natriuretic peptide enzymatic degradation, and/or (6) increased activity of the renin-angiotensin-aldosterone system. The impaired capacity to release atrial natriuretic peptide may be the result of chronic volume and pressure overload and inability of the atria to meet the demand of the system. Thus, a relative deficiency may develop in patients with chronic heart failure with biologic consequences. It may therefore be hypothesized that the diminished response to and impaired release of atrial natriuretic peptide contributes to the pathophysiology of sodium and water retention and systemic vasoconstriction in patients with heart failure (Brandt, Wright, Redfield, et al., 1993).

**Alterations in Vasoreactivity**

The above mentioned neurohumoral factors exert potent systemic and regional vasoconstriction in patients with heart failure. However, it is surprising that there is a poor correlation between plasma neurohumoral factors and systemic vascular resistance. This suggests that there are still other factors that affect vascular tone. In fact clear evidence indicates
that patients with heart failure have impaired vasodilatory capacity (Drexler, Hayoz, Munzel, et al., 1992; Wilson & Ferraro, 1985). Moreover, ACE-inhibitors do not restore the vasodilatory response following acute administration, indicating that blockade of the renin-angiotensin-aldosterone system does not result in an immediate improvement in blood flow to working muscle. Thus, it appears that there are other mechanisms involved in the impaired vasodilatory capacity of patients with heart failure. There currently are three potential mechanisms, which may explain the vasodilatory impairment seen in heart failure: (1) endothelial dysfunction, (2) vascular stiffness, (3) vascular deconditioning, and (4) changes in venous function.

There is now compelling evidence that endothelium-mediated relaxation is attenuated in both the coronary and peripheral circulation of patients with heart failure (Drexler, Hayoz, Munzel, et al., 1992). The potential mechanism(s) of endothelial dysfunction are currently unknown, although several hypotheses have been proposed. These hypotheses include (1) alterations in endothelial cell surface receptors, (2) decrease in endothelial derived relaxing factor synthesis, (3) rapid degradation of endothelial derived relaxing factor, and (4) increased production of endothelium-derived contracting factors.

Alterations in endothelial cell surface receptors may be secondary to the atherosclerotic process or may be a consequence of chronic low flow resulting in lack of stimulation of the endothelial apparatus to produce dilating factors, such as nitric oxide and prostaglandins. It is unclear if the production of endothelium-derived relaxing factor is perhaps secondary to nutritional deficiencies in L-arginine, and/or the cofactors needed in the production process. Rapid degradation of endothelial derived relaxing factor has been linked to increased oxygen-derived free radical activity. The oxygen-derived free radical superoxide is a known inactivator of endothelial derived relaxing factors. Oxygen-derived free radical production is increased in
patients with heart failure (Belch, Bridges, Scott, et al., 1991). Thus, free radical-mediated inactivation of endothelium-derived relaxing factor in the vasculature of patients with heart failure could contribute to the impaired vasodilatory response.

Vascular stiffness may in part be the result of an increase in the vascular sodium content subsequent to the hyperactivity of the renin-angiotensin-aldosterone system (Sinoway, Minotti, Musch, et al., 1987). The increase in vascular sodium and water content leaves the vessels stiff, less responsive to local metabolic stimuli, and may result in a change in the capillary basement membrane morphometry. In fact, approximately one third of the reduced vasodilatory response during exercise in patients with heart failure can be attributed to increased sodium and water content in the vascular wall (Sinoway, Minotti, Musch, et al., 1987).

Impaired vascular function may also be the result of chronic vascular deconditioning (Drexler, 1991). Immobilization of the forearm reportedly reduces vasodilatory capacity. Conversely, exercise training improves peak vasodilatory capacity (Hornig, Maier, & Drexler, 1996). Thus, vascular deconditioning may be secondary to a chronic decrease in blood flow (see Figure 5).

Interestingly, recent investigations also report diminished venous function in patients with heart failure (Welsch, Alomari, Parish, et al., 2002; Ikenouchi, Iizuka, Sato, et al., 1991). Moreover, measures of
distance achieved on the 6-minute walking test, a measure of exercise tolerance (see Figure 6a and b) (Welsch, Alomari, Parish, et al., 2002). These findings suggest factors that contribute to exercise impairment in heart failure patients may extend to the venous system. Although the precise factors are not entirely understood, the important contributions of the venous system in terms of metabolic waste removal and end-diastolic volume, would suggest that any change in this system could have a profound impact on the exercise response. Finally, evidence that venous function influences arterial inflow through the venoarterial reflex (Tschakovsky & Hughson, 2000) suggests the importance of addressing venous health in heart failure.

**Skeletal Muscle Compensatory Adaptations**

Considerable attention has been given to intrinsic alterations in skeletal muscle which may contribute to the clinical severity of patients with heart failure (Drexler, Riede, Munzel, et al., 1992; Drexler, Riede, Hiroi, et al., 1988; Sullivan, Green, & Cobb, 1990; Sullivan, Green, & Cobb, 1991). The consensus of these studies indicates significant skeletal muscle abnormalities including (1) structural changes, such as muscle atrophy; (2) a marked decline in mitochondrial
enzyme concentration and activity (Succinate dehydrogenase, Citrate synthase and cytochrome oxidase); and (3) a reduction in mitochondrial volume and density.

**Skeletal muscle atrophy**

Muscle atrophy is common in patients with heart failure (Drexler, Riede, Munzel, et al., 1992; Sullivan, Green, & Cobb, 1990). The mechanism for muscle atrophy in heart failure is not entirely clear but has been linked to malnutrition, deconditioning, an increased catabolic state due to sympathetic nervous system hyperactivation, an increase in serum cortisol, corticotropin, and/or tumor necrosis factor. Thus, it appears that skeletal muscle atrophy could be an important and potentially reversible contributor to exercise intolerance in patients with heart failure.

**Histologic and biochemical alterations in skeletal muscle**

It appears that skeletal muscle atrophy in heart failure is somewhat selective and more pronounced in the Type I (high-oxidative) muscle fibers, compared to other fiber types. In addition, to these morphologic changes, a decrease in the number of capillaries per fibers for type I and type IIa fibers are also reported (Drexler, Riede, Munzel, et al., 1992; Drexler, Riede, Hiroi, et al., 1988; Sullivan, Green, & Cobb, 1990).

The apparent loss in oxidative capacity in heart failure is further evident from studies which have performed biochemical analysis of skeletal muscle (Drexler, Riede, Munzel, et al., 1992; Drexler, Riede, Hiroi, et al., 1988; Sullivan, Green, & Cobb, 1990). A consistent observation in these patients is a marked reduction in mitochondrial enzyme concentration for succinate dehydrogenase citrate synthetase, and 3-hydroxacyl-coenzyme A-dehydrogenase and enzymatic activities. In addition, muscle glycogen levels are also reduced. Ultrastructural morphometry of muscle biopsies of the vastus lateralis indicated significant abnormalities of skeletal muscle as compared to normals (Drexler, Riede, Munzel, et al., 1992; Drexler, Riede,
Hiroi, et al., 1988). The volume density of mitochondria and surface density of mitochondrial cristae, markers of structural correlates of oxidative capacity, were significantly reduced by 20% in patients with severe heart failure. Capillary length density was reduced and fiber type distribution of skeletal muscle was shifted to type II fibers. Cytochemical analysis of cytochrome oxidase activity also revealed significant decreases in heart failure. Both the volume density of mitochondria and surface density of mitochondrial cristae were significantly related to VO$_{2}\text{peak}$ and VO$_2$ at anaerobic threshold, but inversely related to the duration of heart failure (Drexler, Riede, Munzel, et al., 1992; Drexler, Riede, Hiroi, et al., 1988). From these studies, it appears that the literature supports the notion that a major component of heart failure is a reduction in oxidative capacity due to intrinsic alterations in skeletal muscle.

Although, the mechanisms for the alterations in skeletal muscle metabolism in heart failure patients are unknown, several factors (neurohumoral, chronic reductions in muscle perfusion, and deconditioning) may be involved (Adamopoulos & Coats, 1991; Stratton, Dunn, Adamopoulos, et al., 1994; Drexler, Riede, Munzel, et al., 1992). Chronic deconditioning may be a key factor in the alterations in skeletal muscle metabolism, since recent studies have shown that physical training can improve exercise capacity in patients with heart failure by delaying the onset of anaerobic metabolism. However, chronic muscle underperfusion (at rest or during exercise) and/or increased sympathetic stimulation could also cause many of the above-mentioned abnormalities in skeletal muscle metabolism. Finally, “mal”-nutrition in these patients may also contribute to the observed changes.

**GOALS OF TREATMENT**

Because of the multi-factorial, and often patient-specific, nature of the illness, treatment of heart failure is extremely challenging and patients require close monitoring (Caldwell MA &
The primary goals of heart failure management are to reduce the frequency of heart failure exacerbations, extend survival, and improve quality of life. Additional goals include maximizing independence, improving exercise capacity, enhancing emotional well-being, and reducing resource use and cost of care (Rich, 1999). To achieve these goals, the ACC/AHA Guidelines for the Evaluation and Management of Chronic Heart Failure in the Adult (2001) have recently decided to take a new approach to the classification of HF that emphasizes both the evolution and progression of the disease (Hunt, Baker, Chin, et al., 2001). In doing so, 4 stages of HF are identified as shown in Figure 7 and Table I. **Stage A** identifies the patient who is at high risk for developing HF but has no structural disorder of the heart; **Stage B** refers to a patient with a structural disorder of the heart but who has never developed symptoms of HF; **Stage C** denotes the patient with past or current symptoms of HF associated with underlying structural heart disease; and **Stage D** designates the patient with end-stage disease who requires specialized treatment strategies such as mechanical circulatory support, continuous inotropic infusions, cardiac transplantation, or hospice care. The treatment goals within each stage differ and focus on the control of risk and early detection of ventricular dysfunction in **Stage A** patients; prevention of cardiovascular events and early detection of HF symptoms in **Stage B** patients; pharmacologic approaches and behavior interventions in **Stage C**; and **Stage D** patients aggressive management of fluid status, utilization of neurohumoral inhibitors, intravenous drug therapy and mechanical or surgical intervention. The goals and steps for treatment are further depicted in the figure below as developed by the ACC/AHA guidelines (Hunt, Baker, Chin, et al., 2001).
Pharmacological Treatment

The most common strategy used to manage patients with chronic heart failure is through the use of pharmacological agents. Clearly, the purposes of pharmacologic therapy are to reduce mortality, to alleviate the symptoms of HF, and to improve the patient’s functional capacity (Hunt, Baker, Chin, et al., 2001). Recent consensus guidelines (2001) recommend that most patients with symptomatic left ventricular dysfunction should be routinely managed with a combination of 4 types of drugs: an ACE inhibitor, a beta-adrenergic blocker, a diuretic, and (usually) digitalis (Packer, Cohn, et al., 1999; Hunt, Baker, et al., 2001). The value of these drugs has been established in numerous large-scale clinical trials, and the evidence supporting a central role for their use is compelling and persuasive. The purpose of this section of the review is to provide evidence for the use of the aforementioned drugs. In so doing it must be recognized that the review is somewhat biased toward individuals with left ventricular dysfunction, secondary to coronary artery disease. Heart failure patients with other underlying etiologies may require similar or vastly different pharmacological approaches from the consensus guidelines.
Management of the heart failure patient with Diuretic Agents

Clinical trials have clearly demonstrated the benefits of using diuretic agents for fast relief of sodium retention and symptoms of fluid overload (Patterson, Adams, Appelfeld, et al., 1994; Sherman, Liuand, Baumgarden, et al., 1986). Moreover, diuretics contribute to improved cardiac function and exercise tolerance (Wilson, Reichem, Dunkman, et al., 1981). Recent guidelines suggest that diuretics should be prescribed to all patients who have evidence of, and to most patients with a prior history of, fluid retention (Hunt, Baker, Chin, et al., 2001). Diuretics should be administered promptly to patients with HF who present with symptoms of congestion and patients should continue using these agents after improvement of symptoms (Konstam, Dracup, Baker, et al., 1994; Packer & Cohn, 1999; Wilson, Reichem, Dunkman, et al., 1981).

Diuretics eliminate excess fluid volume and relieve symptoms related to circulatory congestion (e.g., orthopnea and paroxysmal nocturnal dyspnea) by inhibiting the reabsorption of sodium or chloride at specific sites in the renal tubules. Thiazides, metolazone, and potassium-sparing agents (e.g., spironolactone) act in the distal portion of the renal tubule; whereas, loop diuretics (i.e., Bumetanide, furosemide, and torsemide) act at the loop of Henle (Brater, 1998; Cody, Kubo, Pickworth, 1994). These two classes of diuretics differ in their pharmacologic actions. The loop diuretics increase sodium excretion up to 20% to 25% of the filtered load of sodium, enhance free water clearance, and maintain their efficacy unless renal function is severely impaired (Damle & Talano, 1991; Hunt, Baker, Chin, et al., 2001). In contrast, thiazide diuretics increase the fractional excretion of sodium to only 5% to 10% of the filtered load, tend to decrease free water clearance, and lose their effectiveness in patients with moderately impaired renal function (creatinine clearance up less than 30 mL per min) (Damle & Talano, 1991; Hunt, Baker, Chin, et al., 2001). Consequently, in some patients with mild heart failure, a
A thiazide diuretic (e.g., hydrochlorothiazide) may be adequate, but most patients require a more potent loop diuretic because they are often needed to treat the volume overload associated with HF disease pathophysiology (Hunt, Baker, Chin, et al., 2001).

The response to a diuretic is dependent on the concentration of the drug and the time course of its entry into the urine (Brater, 1998; Cody, Kubo, Pickworth, 1994). Patients with mild HF respond favorably to low doses because they absorb diuretics rapidly from the bowel and deliver these drugs rapidly to the renal tubules. However, as the HF condition worsens, the absorption of the drug may be delayed by bowel edema or intestinal hypoperfusion, and the delivery of the drug may be impaired by a decline in renal perfusion and function (Vasko, Cartwright, Knochel, et al., 1985; Brater, Chennavasin, Seiwell, et al., 1980; Vargo, Kramer, Black, et al., 1995). Consequently, the clinical progression of HF is characterized by the need for increasing doses of diuretics.

Because diuretics intensify the activation of the renin-angiotensin-aldosterone system by decreasing renal perfusion, patients should be maintained on the lowest dose possible and may even be used p.r.n. if symptoms are mild (Connolly, 2000). Although diuretics are successful in controlling acute symptoms and fluid retention, diuretics alone are unable to maintain the clinical stability of patients with HF for long periods of time (Richardson, Bayliss, Scriven, et al., 1987). Therefore, diuretics should not be used as monotherapy in the treatment of HF. The risk of clinical decompensation can be reduced, however, when diuretics are combined with an ACE inhibitor, a beta-blocker, and digoxin (Captopril-Digoxin Multicenter Research Group, 1988; Hunt, Baker, Chin, et al., 2001).

Appropriate use of diuretics is a key element in the success of other drugs used for the treatment of HF. The use of inadequately low doses of diuretics will cause fluid retention,
which can diminish the response to ACE inhibitors and increase the risk of treatment with beta-blockers (Cody, Franklin, Laragh, 1982). Conversely, the use of inappropriately high doses of diuretics will lead to volume contraction, which can increase the risk of hypotension with ACE inhibitors and vasodilators (Cody, Franklin, Laragh, 1982; Massie, Kramer, Haughom, 1981) and increase the risk of renal insufficiency with ACE inhibitors and angiotensin II receptor antagonists (Packer, Lee, Medina, 1987).

The effectiveness of diuretic therapy is enhanced when the patient follows a reduced-sodium diet. Sodium intake is strictly correlated with the administration of diuretics. If the diuretic dose is increased to compensate for a more liberal sodium intake, the renin-angiotensin system will be strongly activated and will promote thirst, as well as deplete potassium and magnesium (Haller C, Salbach P, et al., 1995). Moreover, in the absence of sodium restriction, diuretics become less effective (Cody RJ, Kubo SH, et al., 1994). Furthermore, patients may become unresponsive to high doses of diuretic drugs if they consume large amounts of dietary sodium, are taking agents that can block the effects of diuretics (e.g., nonsteroidal anti-inflammatory drugs (Herchuelz, Derenne, Deger, et al., 1989; Gottlieb, Robinson, Krichten, et al., 1992; Brater, Harris, Redfern, et al., 2001), or have a significant impairment of renal function or perfusion (Risler, Schwab, Kramer, et al., 1994).

The principal adverse effects of diuretics include electrolyte depletion as well as hypotension and azotemia. Diuretics can cause the depletion of important cations (i.e., potassium and magnesium), which can predispose patients to cardiac arrhythmias, particularly in combination with digitalis therapy (Steiness & Olesen, 1976). The loss of electrolytes is related to enhanced delivery of sodium to distal sites in the renal tubules and the exchange of sodium for other cations, a process that is potentiated by activation of the renin-angiotensin-aldosterone
system (Cody, Kubo, Pickworth, 1994). Potassium deficits can be corrected by the short-term use of potassium supplements, or if severe, by the addition of magnesium supplements (Solomon, 1987). Concomitant administration of ACE inhibitors alone or in combination with potassium-retaining agents (such as spironolactone) can prevent electrolyte depletion in most patients with HF who are taking a loop diuretic. Therefore, when these drugs are prescribed, long-term oral potassium supplementation is frequently not needed and may be deleterious (Hunt, Baker, Chin, et al., 2001).

Patients should be educated about the intended benefit of the medication, dosage, and optimal time of day for ingestion (i.e., in the morning) (Baker, Dracup, Dunbar, 1994; Godden, 1994). Patients should also be informed about the rapidity of the diuretic effect and the need to have access to a bathroom (Godden, 1994). Possible adverse effects should be mentioned in advance, particularly those such as postural hypotension, which might precipitate falls in the elderly (Dracup, 1996). The patient should be monitored for signs of overdiuresis or hypokalemia, especially because symptoms such as lethargy and drowsiness are often overlooked (Dracup, 1996).

Overdiuresis should be particularly avoided in patients who are beginning therapy with ACE inhibitors because of the potential for hypotension or renal insufficiency. Once ACE-inhibitor treatment has been established, the diuretic dose may be increased as needed to control any persisting symptoms of volume overload (Konstam, Dracup, Baker, et al., 1994; Baker, Konstam, Bottorff, 1994).

In summary, the efficacy of diuretics is well established, especially in combination with other heart failure drugs. Diuretics are particularly useful in the day-to-day management of the heart failure patient. As patients exhibit a sudden increase in bodyweight (e.g. secondary to
dietary intake of foods high in sodium) and concomitant exacerbation of heart failure symptoms, an increase in the dose of diuretic will often result in rapid relief. As the symptoms subside the dosage may once again be decreased.

Management of the heart failure patients with ACE-inhibitors

The use of angiotensin-converting enzyme (ACE) inhibitors in the treatment of heart failure is now considered a gold standard of care (Packer, Cohn, et al., 1999; Hunt, Baker, et al., 2001). Published guidelines from the Agency for Healthcare Policy and Research (Konstam, Dracup, Baker, et al., 1994), the American College of Cardiology and the American Heart Association Task Force (Hunt, Baker, Chin, et al., 2001), and the European Society of Cardiology Task Force (1997) all recommend ACE inhibitors for first-line therapy for patients with heart failure. ACE-inhibitors decrease systemic vascular resistance and have been shown to improve survival, reduce hospitalizations, and enhance quality of life in a wide range of patients with left ventricular systolic dysfunction (Pfeiffer, Braunwald, Moye, et al., 1992; AIRE Study investigators, 1993; SOLVD Investigators, 1992; SOLVD Investigators, 1991). As established by the Studies of Left Ventricular Dysfunction (SOLVD) Prevention Trial, ACE-inhibitor therapy is indicated in all patients with asymptomatic left ventricular dysfunction (SOLVD Investigators, 1992). Additionally, controlled trials suggest that patients with advanced heart failure respond favorably to treatment with both ACE-inhibitors and beta blockers in a manner similar to those with mild to moderate disease (The CONSENSUS Trial study group, 1987; Packer, Coats, Fowler, et al., 2001).

ACE-inhibitors act by inhibiting the enzymatic conversion of angiotensin I to angiotensin II, a potent vasoconstrictor. Angiotensin II is elevated in patients with heart failure secondary to poor left ventricular performance and hypoperfusion of the kidneys. The response to this
situation is activation of the renin-angiotensin-aldosterone system in an effort to maintain adequate perfusion of the organs. Unfortunately, in chronic heart failure the renin-angiotensin-aldosterone system contributes to significant cardiovascular mal-adaptations that contribute to the heart failure syndrome. The result of the inhibition of the converting enzyme is a decrease in afterload. Moreover, ACE-inhibitors also inhibit the stimulation of the adrenal cortex to release aldosterone. Consequently, sodium excretion is promoted and fluid retention controlled. Additionally, ACE inhibitors also inhibit the breakdown of bradykinin, a potent vasoactive peptide that stimulates the endothelium to produce nitric oxide, another potent vasodilator. The combined effects of ACE-inhibitors, therefore, is a significant increase in cardiac index and decrease in left ventricular filling pressures and systemic vascular resistance (Jessup, 1988). The beneficial effects of ACE inhibitors in heart failure and after a myocardial infarction include a marked improvement in survival and heart failure symptoms, and a reduction in the rate of hospitalization. In addition, ACE-inhibitors are also cardioprotective and limit the negative effects of ventricular remodeling (Greisinger, Espadas, & Ashton, 1998; Pinkowish, 1997). The peak effect of the drug occurs somewhere between 1 hour and 90 minutes after oral administration (Jessup, 1988). The benefits of ACE inhibition are usually seen during the first 90 days of therapy and extend to all patients, regardless of age, sex, etiology of CHF or NYHA class (Pinkowish, 1997). Therefore, recent consensus guidelines recommend ACE-inhibitor therapy for many patients with stage A heart failure and all patients with stage B, C, or D heart failure (Hunt, Baker, et al., 2001).

Despite overwhelming evidence of the proven benefits of ACE-inhibitors, the unfortunate reality is that only 30-40% of patients with CHF are receiving treatment with ACE inhibitors (Fletcher & Thomas, 2001). Moreover, up to 50% of patients admitted to the hospital with
chronic heart failure are discharged without prescriptions for ACE-inhibitors (Philbin, Rocco, Lindenmuth, et al., 1999). These statistics highlight the need for motivating physicians to learn more about current developments and guidelines in heart failure management.

It is not entirely clear what barriers underlie the underutilization of these drugs. However, 1) the physician’s uncertainty of the optimal dosage and 2) fear of potential side effects (i.e., nonproductive cough and hypotension), have been suggested. Yet side effects are fairly predictable and reversible and can usually be successfully managed (Jessup, 2003). Consequently, physicians should be familiar with current guidelines and inform the patients of what to expect, such as providing information regarding the function, therapeutic dosing of ACE-inhibitors, and side effects may improve the rate of utilization and treatment with this class of drug.

Furthermore, patients should be informed about the purpose and importance of ACE-inhibitors to survival, quality of life, and long-term prognosis (Dracup, 1996). Patients should be monitored for adverse effects such as hypotension and renal insufficiency, which may be related to volume depletion, and hyperkalemia (serum potassium ≥ 5.5 mmol/liter) (Heart Failure Guideline Panel, 1994; Dracup, Baker, Dunbar, et al., 1994). To avoid induction of hyperkalemia, patients should be warned not to use potassium-containing salt substitutes without first obtaining medical advice (Konstam, Dracup, Baker, et al., 1994). Patients should be informed of possible side effects and understand that dehydration, excessive perspiration, vomiting, or diarrhea may lead to volume depletion and a fall in blood pressure (Dracup, 1996).

In summary, the evidence for the use of ACE-inhibitors is overwhelming and should represent one of the cornerstones in the management of the heart failure patient. Barriers against
the use of ACE-inhibitors should be aggressively dealt with through education and continued
emphasis on available literature.

Management of the heart failure patient with Beta-blockers

The use of Beta-blockers in the management of patients with heart failure has remained
controversial for many years. However, recent large-scale clinical trials (Abraham, 2000) have
clearly shown their efficacy, especially in the long-term management of patients with HF. Recent
consensus guidelines recommend the addition of beta-adrenergic blockade to therapy with
diuretics and ACE-inhibitors for most patients with mild to moderate heart failure and left
ventricular systolic dysfunction (1999). Furthermore, although controlled clinical trials are
lacking, the use of beta-blockers in addition to ACE-inhibitor therapy for asymptomatic left
ventricular dysfunction (Stage B heart failure) may provide further protection from progression
to more severe HF. Consequently the use of these agents has recently been promoted (Hunt,
1997).

In the most recent Consensus Guidelines it is even suggested that in patients who respond
favorably to diuretic therapy, additional treatment with an ACE inhibitor and a beta-blocker is
warranted and should be maintained in patients who can tolerate them, because they have been
shown to favorably influence the long-term prognosis of HF (Hunt, Baker, Chin, et al., 2001).
Additionally, several studies have shown that beta-blockers may reduce hospitalizations and
mortality and improve quality of life in patients with systolic heart failure (Doughty, Rodgers,
Sharpe, et al., 1997; Packer, Bristow, Cohn, et al., 1996). Furthermore, beta-adrenergic blockade
has been shown to improve left ventricular ejection fraction to an extent greater than any other
form of pharmacological therapy for systolic heart failure (Abraham & Scarpinato, 2002). Recent
data show that when a beta-blocker is added to an ACE inhibitor and diuretic, disease progression is slowed and morbidity and mortality are significantly reduced (Packer, Bristow, et al., 1996; Cardiac Insufficiency Bisoprolol Study II, 1999; MERIT-HF, 1999).

The evidence of improved ejection fraction with regression of left ventricular hypertrophy is substantial, making an important addition to the standard treatment of ACE inhibitors, diuretics, and digoxin (Connolly, 2000). A comprehensive analysis of 18 double-blind, placebo-controlled trials of beta-blocker use in patients with chronic heart failure revealed an improved overall ejection fraction of 29%, and reduced risk of mortality by 32%. These findings are attributed to the antagonizing effects of these drugs on sympathetic nervous system activity. Again in an effort to maintain adequate pressure in the face of poor left ventricular performance, HF patients have elevated catecholamine levels. Sympathetic activation can increase ventricular volumes and pressure by causing peripheral vasoconstriction (Smith, Macmillan, & McGrath, 1997) and by impairing sodium excretion by the kidneys (Elhawary & Pang, 1994). Norepinephrine can also stimulate cardiac hypertrophy needed to provide a greater contractile force to eject the volume of blood. Moreover, catecholamines can also increase heart rate and potentiate the activity and actions of other neurohormonal systems needed to help the failing heart.

Unfortunately, the chronic elevation of these hormones and the hyperactivity of the autonomic nervous system ultimately contribute to the worsening heart failure syndrome. For example, ventricular hypertrophy necessitates a greater coronary blood supply. Thus, patients with advancing coronary artery disease may consequently have greater myocardial oxygen demands and increased myocardial ischemic episodes (Knowlton, Michel, Itani, et al., 1993). Activation of the sympathetic nervous system can also promote arrhythmias by increasing the
automaticity of cardiac cells, and due to the development of hypokalemia (Reid, Whyte, & Struthers, 1986; Billman, Castillo, Hensley, et al., 1997). Finally, by stimulating growth and oxidative stress in terminally differentiated cells, norepinephrine can trigger programmed cell death or apoptosis (Communal, Singh, Pimentel, et al., 1998). These deleterious effects are mediated through actions on alpha-1, beta-1, and beta-2 adrenergic receptors (Reid, Whyte, & Struthers, 1986; Smith, Macmillan, & McGrath, 1997; Elhawary & Pang, 1994; Knowlton, Michel, Itani, et al., 1993; Billman, Castillo, Hensley, et al., 1997; Communal, Singh, Pimentel, et al., 1998).

The effects of Beta-blockers are to occupy beta-adrenergic receptor sites and to prevent norepinephrine and epinephrine from binding to these receptors and producing their stimulating effects. In addition, Beta blockers also slow the conduction time through the atrioventricular node, decreasing the chance of tachyarrhythmias, and they also help prevent the complications associated with acute ischemia (Fletcher & Thomas, 2001). Most all types of Beta-blockers that have been shown to be effective in the treatment of HF including those that selectively block beta-1 receptors (e.g., bisoprolol and metoprolol) and those that block alpha-1, beta-1, and beta-2 adrenergic receptors (e.g., carvedilol) (Hunt, Baker, Chin, et al., 2001).

In a recent sub-analysis of the SOLVD data, HF hospitalizations and mortality were found to be decreased in patients receiving a combination of ACE inhibitor and β-blocker, independent of etiology of left ventricular dysfunction (Exner, Dries, Waclawiw, et al., 1999). Analysis of the Survival and Ventricular Enlargement (SAVE) study demonstrated similar cardioprotective effects of β-blockers in a cohort of post MI patients with decreased ejection fraction. The use of β-blockers was associated with a decreased incidence of symptomatic HF as well as decreased cardiovascular mortality (Vantimpont P, Rouleau JL, Wun C, et al., 1997).
More recent trials further confirm the beneficial effects of beta-blockers involving patients with heart failure from various etiologies and stages of severity (Jessup, 2003; Hunt, Baker, Chin, et al., 2001). These effects include a reduction in mortality and morbidity, a decrease in rate of hospitalizations and the incidence of sudden death, improvements in ejection fraction and measures of quality of life, and favorable control of cardiac remodeling, (Foody, Farrell, Krumholz, 2002; Farrell, Foody, Krumholz, 2002).

Interestingly, the short-term effects of beta-blockers may result in a temporary exacerbation of symptoms (Packer, 1998). The precise mechanism for this is not understood but may in part be secondary to the slight vasoconstricting effects of many of these agents. More recent studies, which have used both alpha and beta blocking agents, such as carvedilol, appear to be even more effective in the management of the patient, and do not seem to have the initial negative effects of the traditional beta-adrenergic blockers (Bristow, Gilbert, Abraham, et al., 1996). Regardless, the long-term effects of beta-blocking agents are uniformly beneficial and improve the clinical status of patients (Packer, 1998). Placebo-controlled trials involving long-term treatment have shown improved systolic function after three months of treatment and reverse remodeling after four months of treatment (Saxon, De Marco, Schafer, et al., 2002; Bristow, 2000; Groenning, Nilsson, Sondergaard, et al., 2000). An important consideration is that the beneficial effects of beta-blockers were also seen in patients already taking ACE-inhibitors (Abraham & Scarpinato, 2002). This suggests that combined blockade of these two neurohormonal systems can produce additive effects.

Given the potential complications associated with the initiation of beta-blocker therapy close monitoring of the patient is warranted. Patients may have increased dyspnea and edema, and may also experience symptomatic bradycardia with or without associated hypotension. It
must also be recognized that these symptoms may return during titration phases. However, the long-term benefits of using beta-blockers in the treatment of HF are far greater than the potential period of increased symptomatology during intitiation of therapy; therefore, clinicians are urged to add beta-blockers to treatment regimens without delay.

Beta-blockers should be used in all patients with stable heart failure without substantial fluid retention and without recent exacerbations of heart failure requiring ionotropic therapy (Hunt, Baker, Chin, et al., 2001). Beta-blockers should not be used, or should be used with caution, in patients with reactive airway disease, patients with diabetes associated with frequent episodes of hypoglycemia, and those patients with bradyarrhythmias or heart block who do not have a pacemaker (Jessup, 2003).

Once the target dose has been achieved, patients can generally be maintained on long-term therapy with a beta-blocker with little difficulty. Patients should be advised that clinical responses to the drug are generally delayed and may require 2 to 3 months to become apparent (Massie, Kramer, & Haughom, 1981). Even if symptoms do not improve, long-term treatment should be maintained to reduce the risk of major clinical events. Abrupt withdrawal of treatment with a beta-blocker can lead to clinical deterioration and should be avoided (Waagstein, Caidahl, Wallentin, et al, 1989).

In summary, the long-term effects of beta-blockers are of significant benefit to the patient with chronic heart failure. Consequently, the use of these agents should be a part of the management of the patients. Particular care and monitoring should be provided during the initial period following drug administration and during periods when the dose of the drug is increased.
Management of the heart failure patient with Digitalis Glycosides

Digitalis glycosides are of particular importance in providing symptomatic relief in patients with systolic dysfunction and in those with rapid atrial arrhythmias (Fletcher & Thomas, 2001). Digoxin is the only digitalis glycoside evaluated in clinical trials by the USFDA for use in patients with HF (Gheorghiade et al., 1998). Digoxin is a positive ionotrope that acts directly on the myocardium by inhibiting sarcolemmal sodium-potassium adenosine triphosphatase (ATPase) activity (Fletcher & Thomas, 2001; Akera, Baskin, Tobin, et al., 1973). Inhibition of this enzyme in cardiac cells results in an increase in the contractile state of the heart. Inhibition of ATP-ase within the kidney decreases renal tubular reabsorption of sodium and suppresses the renin-angiotensin-aldosterone system (Torretti, Hendler, Weinstein, et al., 1972; Fletcher & Thomas, 2001). Digitalis reduces the renal tubular reabsorption of sodium (Torretti, Hendler, Weinstein, et al., 1972); the resulting increase in the delivery of sodium to the distal tubules leads to the suppression of renin secretion from the kidneys (Covit, Schaer, Sealey, et al., 1983). These observations have led to the hypothesis that digitalis acts in HF primarily by attenuating the activation of neurohormonal systems and not as a positive inotropic drug (Gheorghiade & Ferguson, 1991). The inhibitory effects on the sympathetic nervous system in combination with reduced neurohormonal activity make digoxin an important pharmacologic weapon for controlling HF (Fletcher & Thomas, 2001).

The clinical benefits have traditionally been attributed primarily to its inotropic action (i.e., the ability to increase myocardial contractility). In view of current thinking that the progression of HF and the risk of mortality may be related to the extent of sympathetic activity, however, investigation has focused on the neurohormonal properties of digoxin. In a clinical study of 26 patients with HF, Krum et al., (1995) found that digoxin inhibits sympathetic activity...
while increasing parasympathetic activity and that these effects persist over 4 to 8 weeks of therapy (Krum, Bigger, Goldsmith, et al., 1995).

Several placebo-controlled trials have shown that treatment with digoxin for 1 to 3 months can improve symptoms, quality of life, and exercise tolerance in patients with mild to moderate HF (Captopril-Digoxin Research Group, 1988; Dobbs, Kenyon, Dobbs, 1977; Lee, Johnson, Bingham, et al., 1982; Guyatt, Sullivan, Fallen, et al., 1988; DiBianco, Shabetai, Kostuk, et al., 1989; Uretsky, Young, Shahidi, et al., 1993; Packer, Gheorghiade, Young, et al., 1993). These benefits have been observed regardless of the underlying rhythm (normal sinus rhythm or atrial fibrillation), cause of HF (ischemic or nonischemic cardiomyopathy), or concomitant therapy (with or without ACE-inhibitors). In a long-term trial that enrolled patients who primarily had class II or III symptoms, treatment with digoxin for 2 to 5 years had little effect on mortality but modestly reduced the combined risk of death and hospitalization (DIG Investigators, 1997). In the recently completed DIG study (Digitalis Investigation Group), 6800 patients with heart failure and an ejection fraction of less than 45% were randomized to digoxin or placebo and followed for an average of 37 months (DIG Investigators, 1997). Although digoxin had no effect on overall mortality, heart failure deaths and hospitalizations were significantly reduced (DIG Investigators, 1997). The effects of digoxin were similar across age groups. Consequently, digoxin remains an important agent for heart failure management because of its beneficial effects on hospitalizations and quality of life.

Physicians should consider using digoxin to improve the symptoms and clinical status of patients with HF, in conjunction with diuretics, and ACE-inhibitor, and a beta-blocker (Hunt, Baker, Chin, et al., 2001). If a patient is taking digoxin but not an ACE-inhibitor or a beta-blocker, treatment with digoxin should not be withdrawn, but appropriate therapy with the
neurohormonal antagonists should be instituted (Hunt, Baker, Chin, et al., 2001). Digoxin is prescribed routinely in patients with HF who have chronic atrial fibrillation, but beta-blockers may be more effective in controlling the ventricular response, especially during exercise (Matsuda, Matsuda, Yamagushi, et al., 1991; David, Segni, Klein, et al., 1979; Farshi, Kistner, Sarma, et al., 1999). Digoxin is not recommended for use in patients with pure diastolic dysfunction unless it is used as adjunct therapy in the modulation of the neurohormonal system or for control of atrial arrhythmias Hunt, Baker, Chin, et. al., 2001).

Dosing of digoxin is affected by the patient’s age, weight, and renal function. Low doses (0.125 mg daily or every other day) should be used if the patient is over 70 years old, has impaired renal function, or has a low lean body mass (Jelliffe & Brooker, 1974). Although physicians have been taught that digitalis produces frequent side effects, the drug is well tolerated by most patients with HF (Steiner, Robbins, Hammermeister, et al., 1994). The principle adverse reactions occur primarily when digoxin is administered in large doses, but large doses are rarely needed to produce clinical benefits Arnold, Byrd, Meister, et al., 1980; Gheorghiade, Hall, Jacobsen, et al., 1995, Slatton, Irani, Hall, et al., 1997). The major side effects include cardiac arrhythmias (e.g., ectopic and re-entrant cardiac rhythms and heart block), gastrointestinal symptoms (e.g., anorexia, nausea, and vomiting), and neurological complaints (e.g., visual disturbances, disorientation, and confusion). Digitalis toxicity is commonly associated with serum digoxin levels more than 2 ng per mL but may occur with lower digoxin levels, especially if hypokalemia, hypomagnesemia, or hypothyroidism co-exist (Ingelfinger & Goldman, 1976). Digoxin toxicity is potentiated by hypoxemia, electrolyte imbalances (hypokalemia and hypomagnesemia), renal insufficiency, dehydration, and hypothyroidism. The side effects associated with digoxin toxicity include cardiac block, gastrointestinal disturbances.
(anorexia, nausea, and vomiting) and visual disturbances (Fletcher & Thomas, 2001). The possibility of drug interactions is a concern, as the concomitant use of quinidine, verapamil, spironolactone, flecainide, propafenone, or amiodarone can increase serum digoxin levels and may increase the likelihood of digitalis toxicity (Dracup, 1996). The dose of digoxin should be reduced if treatment with these drugs is initiated. In addition, a low lean body mass and impaired renal function can also elevate serum digoxin levels, which may explain the increase risk of digitalis toxicity in elderly patients (Hunt, Baker, Chin, et al., 2001).

Patient education should include information about dosage, particularly if drug amounts are changed, and counseling regarding possible signs and adverse effects of digitalis toxicity. Additionally, the patient should inform the prescribing health care provider of any other medications prescribed by other health care providers or taken over the counter (Dracup, 1996).

In summary, the use of digitalis glycosides in the management of chronic left ventricular heart failure appears to be warranted despite the lack of understanding as to the mechanisms behind the agents. Digitalis glycosides do not appear to be effective for all heart failure patients. The narrow therapeutic window of these drugs warrants careful control and frequent monitoring. Patients should be educated about these drugs and in regards to their potential side effects.

Management of the heart failure patient with combination drugs

Recent consensus guidelines recommend that patients classified as Stage C Heart Failure: Symptomatic Left Ventricular Dysfunction should be routinely managed with a combination of the 4 types of drugs discussed above (a diuretic, an ACE inhibitor, a beta-adrenergic blocker, and (usually) digitalis) (Packer, Cohn, et al., 1999; Hunt, Baker, Chin, et al., 2001). The value of these drugs has been established in numerous large-scale clinical trials, and has been discussed in each section. The evidence supporting a central role for their use is
compelling and persuasive. Patients with evidence of fluid retention should be given a diuretic to reduce blood volume and edema, and diuretic therapy should be continued to prevent the recurrence of fluid retention. Even if the patient has responded favorably to the diuretic, treatment with an ACE inhibitor and a beta-blocker should be initiated and maintained in patients who can tolerate them, because they have been shown to favorably influence the long-term prognosis of HF (Hunt, Baker, et al., 2001). Recent data show that when a beta-blocker is added to an ACE inhibitor and diuretic, disease progression is slowed and morbidity and mortality are significantly reduced (Packer, Bristow, et al., 1996; Cardiac Insufficiency Bisoprolol Study II, 1999; MERIT-HF, 1999). ACE inhibitors decrease systemic vascular resistance and have been shown to improve survival, reduce hospitalizations, and enhance quality of life in patients with left ventricular systolic dysfunction (Pfeiffer, Braunwald, Moye, et al, 1992; AIRE Study Investigators, 1993; SOLVD Investigators, 1992; SOLVD Investigators, 1991). Beta-blockers interrupt the “toxic effects” of the over-active sympathetic nervous system. Additionally, several studies have shown that beta-blockers may reduce hospitalizations and mortality and improve quality of life in patients with systolic heart failure (Doughty, Rodgers, Sharpe, et al., 1997; Packer, Bristow, Cohn, et al., 1996). Therapy with digoxin may be initiated at any time to increase the force of left ventricular contraction, reduce symptoms, and enhance exercise tolerance (Ware, Snow, Luchi, et al., 1984; Packer, Cohn, et al., 1999, Hunt, Baker, et al., 2001).

Management of the heart failure patient with other drugs

The pharmacological management of the patient with chronic heart failure is constantly changing due to the advancing research and available data concerning new agents. The decision to add or replace conventional therapies with such agents rests with the physician in charge of the patient and should be based on the strength of evidence.
Currently there are several agents under investigation, which may ultimately add to or change the current recommendations. Examples of some of these new investigational drugs include: vasopeptidase inhibitors, cytokine antagonists, angiotensin II antagonists, and endothelin antagonists. In some trials there appears to be some evidence for the use of these new agents, however, the strength of evidence is still limited in terms of long-term outcomes.

Finally, there is a distinct trend toward self-management by patients with heart failure. Many patients are looking toward supplements and hormonal therapies to improve their heart failure condition. The value of the majority of such agents remains unproven, and the long-term safety has not been established. Examples of such supplements include: coenzyme Q10, carnitine, taurine, and antioxidants. Growth hormone and thyroid hormone are also therapies under consideration. Again, the decision to implement these unconventional practices must be considered on an individual basis with careful attention to the strength of evidence provided for the type of patient under care.

**Pharmacological agents heart failure patient must avoid**

Three classes of drugs should be avoided in most patients with Stage C heart failure because they can exacerbate the HF syndrome. These drugs include: 1) antiarrhythmic agents, 2) Calcium channel blockers, and 3) Nonsteroidal anti-inflammatory drugs (Hunt, Baker, Chin, et al., 2001). Antiarrhythmic agents can exert important cardiodepressant and proarrhythmic effects (Packer, 1991). Of available agents, only amiodarone has been shown not to adversely affect survival (Hunt, Baker, Chin, et al., 2001). Calcium channel blockers can lead to worsening heart failure and have been associated with an increased risk of cardiovascular events (Packer, Kessler, Lee, 1987). Of available agents, only amlodipine has been shown not to adversely affect survival (Hunt, Baker, Chin, et al., 2001). Nonsteroidal anti-inflammatory drugs can cause sodium

**Problems with implementation of optimal pharmacological care**

Importantly, despite the clear efficacy of the above-described pharmacological approaches for treatment of heart failure, there is consistent evidence that many physicians fail to properly treat their patients. In the latest study concerning this issue, Dr. Gregg Fonarow of the University of California, Los Angeles, looked at how often patients hospitalized with heart failure were discharged with four standard kinds of care. He found they are often missing, although stated this varied widely from hospital to hospital. "There are certain hospitals in the United States where 100 percent of the patients get this," he said. "There are others where patients had a better chance of winning the lottery than getting the indicated care." Clearly these discrepancies point at significant barriers that exist on the providers’ side in the proper delivery of care.

**Non-Pharmacological Management**

It is interesting to consider that despite the available pharmacological strategies, the prevalence of heart failure continues to rise, as is the number of deaths from the disease. Furthermore, it is important to recognize that in spite of the overwhelming evidence that the aforementioned drugs are effective in the management of chronic heart failure the reduction in mortality and improvements in clinical manifestations of the disease are relatively modest. Finally, it must be recognized that heart failure patients in the general population, who are
receiving appropriate drug therapy, do not appear to fare as well as those patients participating in clinical trials.

These factors clearly point at the complexity of the heart failure syndrome and the need for constant vigilance on part of the physician and patient. The purpose of the following section is to describe some available non-pharmacological strategies that with optimal pharmacotherapy appear to be of extreme importance in managing the heart failure syndrome. The fact, that many of these factors appear to have a large behavioral component, one must clearly recognize that the management of this disease has become quite multidisciplinary.

A major goal in the non-pharmacologic management of the heart failure syndrome is aimed principally at modifying lifestyle and obtaining better compliance with the therapeutic regimen (Colonna, Sorino, D’Agostino, et al., 2003). Modifications of lifestyle can be helpful in controlling the symptoms of heart failure and maintaining clinical stability. For example, it has been suggested that basic habits of moderate sodium restriction, weight monitoring, exercise, and adherence to medication schedules may aid in avoiding fluid retention or alerting the patient to its presence (Jessup, 2003 NEJM). In a review of the literature from 1966 to 1993 (Dracup, Baker, Dunbar, et al., 1994), counseling and health education increased life expectancy and quality of life, and reduced hospitalization of patients with heart disease. In 1994, the Agency for Healthcare Policy and Research (AHCPR) published guidelines for the management of patients with HF. Suggested topics for education and counseling of patients with heart failure are listed in Table II (AHCPR, 1994).

**Sodium Restriction**

Sodium retention is in part a consequence of neurohumoral activation, which is a fundamental hallmark of CHF. The value of this compensatory strategy is to retain fluid
necessary to raise blood volume in the face of a reduction of contractile function. The downside of this strategy is that patients are at significant risk for exacerbations of their condition when sodium intake is increased. Thus careful day-to-day management of sodium intake is a crucial component of heart failure care.

Excess dietary intake of sodium can induce sodium and water retention, especially in persons who are more sensitive to sodium intake, such as obese patients (Hall, 1997; Luft & Weinberger, 1997). Sodium and water retention plays an important role in the pathogenesis of hypertension and congestive heart failure (CHF) (Reisin, 1990; Andreoli, 1999). Chronically high dietary intake of sodium may contribute to the development of CHF by increasing blood pressure (pressure overload) or extracellular fluid (volume overload).

Several cross-sectional epidemiologic studies (Liebson, Grandits, Prineas, et al., 1993; Messerli FH, Schmieder, Weir, 1997; Schmieder, Messerli, Garavaglia, et al., 1988; Kupari, Koskinen, Virolainen, 1994) have suggested a significant and independent association between dietary sodium intake and left ventricular hypertrophy. In the Treatment of Mild Hypertension Study (Liebson, Grandits, Prineas, et al., 1993), dietary sodium intake was estimated from 2 consecutive overnight urine collections and left ventricular structure was assessed by M-mode echocardiography in 511 men and 33 women with mild hypertension. After adjusting for age, sex, race, body mass index (BMI), previous medication, alcohol consumption, cigarette smoking, physical activity, and systolic blood pressure, a difference of 25 mmol per 8 hours in urinary sodium excretion was associated with a 41% (95% confidence interval, 22%-63%) increase in the odds of left ventricular hypertrophy. Messerli and colleagues (Messerli FH, Schmieder, Weir, 1997) revealed 9 cross-sectional studies in which the association between dietary sodium intake and left ventricular mass was assessed. The correlation coefficients for the relationship varied
from 0.22 to 0.61, with p<.05 in each of the studies. Animal studies (Frohlich, Chien, Sesoko, et al., 1993; Sugimoto, Fujimura, Takasaki, et al., 1998) also indicate that high sodium intake is an independent risk factor for the development of cardiac hypertrophy. However, there are sparse data on the relationship between dietary sodium intake and the risk of HF from prospective cohort studies.

A recent study by Jiang, et al. (2002) took advantage of the large sample size and prolonged follow-up experience of participants in the first National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up Study (NHEFS) to examine the relationship between dietary sodium intake and incidence of CHF in a nationally representative sample of the US general population. Study participants consisted of 5233 nonoverweight and 5129 overweight men and women without a history of CHF at their baseline examination. Overweight was defined as a body mass index (calculated as weight in kg divided by the square of height in meters) of 25.0 or greater for men and women. Dietary sodium and other nutrient intake estimates were obtained by a 24-hour dietary recall method at the baseline examination, conducted from 1971 to 1975. The incidence of CHF was assessed using medical records and death certificates obtained in 1982 to 1984, 1986, 1987, and 1992. During an average of 19 years of follow-up, 413 cases of CHF in nonoverweight and 679 cases of CHF in overweight participants were documented. The cumulative incidence of CHF was not significantly associated with baseline sodium intake in the nonoverweight participants. For example, the cumulative incidence of CHF at 90 years, adjusted for total caloric intake, was 35.6%, 42.9%, 37.4%, and 47.4% among patients within the first, second, third, and fourth quartiles of dietary sodium intake, respectively (p=.48 for trend). In contrast, dietary sodium intake was significantly associated with risk of CHF among overweight individuals. The cumulative incidence of CHF at
age 90 years, adjusted for total caloric intake, was 44.0%, 43.6%, 53.6%, and 63.1% among patients within the first, second, third, and fourth quartiles of dietary sodium intake, respectively (p=.02 for trend). Furthermore, after adjustment for known CHF risk factors, the relative risk of CHF among overweight participants was 1.43 (95% CI, 1.07-1.91) for those whose sodium intake was greater than 113.6 mmol/d compared with those whose intake was less than 50.2 mmol/d. The relative risk of CHF for a 100 mmol/d higher intake of sodium or per 1743 kcal (average energy intake in the study population) were 1.26 (95% CI, 1.03-1.53) and 1.21 (95% CI, 1.04-1.40), respectively. Data suggest that a high dietary intake of sodium is an independent risk factor for congestive heart failure in overweight persons. Furthermore, the findings suggest that sodium reduction may play an important role in the prevention of CHF in the US general population.

A reduction in dietary sodium intake can have substantial hemodynamic and clinical benefits in patients with advanced heart failure (Cody, Kubo, and Pickworth, 1994). Interestingly, the magnitude of sodium restriction is not clear. In a review article, many physicians, primarily cardiologists, showed a wide array of opinions on sodium restriction. Only 25% suggested a sodium diet of ≤2g, whereas, 33% of the physicians suggested no added salt in cooking for patients with NYHA class II CHF (Hlatky, Fleg, et al., 1986). Although the efficacy of restricting sodium to specific levels has not been studied, in general the degree of sodium restriction depends on the severity of heart failure. It has been suggested that sodium should be limited to a maximum of 2-3 g per day for mild to moderate heart failure, and less than 2 g per day for severe heart failure (Weinberger & Kenny, 2000; Konstam, Dracup, Baker, et al., 1994). A 2 g sodium diet is frequently recommended (HF Guideline Panel, 1994; Dracup K, Baker DW, et al., 1994). However, no studies have been conducted to evaluate specific recommendations
related to sodium restriction (Konstam, et al., 1994). In general, a 2 g sodium diet is unpalatable for many patients, whereas a 3 g sodium diet may be a more realistic goal for patients with mild to moderate heart failure (Grady KL, Dracup K., et al., 2000). It can be achieved by avoiding salty foods (e.g, canned or frozen foods) and by not adding salt to foods after cooking. When this goal is met the clinical results indicate improved hemodynamics and decreased CHF exacerbations. If sodium restriction strategies remain ineffective, patients may require larger doses of diuretic agents for adequate control. (Tucker, Van Den Berg, & Knox, 1980). More importantly, moderate sodium restriction permits the use of lower doses of diuretics (Consensus Recommendations, 1999), which is clearly advantageous to the patients considering the problems associated with long-term diuretic use (such as electrolyte imbalance and worsening lipid profiles). The effectiveness of diuretic therapy is enhanced when the patient follows a reduced-sodium diet. Sodium intake is strictly correlated with the administration of diuretics. If the diuretic dose is increased to compensate for a more liberal sodium intake, the renin-angiotensin-aldosterone system will be strongly activated and will promote thirst, as well as deplete potassium and magnesium (Haller C, Salbach P, et al., 1995). Moreover, in the absence of sodium restriction, diuretics become less effective (Cody RJ, Kubo SH, et al., 1994).

Dietary sodium indiscretion is a common reason for exacerbations of heart failure, and inadequate patient education can contribute to failure to follow the prescribed diet. Both patients and their families or caregivers need thorough, constant and specific instructions about how to achieve the prescribed sodium restriction. Most people are knowledgeable about obvious sources of sodium but are unaware of the sodium content of less obvious sources. Patients should be advised not to add salt to food during preparation and to avoid foods containing large amounts of sodium, such as highly processed foods, canned foods, luncheon meats, and “fast” foods.
Patients should be taught to look for words other than “salt” on food labels, for example sodium or potassium hydrochloride (Fletcher & Thomas, 2001). The use of salt substitutes and spices, such as lemon, pepper, and garlic, may be helpful (Haller C, Salbach P, et al., 1995). Dietary instruction must take into account ethnic preferences and may require individualized counseling by a dietician (Grady, Dracup, et al., 2000). Referral to a dietician or advanced practice nurse with expertise in diet counseling may promote better patient and family understanding of the diet and of the options for making a sodium-restricted diet palatable (Konstam, Dracup, et al., 1994).

In summary, it appears that indiscretion of sodium intake contributes to heart failure exacerbations. The main problem patients face is that given the heightened neurohumoral milieu many patients are on a tightrope in terms of their fluid balance. Any fluctuation in sodium intake may therefore contribute to a condition of fluid overload, which causes additional stress on a weak cardiovascular system and lead to acute congestive heart failure. Consequently, patients must receive thorough, constant and specific instructions about how to control sodium intake. The evidence that moderate to aggressive sodium restriction is beneficial to the heart failure patient is strong, preventing hospitalization, lowering medical costs and reducing mortality.

Alcohol

Alcoholic beverages can be detrimental in patients with HF because alcohol is a myocardial depressant and may, even in small doses, further depress myocardial contractility (Regan, 1990). However, no studies of the effect of moderate ingestion of alcohol on functional status or death have been conducted. In general, alcohol intake should be strongly discouraged and patients with HF should limit consumption to one drink per day (HF Guideline panel, 1994; Grady, Dracup, Kennedy, et al., 2000). Alcohol avoidance is clearly imperative in patients with
alcohol-induced cardiomyopathy and, if necessary, these patients should be encouraged to attend Alcoholics Anonymous to maintain long-term sobriety (Soler-Soler & Permanyer-Miralda, 1994; Fletcher & Thomas, 2001).

**Daily Weights**

Periodic self-examination of certain parameters can be useful for the management of the disease. A daily weight check represents an index to identify any possible problems of water retention. In a retrospective review of 585 patients hospitalized for CHF, 59% of the exacerbations were traceable to excessive sodium retention, with a subsequent overloading of the circulation (Bennett, Huster, and Baker, et al., 1998).

All patients should be instructed to weigh themselves each morning (after urinating and before eating) and record the data in a log, which should be taken to every visit with the clinician (Konstam, Baker, Dracup, et al., 1994). An unjustified increase in weight of 3-5 pounds in 1-3 days should induce the patient to consult his or her physician for any eventual therapeutic adjustments that, if carried out in time, may help avoid hospitalization (Konstam, Baker, Dracup, 1994; Fletcher & Thomas, 2001; Colonna, Sorino, D’Agostino, et al., 2003). It has been suggested that highly cooperative patients can be given a diuretic regimen that they can self-adjust based on daily weights (Dracup, Baker, Dunbar, et al., 1994; Colonna, Sorino, D’Agostino, et al., 2003). It is imperative that the patient understands that weight gain may mean the body is retaining fluid and a phone call to the doctor or specific center may help prevent an exacerbation (Colonna, Sorino, D’Agostino, et al., 2003).

**Fluid Restriction**
Drinking large amounts of fluids should be avoided, although fluid restriction is not recommended unless hyponatremia develops (HF Guideline Panel, 1994). Whereas sodium restriction has been a standard suggestion, the reduction of water intake in patients with HF has not always been recommended. The controversy arises from the suggestion to restrict water intake only in hyponatremic patients (Konstam, Dracup, Baker, 1994). No controlled prospective trials have examined this issue. However, patients with advanced HF may need to have their daily fluid restricted to 2 L per day (Fletcher & Thomas, 2001). This is a clinical judgment based on signs of congestion, fluid overload, and weight gain. Limiting fluid intake to 2 L per day usually helps to maintain weight and can reduce the use of large doses of diuretics. It is important to remind patients that certain foods, such as fruits or soups, contain a large amount of water (Colonna, Sorino, D’Agostino, et al., 2003).

*Smoking Cessation*
Smoking of tobacco is to be forbidden in patients with HF (Konstam, Dracup, Baker, et al., 1994). Besides the well-known coronary risk factors that lead to atherosclerotic disease, smoking has certain hemodynamic effects that aggravate the condition of the patient with HF. It leads to an increase in heart rate and systematic arterial pressure. Additionally, there is a slight increase in the pulmonary arterial pressure, the filling of the left ventricle, and peripheral vascular and pulmonary resistance, along with a reduction in the cardiac output, especially in patients with ischemic cardiomyopathy. Smoking may induce a slight reduction in the volume of left ventricular ejection. This is associated with the increased need for oxygen because of the increased cardiac workload caused, in turn, by the increase in heart rate and peripheral resistance, as well as by the reduction in amount of oxygen because of the presence of carboxyhemoglobin. In patients with HF, this series of cardiocirculatory effects associated with bronchopathic breathing problems, typical for smokers, does not...
nothing to precipitate or aggravate CHF.

*Physical Activity*

As discussed in the section on pharmacological approaches to the treatment of heart failure there is clear evidence that numerous pharmacological agents are available which help improve central hemodynamics by reducing cardiac afterload or enhancing myocardial contractility. Additional pharmacological agents are used to reduce excessive fluid retention. Following initiation of such therapy mortality is reduced, and many patients experience resolution of their symptoms at rest (Hunt, Baker, Chin, et al., 2001). However, most patients continue to experience activity-related symptoms, including shortness of breath, muscle fatigue, and weakness. As a result patients with heart failure often complain of chronic fatigue and are unable to perform many of their normal activities of daily living. Thus, despite traditional pharmacologic treatment, the clinical phase of heart failure includes a marked decline in functional state, as defined by exercise tolerance and capacity with a subsequent decrease in quality of life.

**Cardiac Responses to Acute Exercise in Heart Failure**

Previous studies which have examined the cardiac response to an acute bout of exercise in patients with heart failure demonstrated characteristic responses to dynamic exercise (see Figure 8a-c) (Sullivan, Knight, Higginbotham, et al., 1989). However, as functional class declines there is a progressive decrease in the cardiac output, stroke volume, blood pressure and heart rate reserve capacity (Hanson, 1994). A reduction in cardiac output during exercise and perhaps more importantly a loss in cardiac reserve is an important factor limiting exercise tolerance in patients with heart failure.
Circulatory Responses to Acute Exercise in Heart Failure

Studies which have examined circulatory responses to an acute bout of exercise in patients with heart failure generally report a reduction in nutritive flow to muscle (see Figure 9) (Sullivan, Knight, Higginbotham, et al., 1989). Consequently, exercise performance is markedly reduced in the majority of patients. It is, however, important to recognize that the reduction in blood flow to working muscle is not entirely due to a reduction in cardiac output or local vascular impairment. In fact, a major consideration is a change in the distribution of blood flow during exercise (Wilson & Ferraro, 1985).

Whereas the blood flow distribution in a healthy individual may lead to as much as 75 to 80% of the cardiac output reaching the working muscle, this is not the case in the heart failure patient. Not only do patients with heart failure have difficulties opening up tissue beds, but due to the overall stiffness of the vasculature these patients also have an inability to constrict in non-working tissue (Wilson & Ferraro,
1985). Consequently, blood flow abnormalities are complex and not solely due to impaired vasodilatory function. Moreover, if the vascular problems indeed extend to the venous system, the inability to properly remove metabolic end-products from the tissue beds and the inability to increase pre-load with exercise may contribute to the reduced blood flow to tissue. Considering the cardiovascular system is a closed circuit, we speculate cardiac insufficiency, decreased arterial reactivity, reduced muscle blood flow, venous alterations and elevated cardiac pressures contribute to a reduction in the driving pressure across metabolic tissue. Consequently, decreased driving pressure could affect metabolic waste removal, alter cardiac filling kinetics and decrease exercise tolerance (Welsch, Alomari, Parish, et al., 2002).

**Skeletal Muscle Responses to Acute Exercise in Heart Failure**

Skeletal muscle abnormalities contribute to the clinical severity of the heart failure syndrome. It is, therefore, no surprise that patients with heart failure have higher lactate levels at submaximal workloads compared to controls (see figure 10a and b) (Sullivan, Knight, Higginbotham, et al., 1989).

Recent reports also suggest the rate of change in oxygen kinetics is significantly altered in patients with heart failure (see Figure 11) (Cohen-Solal, Laperche, Morvan, et al., 1995). Heart failure patients have much slower recovery on-kinetics and off-kinetics as a result of a bout of exercise. In particular the slower recovery from physical activity may carry some significant prognostic
information, and may in part explain why patients with heart failure often complain of symptoms of chronic fatigue.

Finally, skeletal muscle atrophy contributes to a significant reduction in both muscle strength and endurance in patients with heart failure. Consequently many daily tasks are indeed more than a chore and often result in excessive fatigue and shortness of breath. Unfortunately, the chronic fatigue and shortness of breath contributes to the vicious cycle of deconditioning as the patient becomes more and more reluctant to engage in these sorts of activities.

**Evidence for the Importance of Exercise Training**

Until the late 1980s physical activity for heart failure patients was discouraged and many patients were told to refrain from physical exertion (Smith, Braunwald & Kelly, 1992). This conservative approach was due to a concern for a greater risk for cardiovascular complications during exercise. Arguably, this conservative approach has contributed to the considerable morbidity in heart failure patients. Reports since the 1980s clearly indicate that heart failure patients can safely participate and benefit from exercise training programs. As a result exercise training has emerged as a beneficial adjunct to the management of patients with heart failure (see Table III and IV).

The first report indicating that heart failure patients could safely participate and benefit from a cardiac rehabilitation program dates back to 1979 (Lee, Ice, Blessy, 1979). In this study, post myocardial infarction patients, with an average ejection fraction of 18% were trained at 70% to 85% of their maximal heart rate for 20 to 45 min, 4 days per week. The training program averaged about 19 months and resulted in a significant increase in exercise tolerance (Lee, Ice, Blessy, 1979). Since that study, a number of studies have been conducted, and despite considerable variation in the duration, intensity and length of training, a consistent finding is that
heart failure patients can increase exercise capacity and tolerance following a period of exercise training without increasing the risk for cardiovascular complications (see Table III) (Jette, Heller, Landry, et al., 1991; Belardinelli, Scocco, Mazzanti, et al., 1992; Coats, Adamopoulos, Radaelli, et al., 1992; Belardinelli, Georgiou, Cianci, 1995; Hambrecht, Niebauer, Fiehn, et al., 1995; Keteyian, Levine, Brawner, et al., 1996; Radaelli, Coats, Leuzzi, et al., 1996; Welsch, 1996; Dubach, Myers, Dziekan, et al., 1997; Willenheimer, Erhardt, Cline, et al., 1998; Callaerts-Vegh, Wenk, Goebbles, et al., 1998; Reinhart, Dziekan, Goebbles, et al., 1998; Belardinelli, Georgiou, Cianci, et al., 1999; Taylor, 1999; Sturm, Quitan, Wiesinger, et al., 1999; Keteyian, Brawner, Schairer, et al., 1999; Wielenga, Huisveld, Bol, et al., 1999; Kiilavuori, Naveri, Salmi, et al., 2000; McKelvie, Teo, Roberts, et al., 2002; Erbs, Linke, Gielen, et al., 2003; Giannuzzi, Temporelli, Corra, et al., 2003). The average increase in exercise capacity defined as VO₂peak is approximately 25%, with the majority of the improvement occurring by the third week, although improvements continue slowly up to 6 months. In addition to the consistent improvements in maximal exercise performance, indices of submaximal exercise such as measured by the 6-minute walk also improve (Parish, Alomari, Wood, et al., 2002).

The mechanism(s) involved in the improvements observed with exercise training suggest that the changes in exercise capacity and tolerance are more related to reversing the peripheral compensatory abnormalities, rather than improvements in cardiac function (see Table IV). Cardiac output shows either no change (Sullivan, Higginbotham, & Cobb, 1988), or a small increase following a period of chronic exercise training (Coats, Adamopoulos, Radaelli, et al., 1992). However, it is important to note that exercise training does not appear to worsen the process of left ventricular remodeling. In fact, randomized trials do not report any adverse effects
of exercise training on regional wall motion, left ventricular systolic function and dimensions (Erbs, Linke, Gielen, et al., 2003; Giannuzzi, Temporelli, Corra, et al., 2003).

Exercise training improves respiratory muscle function and markers of work of breathing (Coats, Adamopoulos, Radaelli, et al., 1992; Mancini, Henson, La Manca, et al., 1995). In particular, a selective respiratory muscle training program contributed to both physiological and clinical improvements in patients with chronic heart failure. The improvements were evident in terms of greater ventilatory muscle endurance, and increases in strength of both the inspiratory and expiratory muscles (Mancini, Henson, La Manca, et al., 1995). Moreover, training resulted in an increase in the maximum walking distance on the 6-minute walk test. Perhaps, most importantly, the majority of the patients engaged in this type of training reported a subjective decrease in dyspnea during activities of daily living (Mancini, Henson, La Manca, et al., 1995).

A consistent response of exercise training in patients with heart failure is improved autonomic balance (Coats, Adamopoulos, Radaelli, et al., 1992; Radaelli, Coats, Leuzzi, et al., 1996; Kiilavuori, Toivonen, Naveri, et al., 1995; Roveda, Middlekauff, Rondon, et al., 2003). This is reflected through an apparent shift away from the hyperadrenergic state typically observed in these patients. Markers of the autonomic system including resting heart rate, heart rate variability, sympathetic nerve activity and plasma catecholamine concentrations are all favorably altered following exercise training (Coats, Adamopoulos, Radaelli, et al., 1992; Radaelli, Coats, Leuzzi, et al., 1996; Kiilavuori, Toivonen, Naveri, et al., 1995; Roveda, Middlekauff, Rondon, et al., 2003). In addition, the concentration of the fluid regulatory hormones angiotensin II, aldosterone, vasopressin and arginine vasopressin under resting conditions are significantly reduced perhaps reflecting the improved autonomic balance (Braith, Welsch, Feigenbaum, et al., 1999).
Recent evidence also indicates the benefits of exercise training on reversing the stiffness and lack reactivity of peripheral arteries (Hornig, Maier, & Drexler, 1996; Hambrecht, Fiehn, Weigl, et al., 1998; Kobayashi, Tsuruya, Iwasawa, et al., 2003). Presumably, vessels that are less stiff and better able to dilate or constrict contribute to improved distribution of the available cardiac output to working skeletal muscles. Interestingly, the improved vasodilatory capacity appears to be specific to the area trained as 4 weeks of handgrip exercise only showed restored flow-dependent dilation in the trained arm. Moreover, the beneficial effect of training was also lost after 6 weeks of cessation of training (Hornig, Maier, & Drexler, 1996). This suggests the importance of a well-rounded training stimulus, but also emphasizes the benefits of local training on vascular beds, something that may be particularly useful in patients with severe heart failure. In fact, it is interesting to consider that a whole-body training program increases coronary flow reserve as evidenced by increased vasoreactivity of epicardial vessels (Hambrecht, Wolf, Gielen, et al., 2000). Combined these findings indicate the enormous potential of exercise training in reversing the maladaptive vascular changes evident in these patients.

Exercise training significantly improves skeletal muscle function, blood flow and metabolic capacity in patients with heart failure (Coats, Adamopoulos, Radaelli, et al., 1992; Sullivan, Higginbotham, & Cobb, 1988; Stratton, Dunn, Adamopoulos, et al., 1994; Hambrecht, Fiehn, Yu, et al., 1997; Pu, Johnson, Forman, et al., 2001). The magnitude of leg muscle blood flow increases reportedly are similar in heart failure patients compared to healthy normal controls, indicating the adaptive response is preserved (Sullivan, Higginbotham, & Cobb, 1988). Following a local forearm training protocol, muscle bioenergetics, as assessed by $^{31}$P-NMR spectroscopy, improved only in the trained forearm. Skeletal muscle responses to exercise after the one month program indicated less phosphocreatine utilization, higher muscle pH at
submaximal workloads, and improvement in phosphocreatine recovery kinetics. In part, these changes are indicative of an improved mitochondrial ATP synthesis rate. Finally, patients with heart failure who engage in regular physical exercise show enhanced oxidative enzyme activity in the working skeletal muscle and a concomitant re-shift to type I fibers. The improvements are at least in part secondary to a significant increase of the surface density of cytochrome c oxidase-positive mitochondria and the surface density of mitochondrial cristae (Hambrecht, Fiehn, Yu, et al., 1997).

Moreover, recent evidence supports the safety and efficacy of resistive training in patients with heart failure (Pu, Johnson, Forman, et al., 2001; Hare, Ryan, Selig, et al., 1999). Recognizing the overwhelming evidence that resistive training can have a significant impact on functional ability, implementation of a tailored resistive program may be an important component in the management of these patients. Evidence that heart failure patients can adapt to resistance training was recently shown. Training resulted in significant increases in strength and endurance associated with a lower O2 consumption at submaximal workloads (Pu, Johnson, Forman, et al., 2001). No complications with the training program were observed. Thus, it would appear a program of combined aerobic and resistance training could be quite beneficial. However, given the lack of large clinical trials the safety of resistance training in patients with HF needs to be further established. Combined, these findings suggest that skeletal muscle abnormalities in heart failure are, in part, due to a deconditioning process, and can be partially reversed through exercise training.

Thus, there is growing evidence that exercise training may reverse many of the peripheral abnormalities present in the heart failure patient. Exercise training may improve autonomic function, skeletal muscle blood flow and localized oxidative capacity (see Table IV). Together,
these changes may translate in an increased exercise tolerance, reduction in activity-related symptoms, and improved quality of life. These findings assume added importance in light of previous reports that exercise capacity is one of the most powerful predictor of survival of heart failure patients (Bittner, Weiner, Yusuf, et al., 1993). Perhaps most importantly, a recent meta-analysis of randomized controlled exercise training trials reports a significant improvement in survival time in patients with chronic heart failure (see Figure 12a) (Piepoli, Davos, Francis, et al., 2004). Time to death or admission to hospital was also significantly extended (see Figure 12b) (Piepoli, Davos, Francis, et al., 2004).

Guidelines, Risk Stratification, and Exercise Prescription

The Committee on Exercise, Rehabilitation, and Prevention of the American Heart Association Council on Clinical Cardiology American Heart Association, recently, published a scientific statement on the role of exercise in heart failure (Pina, Apstein, Balady, et al., 2003). The Committee concludes that exercise training in patients with heart failure seems to be safe and beneficial in improving exercise capacity, exercise duration, and parameters of submaximal
exercise performance. In addition, quality of life improves in parallel to the improvements in exercise capacity. Furthermore, benefits have been reported in muscle structure and physiological responses to exercise, such as improvements in endothelial function, catecholamine spillover, and oxygen extraction in the periphery, among others. The committee encourages the stratification of individuals in risk categories prior to engaging in a physical activity program. These risk categories should be based on the individuals’ clinical characteristics and likelihood of untoward events. Patients classified as Stage A, should be encouraged to participate in exercise training programs to prevent the further development of the disease. Stage B and C patients are also encouraged to participate in activity programs, but these patients may require more specific attention in terms of monitoring and exercise prescriptions. Patients in Stage D have symptoms at rest or on minimal exertion (including profound fatigue), and generally cannot perform most activities of daily living. Consequently, physical activity should be limited until these patients have improved hemodynamic function secondary to specialized treatments.

Importantly, it must be recognized that agreement on a universal exercise prescription for heart failure patients does not exist. Consequently, an individualized approach is recommended, using standards provided in the American Heart Association Standards (Fletcher, Balady, Amsterdam, et al., 2001). Prior to starting the program a clear understanding of the patient's medical history, present medical and physiological status, and personal need is necessary to maximize safety and efficacy. Once the heart failure patient is deemed medically stable, and fluid status is adequately controlled, the patient should be introduced to an exercise training program. The exercise prescription should have specific guidelines concerning the frequency, intensity, duration, mode, and progression of the exercise program. Initially, because of the
marked exercise intolerance, it may be necessary to use an interval training approach, with 2-6 min low level activity interspersed with appropriate periods of rest. Frequency of training may be as much as 2 to 3 times a day during the early stages of the program. Warm-up and cool-down periods should be longer to allow adequate time for the body to prepare and recover from the activity. Depending on the patient's medical status, reported symptoms during training, and tolerance of the exercise session, intensity, duration and frequency may be altered.

Determination of an appropriate exercise intensity for the heart failure patient on the basis of maximal exercise capacity is often difficult. If a symptom-limited graded exercise test is used the exercise prescription should be based on VO2\(_{\text{reserve}}\), rather than heart rate reserve, secondary to frequent impaired chronotropic responses. The use of the VO2\(_{\text{reserve}}\) method has been recommended by the American College of Sports Medicine especially for low-fit clients (ACSM Position Stand, 1998). The starting intensity for patients with heart failure is generally quite low and should be as tolerated. As the patient responds favorably a more defined program may be developed starting at 40-50% of VO2\(_{\text{reserve}}\), or slightly below any significant symptoms, such as angina, exertional hypotension, dysrhythmias, and shortness of breath. More constant supervision may be needed during the early stages of the exercise program for all heart failure patients, with the use of more intensive monitoring of blood pressure responses and electrocardiograms. In addition, the rating of perceived exertion scales should be used, guiding patients to a rating of 11-14 (on the 15-grade category Borg scale), whereas symptoms of angina and dyspnea should not exceed 2+ on a "0-4" scale ("Moderate, Bothersome" on the Angina scale and "Mild, Some Difficulty" on the Dyspnea scale). The duration of exercise should be gradually increased again depending on patient's tolerance. The choice of exercise for heart failure patients has traditionally focused predominantly on cardiovascular activities, such as
walking and cycling. Clearly these activities are necessary to remain independent and it is therefore important to gradually progress the patients to higher intensities and longer durations if additional work is tolerated. However, decisions on progression should not solely be based on the observed responses during exercise, but the clinician should also determine to what extent the exercise impacts the patient’s remainder of the day.

Current guidelines by the American Heart Association and other organizations do not include guidelines for a resistance training component for heart failure patients. However, the Committee recognizes that resistive exercises can offer the opportunity to strengthen individual muscle groups. However, since the safety of resistance training in patients with heart failure needs to be further established in larger trials, it would seem a conservative approach may be to use light to moderate resistance training as part of a well-rounded program for select patients.

Thus, the principles of exercise prescription for heart failure patients are similar to those for healthy people. The major differences relate to the application of these principles to the patient. The goal of an exercise program for the heart failure patient is to reduce morbidity associated with the disease and maintain functional capacity for independent living. Generally, heart failure patients should start out slowly, and initially aim to increase duration of exercise. How well the heart failure patient adapts to the training program should dictate the frequency and magnitude of progression. Finally, patients should be made familiar with the use of a physical activity pyramid to recognize that a gradual increase in overall activities interspersed with proper rest periods throughout the day is pertinent in the management of their condition (see Figure 13).
In summary, patients with medically stable heart failure should be considered for participation in an exercise training program. Guidelines for and components of an exercise program for the heart failure patient are similar to other clinical populations and healthy individuals. However, the exercise prescription should be designed to meet the unique goals and demands of the patient.

**Compliance**

Up to 65% of hospital admissions are due to noncompliance with both pharmacologic and nonpharmacologic treatment regimes (Dahl & Penque, 2000). There are many reasons that patients may not comply with a therapeutic regimen. Lack of knowledge, poor motivation, decreased understanding, lower perceived self-efficacy, forgetfulness, and decreased support from family and other caregivers have been identified as factors that contribute to noncompliance (Bennett, Huster, Baker, et al., 1998; Conn, Taylor, & Kelley, 1991; Happ,
Naylor, Roe-Prior, 1997; Ni, Nauman, Burgess, et al., 1999; Jaarsma, Halfens, Huijer-Abu Saad, 1999; Dracup, Baker, Dunbar, et al., 1994). Additionally, a patient may not comply with a prescribed regimen because he or she is unconvinced of the benefits of doing so or because he or she perceives that the side effects or inconveniences of following the regimen outweigh any benefits (Grady, Dracup, Kennedy, et al., 2000). Furthermore, it has been suggested that one reason for high rates of noncompliance may simply be lack of understanding of the treatment plan (Dracup, Baker, Dunbar, et al., 1994).

Noncompliance with diet and medications can rapidly and profoundly affect the clinical status of patients, and increases in body weight and minor changes in symptoms commonly precede the major clinical exacerbations that require emergency care or hospitalization (ACC/AHA, 2001). In fact, some studies have demonstrated that it is the lack of recognition by the patient of the symptoms of a worsening pathology that has led to a delayed use of appropriate treatment (Friedman, 1997; Francis, 1998). It has been suggested that if patients know the symptoms and signs of worsening heart failure, they may be able to seek care early and avoid hospitalization (Dracup, Baker, Dunbar, et al., 1994; Konstam, Baker, Dracup, et al., 1994). For example, patients should be told that dyspnea and fatigue are normal responses during moderate exertion in patients with heart failure. This explanation will help alleviate anxiety over performing daily activities that might provoke shortness of breath. However, physicians and patients must understand that progressive dyspnea on exertion or sudden changes in orthopnea or paroxysmal nocturnal dyspnea are not expected. Moreover, excessive fatigue during and following exertion must also be considered. In general, a sudden deviation from the normal responses may indicate worsening heart failure and such information should be communicated to the health care provider immediately (Konstam, Baker, Dracup, et al., 1994).
It is important to consider that healthcare providers also contribute to heart failure patient noncompliance and hospital readmissions. Impediments to patient compliance include advising changes that disregard the patient’s current lifestyle and failing to counsel or advise patients on how to adapt their current lifestyle to accommodate recommended changes (Dunbar, Jacobson, & Deaton, 1998). Healthcare providers may fail to follow appropriate treatment guidelines (Fonarow, Stevenson, Walden, et al., 1997; Hunt, Baker, Chin, et al., 2001), or make recommendations without detailing how to implement the recommendations (Grady, Dracup, Kennedy, et al., 2000). For example, clinicians may fail to adequately educate and counsel the patient or support person who may be responsible for purchasing food, cooking, and administering medications (Konstam, Baker, Dracup, et al., 1994). Another important factor that contributes to patient noncompliance and rehospitalization for worsening heart failure is inadequate discharge planning and follow-up after discharge (Vinson, Rich, Shah, et al., 1990).

Therefore, it is important to consider that the barriers to successful management of patients are also present on the healthcare provider’s side. Physicians and other providers should be attuned to the problem of noncompliance and its causes, discuss the importance of compliance at follow-up visits, and assist patients in removing barriers to compliance (eg, cost, adverse effects, or complexity of the therapeutic regimen) (Dracup, Baker, Dunbar, et al., 1994). For example, if medication cost is a factor in noncompliance, suggestions for lower-cost medications or financial assistance programs should be provided (Grady, Dracup, Kennedy, et al., 2000).

Rosenstock (1975) explains that to comply with treatment, patients must understand the nature of their illness, why they are being treated, how long the treatment will last, and the results of treatment (Rosenstock, 1975). Descriptive research of 41 patients with chronic HF found that almost all patients could not correctly define HF, less than half could correctly
identify their medications, and almost three fourths of patients did not weigh themselves daily (Bushnell, 1992). A complete, comprehensible explanation of the illness has been shown to increase compliance with the treatment plan (Bushnell, 1992), improve functional capacity and quality of life, and reduce hospital readmission rates (Rich MW, Beckham, & Wittenburg, 1995; Fonarow, Stevenson, & Walden, 1997; Dahl & Penque, 2000). Therefore, the education of the patient and his family or caregiver represents a fundamental aspect of therapy.

**Education**

Given the complexity of the heart failure syndrome and the available treatment strategies, education and counseling of patients and their families are vitally important for maintenance and clinical stability (Grady, Dracup, Kennedy, et al., 2000). In a review of the literature from 1966 to 1993 (Dracup, Baker, Dunbar, et al., 1994), counseling and health education increased life expectancy and quality of life, and reduced hospitalization of patients with heart disease. Moreover, multiple studies have shown that patients who are educated and knowledgeable about their disease process and understand how their medications work and the importance of compliance have fewer hospital readmissions and experience an increase in functional capacity and quality of life (Rich, Beckham, & Wittenburg, 1995; Fonarow, Stevenson, & Walden, 1997; Dahl & Penque, 2000). Quality of life and social functioning may be more important to patients than physiological impairment and long-term survival (Rideout, Montemuro, 1986; Dracup, Walden, Stevenson, et al., 1992), and practitioners should emphasize that patients with heart failure can live active and enjoyable lives (Dracup, Baker, Dunbar, et al., 1994). A recent study of 51 patients with heart failure revealed that a majority placed greater importance on improved symptoms rather than longer survival as the preferred outcome (Stanek, Oates, McGhan, et al., 2000). Therefore, the goals of education and counseling are to assist patients in compliance with
the therapeutic regimen, to maintain clinical stability and function, and to improve quality of life (Grady, Dracup, Kennedy, et al., 2000). These goals are best achieved when the patient and family are knowledgeable about every aspect of the condition and treatment and are active participants in the plan of care (Konstam, Baker, Dracup, 1994).

A complete, comprehensible explanation of the illness increases compliance with the treatment plan (Bushnell, 1992). Patients and their support group must understand their disease; a specific but simplistic discussion of the basic pathophysiology and etiology of heart failure, using language that the patient can thoroughly grasp, is vital (Dracup, Baker, Dunbar, et al., 1994). The educational needs of heart failure patients have traditionally included topics such as anatomy and physiology, medications, sodium restrictions, dietary changes, activity levels, and psychological responses (Dracup, Baker, Dunbar, et al., 1994; Hagenhoff, Feutz, Conn, et al., 1994). Hagenhoff et al. (1994) studied the perceived learning needs of 30 hospitalized heart failure patients and 26 nurses, who ranked these categories according to importance (Hagenhoff, Feutz, Conn, et al., 1994). Patients and nurses agreed that medication information was the most important to learn. Psychological concerns and activity received the lowest rankings, and the researchers suggested that, because of shorter lengths of hospital stay and decreased opportunity for patient education, these aspects could be taught in the outpatient setting (Hagenhoff, Feutz, Conn, et al., 1994). The general trend across all patient education content areas was for patients to rate the information as more important to learn than the nurses rated the information. These findings suggest that patients value education regarding their condition during their hospitalization for HF and this should continue to be an important focus of care for this population (Hagenhoff, Feutz, Conn, et al., 1994). However, patient comprehension can be limited in the hospital due to the shortened length of stay, the unfamiliar environment, anxiety,
fatigue, and inability to concentrate owing to acute illness (Knox & Mischke, 1999). Therefore, due to the complex nature of the illness, patient education should extend to the outpatient setting (Connolly, 2000) and requires collaboration between the patient and health care providers from the inpatient, outpatient, and home care settings (Knox & Mischke, 1999). The Agency for Healthcare Policy and Research (AHCPR) guidelines for the management of heart failure patients suggest that education become a standard part of management plans and that both content and counseling be included (Konstam, Dracup, Baker, et al., 1994).

A clear and organized plan of patient education and counseling is critical to the achievement of optimal outcomes. Counseling and education have been observed to improve patient outcomes and decrease unnecessary hospitalizations in patients with HF (Dracup, Baker, Dunbar, et al., 1994). Patients with HF benefit most when educated about sodium and fluid restrictions and other dietary issues as well as the pathophysiology of HF, medications, signs and symptoms of worsening heart failure, and activity or exercise (Dracup, Baker, Dunbar, et al., 1994). In 1994, the Agency for Healthcare Policy and Research published guidelines for the management of patients with HF, and suggested topics for education and counseling of patients with heart failure are listed in Table II (Konstam, Dracup, Baker, et al., 1994). Because not all components of the program are appropriate for all patients, treatment must be individualized and adapted to accommodate the needs and circumstances of each patient.

Aggressive management in the outpatient setting is essential to improving survival and reducing the risk for hospitalization (Connolly, 2000). Although it is important to discuss medications and dietary recommendations with patients who are being discharged from the hospital, a full discussion of these topics should be conducted in the outpatient setting and repeated as often as necessary (Connolly, 2000). Patients do not absorb and retain all necessary
information in a single educational session (Mullen, Mains, & Velez, 1992). Therefore, patient education should occur over time and be an ongoing process (Dracup, Baker, Dunbar, et al., 1994). Patient and family understanding needs to be continually assessed and counseling activities adjusted accordingly (Konstam, Baker, Dracup, et al., 1994). Providers should be sensitive to differences in patients’ language, culture, and educational level that may impair understanding and compliance (Estey, Musseau, & Keehn, 1991). In addition, written educational materials and video or audio-tapes can help clarify information and enhance discussions but should serve as adjuncts to and not as replacements for one-on-one education (Grady, Dracup, Kennedy, et al., 2000).

The telephone may be a simple, useful tool for enhancing compliance. Telephone technology was used in the medical field in the diagnosis of respiratory problems as early as 1979 (Grument, 1979). Effective telephone care can yield correct and timely diagnosis and treatment, promote compliance with the treatment regimen, and enhance patient and health care provider satisfaction (Guy, 1995).

Compliance is also enhanced when the patient participates actively in developing the plan of care and when families are informed and supportive partners in this plan (Hubbard, Muhlenkamp, & Brown, 1984; Swain & Steckel, 1981). Therefore, patients and their families should be encouraged to ask questions about any aspect of the management of heart failure or a recommended intervention (Dracup, Baker, Dunbar, et al, 1994). Education regarding proposed interventions should be designed to help patients and their families arrive at realistic expectations about risks and benefits (Konstam, Baker, Dracup, et al., 1994). Nursing interventions, family involvement, and support groups may all help patients cope with heart failure and make the many lifestyle changes required by the disease (Dracup, Baker, Dunbar, et al., 1994).
Of the general measures that should be pursued in patients with HF, possibly the most effective, yet least utilized is close attention and follow-up (Hunt, Baker, Chin, et al., 2001). Patient education and close supervision, which includes surveillance by the patient and his or her family between physician visits, can reduce the likelihood of noncompliance and can often lead to the detection of changes in body weight or clinical status early enough to allow the patient or a healthcare provider an opportunity to institute treatments that can prevent clinical deterioration and hospitalization (Konstam, Dracup, Baker, et al., 1994). In general patient self-management includes monitoring the level and intensity of symptoms (for example, shortness of breath or pain) and objective data (blood pressure and glucose levels) and adjusting the treatment plan accordingly (Dunbar, Jacobson, Deaton, et al., 1998). For patients with heart failure, the self-management plan includes monitoring changes in symptoms such as fatigue, shortness of breath, daily body weights, and knowing when to report the changes to the health provider (Konstam, Dracup, Baker, et al., 1994). Supervision between physician visits ideally may be performed by a nurse or physician assistant with special training in the care of patients with HF. Such an approach has been reported to have significant clinical benefits (Rich, Beckham, Wittenberg, et al., 1995; Shah, Der, Ruggerio, et al., 1998; Fonarow, Stevenson, et al, 1997; Philbin, 1999). A detailed analysis of hospital readmissions in heart failure patients who were participating in a clinical trial that provided comprehensive discharge planning and homecare intervention by an advanced practice nurse revealed that failure to adhere to the treatment plan was the predominant factor related to readmission (Happ, Naylor, Roe-Prior, 1997). Even though patients were provided with individualized intervention by advanced practice nurses who focused on preventing exacerbations of heart failure through symptom recognition, medication, dietary education, and modification of poor health behavior, there was a 33% readmission rate in
the intervention group within the first 6 months after hospital discharge. Most readmissions occurred after the intervention had ended (1 month), suggesting that more follow-up may be needed by some patients (Happ, Naylor, Roe-Prior, 1997). Social support and individual motivation to learn and manage health behavior were also viewed as influential in adherence to the prescribed treatment (Happ, Naylor, Roe-Prior, 1997). These findings illustrate the overall complexity in addressing the education process for heart failure patients.

Education will only work if the patient’s willingness to learn is appreciated. Therefore, the provision to patients and their families/caregivers of behavioral strategies to increase adherence is vital. There are many strategies to assist patients to comply with their heart failure regimen, such as the use of a daily reminder routine, filling a pill box that contains 1 week’s medications, the implementation of incremental monitoring by caregivers, the use of medication information and reminder cards, and counseling (Stewart, Pearson, & Horowitz, 1998).

Behavioral theories, such as the Transtheoretical model of behavior change (Prochaska, Norcross, & DiClemente, 1994), may be useful in designing effective approaches to patient education programs. Although there have been no studies in which outcomes of these methods with heart failure patients have been reported, these approaches could be used individually or in a combined framework to guide strategies that go beyond traditional patient educational approaches (Dunbar, Jacobson, Deaton, et al., 1998).

The Transtheoretical approach views the process of changing health behavior as occurring in several specific stages, referred to as stages of change (Prochaska, Norcross, & DiClemente, 1994). The transtheoretical model of behavior change (TTM) was first described in 1982 as a proposed mechanism of smoking cessation (Prochaska & DiClemente, 1982). This model has been validated and applied to a variety of behaviors that include smoking cessation,
exercise behavior, and dietary behavior (Prochaska, Velicer, Rossi, et al., 1994; Hellman, 1997; Glanz, Patterson, Kristal, et al., 1994). Understanding behavior change as a process rather than a single event, the TTM attempts to explain how, rather than why, behavior change occurs (Prochaska, Norcross, & DiClemente, 1994). The TTM states that there are five distinct stages (see Table 1) involved in behavior change, during which 10 different processes of change (Dunn, Marcus, Kampert, et al., 1997) may be used (see figure 14). The TTM suggests that for successful behavior change, interventions must be tailored to a person’s current stage of readiness and make use of the appropriate processes of change (Prochaska, Norcross, & DiClemente, 1994).

One role of the physician is to assist patients in understanding their health and to help them make the changes necessary for health improvement (Zimmerman, Olsen, & Bosworth, 2000). A change in patient lifestyle is necessary for management of long-term illnesses, such as heart failure (Konstam, Dracup, Baker, et al., 1994). By assessing stage of readiness regarding a particular behavior or a lifestyle pattern and determining whether the patient has experience with attempting the change, the clinician can determine which interventions might be most effective in managing the heart failure patient. The specific motivational interventions vary by stage of change. For example, if patients state that they have never tried a low sodium diet but are considering reducing sodium, they may be in the contemplation phase, and interventions would include raising their consciousness about the
importance through calculating the sodium in food typically consumed and investigating low sodium alternative products at the grocery store. Emotional arousal is also important for successful behavior change at this stage and could include imagery to visualize fluid building up in an overloaded pump (heart). If the patient reports trying to reduce sodium intake in the past but finding the diet intolerable, the patient’s stage of change is relapse. Interventions could include setting up a personal reward system, seeking the help of family members, and helping the patients focus on the positive aspects of what they are doing for their overall health.

**MULTIDISCIPLINARY PROGRAMS**

Heart failure rarely occurs as an isolated disease process, and management is frequently confounded by a host of medical, behavioral, psychological, social, and economic factors. A considerable amount of the economic cost associated with heart failure care is attributable to repeated exacerbations that frequently require hospitalization, with rates ranging from 30% to 50% within 3 to 6 months of the initial discharge (Gooding & Jette, 1985; Rich & Freedland, 1988; Vinson, Rich, et al., 1990). Moreover, behavioral factors contributing to readmissions include nonadherence to diet, medication, and activity regimens, social isolation, inadequate symptom self-assessment and management, inadequacies in patient and care-giver education, and poor discharge planning and follow-up, suggesting that such readmissions could be prevented, or significantly delayed, with better health care and improved patient participation in his or her treatment. (Konstam, Dracup, et al., 1994; Rich, Vinson, et al., 1993; Vinson, Rich, et al., 1990; Dracup, Baker, et al., 1994; Happ, Naylor, et al., 1997; Ghali, Kadakia, et al., 1988; Kaspar, Gerstenblith, et al., 2002; Rich, Beckham, et al., 1995).

It follows that management of these patients requires appropriate attention to all aspects of care, both pharmacologic and nonpharmacologic, and that comprehensive disease
management may best be accomplished through the use of a multidisciplinary team approach (Grady, Dracup, et al., 2000). A recent AHA Scientific statement examined the team management of heart failure patients (Grady, Dracup, et al., 2000) and indicated that components of successful healthcare delivery models for heart failure include staff skilled in the understanding of the pathophysiology of heart failure, patient assessment and evaluation of symptoms, education and counseling (focusing on symptoms and medication compliance), dietary consultation, and physical activity and exercise recommendations (Grady, Dracup, et al., 2000). Therefore, the following section discusses the various multidisciplinary trials that have been conducted over the past 21 years. The trials are presented chronologically, with the observational studies first, followed by the randomized trials. The multidisciplinary trials are further summarized in Tables VI - XI.

Observational Studies

Tables VI-VIII summarizes characteristics from 17 observational studies evaluating the efficacy of various multidisciplinary heart failure disease management strategies. The first observational study (Cintron et al. 1983) combined meticulous management in a HF clinic with easy accessibility to a nurse practitioner. Fifteen HF patients were seen an average of every 3 weeks for 7 to 48 months for a mean follow-up period of 24 months. Assessments included a history, physical examination, and appropriate laboratory studies. Strong emphasis was placed on weight control, diet, home situation, and family support. Medications were reviewed and, when necessary, cardiology consultation was obtained before adjusting therapy or recommending hospitalization. The average age of the study participants was 65 years, and all but three had NYHA Class IV symptoms. When compared with an equivalent period of time before enrollment in the clinic, hospitalizations declined by 61%, and hospital days were reduced by 85%. 
Although annual total costs for outpatient care increased by $11,000, inpatient costs decreased by $131,000, yielding an average cost savings of $8,000 per patient. In addition, all patients reported improved satisfaction with the process of care.

Interestingly, despite the positive findings from Cintron (1983) it was not until 12 years later before the next observational study appeared. Kornowski et al. (1995) described a program of 42 housebound elderly patients (mean age 78±8 years) with NYHA class III or IV heart failure who were examined weekly at home by internists and a paramedical team. Home visits consisted of providing the patient a report about the medical condition, a history and physical exam, review of medications, laboratory studies as necessary, and discussion of a treatment plan for the subsequent week. Physical therapy, oxygen, IV infusions and supplemental visits were also available as needed. The year prior to entry into the program was compared with the first year of home surveillance. Participation in the program was associated with a 62% reduction in total hospital admissions (3.2 ±1.5 to 1.2 ±1.6 hospitalizations/year), a 72% decrease in cardiovascular admissions (2.9±1.5 to 0.8 ±1.1 hospitalizations per year), and 77% fewer hospital days (26±14 to 6 ±7 days per year, \( p=0.001 \)). In addition, functional status as assessed by ability to perform daily activities on the patient global status index (1 to 4 scale), improved from 1.4 ± 0.9 to 2.3 ± 0.7 (\( p<.001 \)). This study showed improved outcomes but at an uncertain trade-off in resource use between increased home visits and decreased hospitalizations for the intervention. Although the cost of the intervention was not assessed, study coordinators projected that the intervention resulted in increased cost savings (Kornowski, Zeeli, Averbuch, et al., 1995).

In 1996, Lasater and coworkers (1996) examined a 6 month nurse-managed, home-based program for cardiomyopathy and heart failure patients. In addition to the nurse, access to a
physician, dietician, and social worker was available as needed. 80 patients discharged with a primary diagnosis of heart failure were automatically enrolled in the program, which focused on preventing heart failure exacerbations through patient education about pharmacotherapy, diet, and activities of daily living. Medication compliance assessments were also performed, and assistance with financial concerns was provided as needed. Follow-up clinic visits were scheduled at the nurse’s discretion and averaged 3.7 visits per patient over the 6-month period. Patients recorded daily weights and a weight gain of 4 pounds served as a threshold for increasing diuretic therapy. Compared to the 6-month period immediately before entry into the program, the overall hospitalization rate decreased by 14%, and the average length of stay declined from 7.3 to 5.7 days, a 22% change. In addition to a 32% reduction in total hospital days, hospital charges decreased by $500 per patient and a retrospective cost analysis concluded that the intervention was cost saving.

Three observational trials were conducted in 1997. In the first of these studies, West et al. (1997) used a strategy of physician-supervised but nurse-mediated, home based heart failure management, not involving home visits (West, Miller Parker, et al., 1997). Like Kornowski et al. (1995), West and colleagues (1997) studied a disease management strategy in a group of patients recruited from a northern California HMO. Patients were followed for an average of 138 ± 44 days. The mean age of the study population was 66 years, with 71% men, and 40% were in NYHA functional class III or IV. Nurses directed the implementation of consensus guidelines to maximize vasodilator doses, reduce dietary salt intake, monitor patients for early evidence of worsening heart failure, and provide patient support and education by frequent telephone contact. The intervention consisted of an initial

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comprehensive visit followed by regularly scheduled telephone calls. The average number of telephone contacts per patient during follow-up was 13.

Compared with the 6 months before enrollment, general medical and cardiology visits declined by 23% and 31%, respectively (p<.03). Hospitalization rates for heart failure and for all causes declined 87% and 74%, respectively (p=0.001), compared with the year before enrollment. Additionally, self-reported dietary sodium intake measured by food-frequency questionnaires showed a persistent and significant reduction of 38%, declining from 3.4 to 2.1 g per day (p<0.0001). Furthermore, patients reported substantial improvements in multiple indices of symptom status and quality of life, including NYHA functional class, Duke Activity Status Index, and both the physical and mental component scores of the Medical Outcomes Study Short Form 36 (SF-36) Health Survey (West, Miller Parker, et al., 1997). Although the investigators did not report on cost of the intervention, it is likely that the marked reduction in resource utilization was associated with significant cost savings.

Also in 1997, Fonarow et al. (1997) described a program of intense inpatient management followed by careful post-discharge follow-up among 214 patients referred for treatment of advanced CHF and evaluation for heart transplant (Fonarow, Stevenson, et al., 1997). Participants in this study were younger than those in previous studies, with an average age of 52 years, 81% were men, and the mean LVEF was 21%. Forty-four percent of the patients were in NYHA class III, whereas 56% were in class IV. After discharge, patients received close follow-up with frequent telephone contact and clinic visits. Telephone calls were made 2-3 days after any major medication change and at routine intervals between 2 and 8 weeks, as warranted by clinical stability and patient need for reassurance.
The protocol consisted of invasive hemodynamic monitoring and intensification of the medical regimen, including high-dose vasodilators, diuretics, and digoxin. Patient education and lifestyle modification were emphasized by nurses with specialized training in heart failure and reinforced by printed teaching materials. Furthermore, regular, unsupervised exercise was recommended, although no specific detail was provided.

Compared to the 6-month period preceding referral, there was an 85% reduction in hospital admissions (Fonarow, Stevenson, Walden, et al., 1997). Factoring in the initial 214 admissions for transplant evaluation yielded a net reduction in total hospitalizations of 44%. Additionally, dosages of ACE-Inhibitors or isosorbide dinitrate, and diuretics markedly increased; whereas calcium channel blockers and type I antiarrhythmic agents were virtually eliminated. Furthermore, NYHA functional class improved significantly ($p<0.001$) with 49% of the patients reclassified as functional class I or II. Finally, peak oxygen consumption increased from a mean of 11.0 ± 3.6 to 15.2 ± 4.4 mL/kg/min, an increase of 38% at the 6-month follow-up, which placed these patients outside of the cardiac transplant range (Fonarow, Stevenson, Walden, et al., 1997). The estimated net savings of the intervention, after subtracting the initial hospital costs and nursing costs during follow-up, was $9,800 per patient. The potential to reduce both symptoms and costs suggests that referral to a heart failure program may be appropriate not only for potential heart transplantation, but also for medical management of patients with functional class III and IV heart failure (Fonarow, Stevenson, Walden, et al., 1997).

A similar study was conducted by Hanumanthu et al. (1997), in which 134 patients were referred to a heart failure and transplantation program for periods ranging from 30 days to 1 year (Hanumanthu, Butler, Chomsky, et al., 1997). The average age of the participants was also 52±12 years and the mean LVEF was 29±11. In comparison to Fonarow’s study, the HF/
transplant team provided comprehensive management, which included intensive medical therapy and patient education. Compared with the 1-year period prior to the intervention, cardiovascular hospitalizations declined from 210 to 104, a reduction of 53% ($p<0.01$), and heart failure admissions decreased from 97 to 30, a 69% reduction. Additionally, at 6-month follow-up, mean peak exercise oxygen consumption improved from $12.8 \pm 4.7$ to $15.7 \pm 4.8$ mL/kg/min ($p<0.01$) an increase of 23%. An added component of this study in comparison to Hanamanthu’s work was that Quality of life was also assessed, using the Minnesota Living with HF Questionnaire (scale: 0 –105, higher score=more impairment). Composite scores improved significantly from $57 \pm 27$ to $35 \pm 26$ ($p<0.01$), a difference of 34 points.

Tilney et al. (1998) referred 1,915 medicare HMO patients with CHF in a proprietary disease management program (Tilney, Whiting, Horrar, et al., 1998). The average age was 74 and 50% of participants were male. In this 12-month program nurse-managers coordinated patient education and clinical surveillance, in collaboration with home care specialists, pharmacists, and the patient’s primary physician. Using patients as their own controls and other historical reference groups, investigators found a 20% reduction in daily dietary salt intake. Additionally, hospitalization rates decreased significantly from 164 to 60, a reduction of 60%, resulting in a marked decrease in health care costs (55%).

The apparent success of the multidisciplinary programs also spurred individual physicians to attempt such strategies in a setting with fewer resources. Smith et al. (1997) followed up 21 patients in a cardiomyopathy clinic composed of a cardiologist and nurse practitioner. New patients referred to the clinic with LVEF < 45% were enrolled in the program. The average age was 61 years, 90% were white and 100% were male. The intervention included comprehensive patient education, optimization of medication dosages, and regular clinic visits.
Compared with the 6-month period preceding entry into the clinic, heart failure admissions and emergency visits declined by 87% (14 to 2, \( p = 0.017 \)) and 100% (8 to 0, \( p = 0.002 \)), respectively. However, the frequency of clinic visits was determined by symptom severity and the need for medication changes and increased 5-fold, averaging approximately 10.5 per patient during a 6-month follow-up period. Additionally, LVEF increased from 24% to 36%, NYHA class improved significantly from \( 2.6 \pm 0.5 \) to \( 2.2 \pm 0.5 \), as did the Minnesota Living with Heart Failure Scores, with an average improvement of 23 points (\( p = 0.001 \)). Finally, exercise time increased from 6.7 to 8.8 min (\( p = 0.005 \)), although maximum oxygen consumption remained unchanged (15.4 ml O2/kg/min initially and 15.3 ml O2/kg/min at the end of 6 months (Smith LE, Fabbri SA, Pai R, Ferry, et al., 1997).

Similar results were obtained in patients enrolled in an outpatient interactive home monitoring program (Shah, Ruggerio, Heidenreich, et al., 1998). In this study, Shah and colleagues examined the utility of a high technology approach that used patient self-assessment with automated reminders (Shah, Ruggerio, Heidenreich, et al., 1998). Twenty-seven men with NYHA class II to IV heart failure and average age of 62 (range 42-81) participated in the 8-week program, which consisted of weekly mailings of heart failure educational materials and weekly telephone counseling sessions by a heart failure nurse. In addition, a paging system was used to transmit computer-generated reminders to the patient to take medications and to maintain daily records of weight, heart rate, and blood pressure, and these data were monitored by a study nurse. Physicians received monthly progress reports, as well as immediate notifications by fax whenever significant changes in clinical status occurred. Patients were followed up for an average of 8.5 months, and hospitalizations for equivalent periods before and after the intervention were compared. Although hospitalization rates declined by 50%, this difference was
not significant. However, cardiovascular admissions were reduced significantly, as were total hospital days and hospital days for cardiovascular causes. Patient acceptance of the program was high; 82% of patients rated the program useful or very useful. Enthusiasm was particularly high among the NYHA class III to IV patients, of whom 15 of 17 (88%) rated the program very useful, compared with 4 of 10 class II patients. These data suggest that close telephone monitoring can prevent hospitalizations for heart failure among both recently discharged patients and ambulatory outpatients and among both elderly and middle-aged persons (Shah, Der, Ruggerio, et al., 1997).

Heidenrich and colleagues (1999) provide further evidence supporting the clinical use and cost-effectiveness of heart failure disease management programs (Heidenreich, Ruggerio, & Massie, 1999). Sixty-eight patients with NYHA class II or III heart failure and an average age of 73 years were enrolled from multiple small practices (largely primary care) in northern California and followed-up for an average of 7.4 months. A nonrandomized parallel control group was composed of 86 patients matched to the intervention group on the basis of medical claims during the preceding year. As an adjunct to physician care, the intervention consisted of a low-intensity, home-based, computer-assisted telemonitoring system supplemented by weekly educational mailings and phone calls. The mailings described 52 HF topics (1 per week for 1 year), including diet, exercise, common therapies, and simple anatomy and physiology. A nurse discussed the topics during 10-minute weekly phone calls and educational points were reinforced. The nurse only offered education and made no changes in management. New symptoms, medications, and physician visits were recorded. Physicians were notified by fax when there was a change in the patient’s clinical condition, but such notification occurred infrequently (approximately once in 3 months per patient) and was nonintrusive, thereby
facilitating physician acceptance. Compared with the pre-intervention period, total medical claims during the 1-year period after implementation of the intervention declined by $1100 per patient in the treatment group but increased by an average of $9600 in the comparison group. Hospital days were also reduced significantly in the intervention group, but there was little change in quality of life as measured by the SF-36. As in other studies, the beneficial effects of the intervention were greater in patients at higher risk for recurrent hospitalizations. The intervention was well accepted by study participants, and compliance rates with the telemonitoring program were high (Heidenreich, Ruggerio, & Massie, 1999).

This study differs in several aspects from previous studies that have noted reduced resource use with multidimensional programs for patients with heart failure. Several of these programs were limited to patients with severe heart failure (Fonarow, Stevenson, Walden, et al., 1997) or were limited to discharge planning (Rich, Beckham, Wittenberg, et al., 1995). Additionally, all medical care was provided by the patient’s physician, and the study nurses served only as counselors and educators. This is in contrast to the programs reported by West et al (1997), and Cintron (1983), which used nurse practitioners to aid in medication management with the supervision of physicians. Because the program is of low cost and does not require direct supervision by the primary physician, it may be easily adaptable to a wide range of health care providers and clinical practice settings. Limitations include the nonrandomized design, small sample size, relatively low recruitment rate (implying potential sampling bias), and inability to assess the effects of individual program components. Despite these limitations, this study is an important contribution to the growing body of literature supporting the use of novel, multidisciplinary programs of patient monitoring, education, and physician notification in the management of heart failure.
Knox et al. (1999) described the efforts of a physician-led multidisciplinary team to provide coordinated care across the continuum of health care for patients with heart failure. The integrated 18-month program comprised components of inpatient consultation and education, an outpatient CHF clinic, home care, and a telephonic system to monitor patient compliance with recommended therapy. The program employed daily monitoring, ongoing education, and consistent communication by all members of the health care team and was designed to decrease length of stay, reduce costs, prevent readmissions, and improve compliance with the treatment regimen. As a result of pathway implementation, direct costs declined 50% and length of stay decreased to 4.0 days compared with 6.2 days before the program’s inception. Results also revealed reductions in the 30-day readmission rate, from 17% to 2.3%, and hospitalization rates of 0.6/pt/year compared with the national benchmark of 1.7/pt/year. After 18 months, telemanagement patients’ compliance rates averaged 89.5%. Additional clinical outcomes included patient satisfaction, improvements in percentage of daily weights recorded, frequency of dietary consultation, documentation of LV function, prescribing appropriate medications, & scheduling follow-up care (Knox & Mischke, 1999).

Results of this study (Knox & Mischke, 1999) support previous reports that hospitalization rates in patients with heart failure can be substantially reduced by improved patient education, patient self-monitoring of weight, and rapid response to early signs of clinical decompensation (Rich, Beckham, Wittenberg, et al., 1995; Fonarow, Stevenson, Walden, et al., 1997; Hanumanthu, Butler, Chomsky, et al., 1997) A unique aspect of this study was that patients were viewed as “co-managers” of their illness and education and treatment were individualized to the specific learning styles and needs of each patient (Knox & Mischke, 1999).
In 1999, Wilson and coworkers examined whether home health care services for heart failure were associated with decreased hospitalization frequency and costs (Wilson, Smith, Dahle, et al., 1999). 35 patients, mean age 57 +11 and average LVEF of 20 +10% were referred to 18 home health agencies for administration of IV diuretics (n=19), home inotropic therapy (n=10), and general monitoring to ensure compliance with diet and medication and to detect clinical deterioration (n=6). Specific instructions for patient care were provided to each home care agency. Patients were enrolled for a mean of 94+94 days and nursing visits averaged 2.8 +1.7 days, and ranged from daily to weekly. The average weekly charges were $348/patient and costs increased to $1,382/patient with inotropic therapy. Patients were hospitalized 47 times for HF during the 3-month period prior to enrollment compared to 52 times after referral (p=NS). Furthermore, after adjusting for deaths, patients were hospitalized at a rate of .45 per month before enrollment compared to .66 per month after (p<0.05). Annualized hospitalization rates averaged 5.4 hospitalizations per year in this study versus 3.2 hospitalizations per year in the study by Kornowski et al (Kornowski, Seely, et al., 1995), and approximately 2.7 hospitalizations per year in a randomized study by Rich et al (Rich, Beckham, et al, 1995).

Despite the use of relatively costly services, no significant decrease in hospitalization rates was seen in this population (Wilson, Smith, Dahle, et al., 1999). Several potential reasons exist why this study, in contrast to previous studies, failed to demonstrate reduced hospitalization rates after home-care referral. First, the overall quality of home health care delivered to these patients was less consistent than in previous studies. For example, the present study used 18 home health agencies with different protocols and nursing staff with varying levels of expertise. In contrast, Kornowski (Kornowski, Seely, et al., 1995), Rich et al. (Rich, Beckham, Wittenberg, et al., 1995), Stewart et al. (Stewart, Pearson, Horowitz, 1998), and Knox and Mischke (1999)
used a single agency of home health care nurses who delivered care using standard protocols. However, the authors argue that the type of protocol used in the present study more likely reflects actual clinical practices in the United States, as most clinicians are compelled to work with a diverse group of home health agencies (Wilson, Smith, Dahle, et al., 1999).

Constantini et al. (2001) assembled a disease management team to achieve goals of adhering to nationally published guidelines (Task Force of the Working Group on HF, 1997) for care of patients with HF, and of identifying opportunities to improve quality & efficiency of hospitalized HF patients (Constantini, Huck, Carlson, et al., 2001). Hospital length of stay, total costs, and use of recommended guidelines were compared between 173 patients before team implementation but with available guidelines, 283 care managed patients, and 126 concurrent non-care managed patients. The nurse provided patient education, assessed discharge needs, evaluated the patient’s ability to comply with a prescribed plan, and recorded daily responses to medical treatment. Based on individual responses, the nurse or cardiologist modified the treatment plan as necessary. Patients were referred as needed to ancillary services such as physical therapy, social services, and dietary and substance abuse counseling. Results revealed that care-managed patients achieved higher rates of ACE-inhibitor use than baseline or non-care managed patients (95%, 60%, & 75%, respectively; p<0.001), as well as increased adherence to guidelines for daily weight monitoring and assessment of LV function. Hospital length of stay was lower (median 3,4, & 5 days, respectively; p<0.001) as were costs of hospitalization (median, $2934, $3209, & $4830, respectively; p<0.01). These results clearly indicate the importance for physicians to strictly follow the available guidelines for the management of these patients (Constantini, Huck, Carlson, et al., 2001).
Hershberger et al. (2001) described a program of extensive telemanagement, preemptive hospitalization for decompensated patients, continuity of care from inpatient to outpatient, and implementation of effective therapy as defined by consensus statements (Konstam, Dracup, Baker, et al., 1994; Williams, Bristow, Fowler, et al., 1995; Packer, Cohn, et al., 1999). One hundred eight patients with HF were enrolled in the university-based outpatient HF management program (Hershberger, Hanyu, Nauman, et al., 2001). Average age of the participants was 52 ±12 years, 73% male, and 87% were white. Nurse coordinators contacted patients weekly or biweekly for 4 to 6 weeks for close symptom surveillance & adherence to medical regimens. Telephone follow-up was estimated at 20 to 30 minutes per patient per month for the first three months, 5 to 10 minutes per patient per month thereafter. The total outpatient visits were 361, with an average of 3.3 per patient during the 6 months of follow-up. Although patients were seen collaboratively, each clinic patient encounter was discussed briefly with the group of 2-4 cardiologists, 4-5 nurses, and social worker to provide comprehensive ongoing knowledge of each patient’s status. Educational topics included sodium restriction, pharmacological therapy, warning symptoms of adverse medical interactions and HF progression, behavioral techniques for improving adherence to dietary and medical therapy, and guidelines of when to notify a nurse of a change in condition. Additionally, patients were given a brochure with information on sodium restriction, physical activity, smoking cessation, self-monitoring of drug related symptoms, and daily monitoring of symptoms and weight. Furthermore, nurses assessed knowledge of HF and care, QOL, confidence to control symptoms, and health habits.

Compared with 6 months before referral, the intervention was accompanied by a 52% reduction in risk of hospitalization for CV causes (56.1% vs. 27.2%, p<.001) and a 72% reduction in ER visits for CV causes (53.6% vs. 14.5%, p<.01). Total hospital admissions decreased by
59% from 94 to 39; whereas, total ER visits decreased from 83 to 19, a difference of 77%. QOL scores improved over time with a change score of 11.2 ($p<.001$) at 3 months & 10.7 ($p<.001$) at 6 months. Finally, the proportion of patients with NYHA class III-IV decreased from 67% at baseline to 49.1% at 6 months ($p=0.01$).

This study was the first to examine the pre-and postprogram differences in patient knowledge of and adherence to self-care recommendations (Hershberger, Hanyu, Nauman, et al., 2001). There was a significant improvement at 6 months after referral in the patients’ knowledge regarding daily weight monitoring, importance of restricting dietary salt intake, and contacting providers if experiencing a sudden weight change. The proportion of patients weighing themselves daily increased by 24% ($p=0.02$). Nevertheless, no changes were observed in self-reported adherence to dietary salt restriction and medical dosage compliance. This finding suggests that an increase in knowledge is not necessarily accompanied by concomitant changes in self-care behaviors among patients with heart failure (Hershberger, Hanyu, Nauman, et al., 2001).

Holst et al. (2001) assessed the ability of a 6-month HF care management program including intensive education, and referral to a tailored exercise program to reduce readmissions and improve quality of life and functional status in 42 outpatients with class III-IV HF. Average age of the population was 54±12 and 75% were male. The program consisted of an initial 1-hour consultation with a cardiologist and a 30 min introductory session with a study nurse to establish communication for subsequent management coordination. All patients later attended a 2-hour education session for partners and families, which was predominately a group session, but done on an individual basis if required. Similar to the study by Knox and Mischke (1999), patients were encouraged to take an active role and follow an action plan with instruction to seek medical
care if symptoms worsened (Holst, Kaye, Richardson, et al., 2001). Purpose of education was to improve patients’ understanding of HF, stressing warning signs & symptoms of deterioration. Additionally, Patients received advice from a dietician regarding diet, fluid, & sodium management, daily weights, and instructions on diuretic adjustment. Medication advice was also outlined, with a goal to optimize use of ACE inhibitors and beta-blockers. Moreover, Patients attended an exercise program 2-3x/week for 8 weeks, which was part of an existing cardiac rehabilitation service. Exercise components included walking, biking, rowing, stepping, weight resistance training, calisthenics, and work and activity conditioning. Patients completed 3 sessions at each attendance, and exercised at an intensity of 50-60% of HR max, a max breathing frequency of 24/min, and a Borg rating of 9-12 for RPE. Furthermore, patients were encouraged to maintain a home program of daily walking for 10-30 min, with aim for total exercise per day of 30-60 min, 5-7 days per week. Patients attended the clinic an average of 3.4 times over the 6 month period, with an average of 4 phone contacts during the first month and 1 per month for the remainder of follow-up.

Compared with the 6 month period prior to enrollment, hospital admissions difference of 87.2%. Additionally, visits to the general practitioner declined from 1.94±2.22 to 0.69±1.28 visits per patient (p=.006). Dosages of ACE-inhibitors and beta-blockers administered increased by 42% (p<.0008) and 61% (p<.0001), respectively. Moreover, NYHA functional class improved from 3.1±.35 to 1.8±.82 (p<0.0001) and exercise capacity, as assessed by the 6MW, improved from 413±117m to 496±93.2m (p<0.0001). Furthermore, data revealed significant improvements in LVEF, cardiac depression scale, and QOL. The program resulted in an estimated cost savings of AUD $6198 per patient over a 6 month time frame (Holst, Kaye, Richardson, et al., 2001).
Also in 2001, Whellan and colleagues (2001) used a strategy of physician-supervised but nurse-mediated heart failure management, incorporating specific concepts from previously described disease management programs (Fonarow, Stevenson, Walden, et al., 1997; Hanumanthu, Butler, Chomsky, et al., 1997; West, Miller, Parker, et al., 1997; and Shah, Der, Ruggerio, et al., 1998). 117 patients with heart failure were followed in a tertiary setting for a median of 4.9 months. The median age of participants was 62 years, 55% were white and 62% male. 50% of the patients were in NYHA Class III or IV, with a median LVEF of 23% (Whellan, Gaulden, Gattis, et al., 2001). Nurses directed the implementation of consensus guidelines (Konstam, Dracup, Baker, et al., 1994; Williams, Bristow, Rowler, et al., 1995; Heart Failure Society of America, 1999) to maximize vasodilator dosage, reduce dietary salt intake, monitor patients for early evidence of worsening heart failure, and provide patient support and education by frequent telephone contact (Whellan, Gaulden, Gattis, et al., 2001). The group developed a patient education manual that reviewed topics such as medication purpose, importance of adherence, potential adverse effects and appropriate actions to take should adverse effects occur, diet, weight monitoring, physical activity, and resources available to HF patients. The manual also included a diary for diet and daily weights. Inpatients were provided with a consultation and a patient education manual and were contacted within 1 week after discharge. Frequency of follow-up was based on clinical stability and severity of illness and could be adjusted by the physician as needed. NYHA Class IV patients received weekly clinic visits for the first month and weekly telephone calls for the first 3 months; whereas, clinic visits for NYHA Class II-III patients were scheduled every 6 weeks with biweekly telephone calls.

Data collection was performed at 3-month intervals and compared to equivalent periods preceding enrollment. Primary outcome measures were medication use and resource utilization.
Results revealed that use of ACE inhibitors was high and did not change; however, there was a 50% increase in target dose ($p<.01$). Beta-blocker use and dose significantly increased from 52% to 76%, ($p<.01$) and from 6% to 25%, ($p<.01$), respectively. Additionally, hospitalization rate decreased from 1.5 to 0 per patient-year ($p<.01$), while the number of clinic visits significantly increased from 4.3 to 9.8 clinic visits per patient-year ($p<.01$). Finally, the total cost of care decreased by a median of $8571 per patient-year, excluding the cost of providing the program and any costs incurred by the patient such as transportation.

Todero et al. (2002) examined symptom occurrence, symptom characteristics, and quality of life in 102 elderly patients recently hospitalized following an acute HF exacerbation. Nurses visited each patient in their home at baseline, approximately 1 month after hospital discharge, and again 2 months later to collect study data. At baseline all participants were shown a patient educational video and were given an educational manual for reference. The program content was derived from AHCPR clinical guidelines (Konstam, Dracup, Baker, et al., 1994) and included routine reminders to monitor symptoms, with suggestions for symptom management (Todero, LaFramboise, & Zimmerman, 2002). Patients received follow-up and further education reminding them when to take medications, weigh daily, reduce dietary sodium, get routine exercise, & manage worsening symptoms by 1 of 4 methods: Health Buddy, phone calls, home visits, or combination of home visits and health buddy. Phone and home visit educational counseling sessions were scheduled approximately weekly over 5-6 weeks until all topics were discussed. The health buddy assessed patient status and provided information in smaller segments daily. A preliminary analysis revealed no differences based on method of follow-up; therefore, data were combined for the analyses. Results revealed significant improvements in QOL as assessed by RP, BP, MH, & VT subscales of the SF-36 questionnaire, with trends
toward improvement in PF & GH subscales. The occurrence of all symptoms was less at 2 months, with the exception of shortness of breath, which persisted. Although participants still reported shortness of breath as the most common symptom, it was less frequent, less severe, and caused less interference with activity and enjoyment. These data provide information on the most common and distressing symptoms in a community-based HF population. This information may be useful in guiding assessments and designing specific interventions to include in a home-based disease management program. Furthermore, results suggest that a home-based disease management program implemented in a variety of ways can improve symptom status and quality of life in heart failure patients after discharge from the hospital (Todero, LaFramboise, & Zimmerman, 2002).

In summary, the available evidence regarding the efficacy of the multidisciplinary programs for patients with heart failure is extensive spanning approx 2 decades, across the globe, and across various stages of the disease. These observational studies suggest that a multidisciplinary approach to HF disease management may be associated with important clinical benefits, including fewer readmissions and hospital days, improved quality of life and patient satisfaction, increased exercise tolerance, and a reduction in cost of care. However, these data are limited by the facts that the studies were nonrandomized (and therefore lacked a suitable control group) and that the before-after comparison with respect to readmissions may have overestimated the magnitude of benefit, as well as the potential cost savings. Furthermore, because few of the studies were blinded, the data on quality of life, exercise tolerance, and patient satisfaction may be confounded by the patient’s desire to please the health care provider, by a learning effect, or other patient or observer biases. Therefore, although the observational
data are encouraging, they are by no means definitive, and they require confirmation by carefully conducted randomized trials.

**Randomized Studies**

At present, sixteen randomized trials regarding the management of heart failure have been conducted. Despite the fact that few trials are similar in design, duration of study, or consistency of the multidisciplinary team, a clear consensus emerges following the review of results. The randomized trials are further summarized in Tables IX-XI.

The first randomized trial to examine the efficacy of a multidisciplinary program was conducted by Rich et al. (1993), and was a prospective randomized pilot study designed to evaluate a nurse-directed multidisciplinary management strategy in elderly patients hospitalized with heart failure (Rich Vinson, Sperry, et al., 1993). The average age of participants was 79±6 years, 41% were men and 50% were nonwhite. Participants were randomized in a 2:1 ratio to traditional care supplemented by a nurse-directed multidisciplinary team (n=63) or traditional care as determined by the patient’s usual physician (n=35). The intervention included comprehensive patient education by a geriatric cardiovascular nurse, a review of medications with recommendations to reduce side effects and improve compliance, individualized dietary instruction by a registered dietician, social services consultation to facilitate discharge planning and aid in the transition to the home environment, and close follow-up after discharge by a home health nurse and the study team. Participants were followed for 90 days and primary endpoints were all-cause readmissions and the number of days hospitalized during follow-up. Readmission rates in the intervention group and control group were 33.3% and 45.7%, respectively, reflecting a difference of 27.1% in favor of the intervention. Additionally, the intervention group spent an average of 4.3 days in the hospital compared with 5.7 days in the control group, an absolute
difference of 1.4 days per patient. Although encouraging, none of these differences were statistically significant. The authors concluded that further investigation in a larger trial was warranted, and that an appropriate cost analysis should be incorporated into such a trial (Rich, Vinson, Sperry, et al., 1993).

In 1994, Kostis et al. (1994) conducted a small, randomized trial involving 20 patients with heart failure. All but one participant was in NYHA Functional Class II, and all were receiving ACE-inhibitors. Participants were randomly assigned to one of three groups: nonpharmacologic treatment (n=7), digoxin (n=7), or placebo (n=6). Nonpharmacologic treatment included exercise training, cognitive therapy, stress management, and dietary instruction aimed at weight control and salt reduction. After 12 weeks, patients randomized to nonpharmacologic therapy experienced significantly greater improvements in exercise tolerance, anxiety and depression scores, and weight control when compared with the digoxin and placebo groups. These benefits occurred despite the fact that ejection fraction increased with digoxin use but was unchanged in the other two groups (Kostis, Rosen, Cosgrove, et al., 1994).

Based on findings from his previous study (Rich, Vinson, Sperry, et al., 1993), Rich and coworkers (1995) performed a controlled trial of a nurse-directed, care management program to determine readmission rates within 90 days of hospital discharge, quality of life, and costs of care for high-risk elderly patients hospitalized with HF (Rich, Beckham, Wittenberg, et al., 1995). A total of 282 HF patients in an urban tertiary center who were at high risk of hospital readmission were randomly assigned to one of two groups: 1) conventional physician-directed care (n=140), or 2) conventional care supplemented by a nurse-directed multidisciplinary team (n=142). The study intervention was similar to their pilot study (Rich et al., 1993) and included intensive patient education prior to discharge, which was reinforced during frequent and regular
contacts by a home health representative and the study team. The intervention continued for 90
days following discharge, and during this period all-cause readmissions were reduced 44%, heart
failure readmissions were reduced 56%, readmissions for other reasons were reduced 29%, and
the proportion of patients requiring multiple readmissions was 61% lower in the intervention
group (Rich, Beckham, Wittenberg, 1995). Additionally, patients receiving the study
intervention reported improved quality of life, enhanced compliance with medications and diet,
and a greater knowledge of the heart failure syndrome (Rich, Beckham, Wittenberg, 1995). The
monetary savings associated with fewer hospitalizations offset the costs of the program, resulting
in an average reduction in medical costs of $460 per patient during the 3-month study.
Importantly, during an additional 9-month post intervention follow-up period, heart failure
readmissions remained 29% lower in the intervention group, suggesting a persistent beneficial
effect of the program and implying additional cost savings.

Weinberger et al. (1996) described a program of intensive primary care during and
immediately following hospital discharge among 1,396 severely ill veterans with CHF, diabetes,
chronic obstructive pulmonary disease or more than one of the three diagnoses (Weinberger,
Oddone, & Henderson, et al., 1996). Six hundred ninety five patients were randomized to the
intervention, which involved close follow-up by a nurse and a primary care physician, beginning
prior to discharge and continuing for six months, while the remaining 701 patients received usual
care. Primary outcome measures were readmissions and secondary outcomes included quality of
life and patient satisfaction with care. The average age of study participants was sixty-three
years, 99% were male, and 65% were white. Of the 504 patients with HF, 51% were in Class III
or IV. During the 6-month follow-up period, patients in the intervention group had significantly
higher rates of readmission per month than those in the control group, 0.19 vs 0.14, respectively.
Additionally, total days of re-hospitalization were significantly higher in the intervention group when compared with controls 10.2 vs. 8.8, respectively. Although patients in the intervention group reported improved satisfaction with care, there were no differences between groups in quality of life scores, which remained very low. The results were similar regardless of the patient’s primary diagnosis.

These findings appear to challenge results from previous studies. There are several possible explanations for the inconsistencies. First, the design is different from that used in other studies. For example, the intervention merely provided increased access to healthcare, rather than represented a "disease management program". Second, in most cases, the primary care physician only had a single contact with the patient before hospital discharge, thereby prohibiting the establishment of an effective physician-patient relationship. Moreover, there was inadequate opportunity to perform a complete evaluation of the patient and optimize treatment during the initial hospitalization. Lastly, the intervention was not disease specific and did not provide any kind of algorithm or systematic approach to the treatment of heart failure exacerbations. These results imply that providing increased access to healthcare without providing an improved structure or algorithm for healthcare delivery is unlikely to enhance outcomes.

Three additional trials (Stewart, Pearson, & Horowitz, 1998; Cline, Israelsson, Willenheimer, et al., 1998; Serxner, Miyaki, & Jeffords, 1998) were published in 1998 that contradicted the findings of the previous study (Weinberger, Oddone, & Henderson, 1998), but supported the findings of Rich (1995). In the first study, Stewart et al. (1998) randomly assigned ninety-seven elderly patients admitted for heart failure to standard care after discharge (n=48) or a home-based intervention (n=49) (Stewart, Pearson, Horowitz, 1998). The intervention was unique in that it comprised a single home visit one week after discharge by either a nurse or a
pharmacist. The purpose of the visit was to optimize medication management, identify early clinical decompensation, and intensify medical follow up and caregiver vigilance as appropriate. The average age of the participants was 75 years and 50% of the patients were women. All patients had at least one prior hospitalization for heart failure, and all but 6 patients were in NYHA Functional Class II (n=48) or III (n=43). The primary end point of the study was the frequency of unplanned readmission plus out of hospital death within 6 months of discharge. Results revealed that patients randomized to the home based intervention had 42.3% fewer unplanned readmissions (36 vs 63; \( p=0.03 \)) and 45.1% fewer out-of-hospital deaths. Additionally, home-based intervention patients also had 43% fewer days of hospitalization (261 vs 452; \( p=0.05 \)) and fewer multiple (≥3) readmissions for HF during follow-up (0 vs 5 patients; \( p=0.02 \)). Furthermore, hospital costs averaged $3,200 per patient in the intervention group compared with $5,400 in the control group, a nonsignificant reduction of 40.7%. The estimated cost of the study intervention was $190 Australian dollars. Outpatient medical costs did not differ between groups.

This study (Stewart, Pearson, Horowitz, 1998) should be compared with two previously reported, randomized controlled investigations (Weinberger, Oddone, & Henderson, 1996; Rich, Beckham, Wittenberg, et al., 1995). In one of these studies, broad interventions (increased access to outpatient primary care) yielded unfavorable results in relation to extent and duration of readmissions (Weinberger, Oddone, & Henderson, 1996). In the other study, however, use of a similar but more intensive intervention specific to management of HF was associated with a significant increase in the time to first readmission or out-of-hospital death at 3 months after discharge (Rich, Beckham, Wittenberg, et al., 1995). As with this study (Stewart, Pearson, Horowitz, 1998), the difference between groups was largely mediated by fewer multiple
readmissions among patients exposed to the nurse-directed home-based intervention (Rich, Beckham, Wittenberg, et al., 1995).

In another report, Cline and coworkers (1998) add further evidence in favor of a nurse-led multidisciplinary intervention following hospitalization due to HF (Cline, Israelsson, Willenheimer, et al., 1998). The unique aspect of this program was that families also received education about the HF syndrome. One hundred ninety patients with HF were randomized by computer-generated allocation to the intervention group (n=56) or usual care (n=76) to evaluate the efficacy of a HF management program on hospitalization and health care costs one year after admission for heart failure. The intervention group and their families received education about heart failure and self-management, with follow-up at an easy access, nurse directed outpatient clinic for one year after discharge. The control group was managed according to routine clinical practice. The education program consisted of two thirty-minute information visits by a nurse during hospitalization and a one-hour information visit for patients and families two weeks after discharge. There was only one prescheduled clinic visit at 8 months after hospital discharge. However, the nurse was available by telephone during clinic hours and was able to see patients at short notice. Adherence to prescribed medication was emphasized and patients received guidelines for self-management of diuretics. The control group was followed up at the outpatient clinic by either cardiologists in private practice or by primary care physicians. One-year mortality did not differ between groups. Time to first readmission over the same period however was 33% longer in the intervention group (106 vs 141 days; p<0.05), with 49% fewer total days of hospitalization (8.2 vs 4.2; p=0.07). Furthermore, there was a trend toward a mean annual reduction in healthcare costs per patient of US $1300 in the intervention group compared with costs in the controls (US$2294 vs 3594; p=0.07). It should be noted that this study recruited
patients with a much lower rate of readmission than those in the previous two studies (Rich, Beckham, Wittenberg, et al., 1995; Stewart, Pearson, Horowitz, 1998).

In a third report, Serxner et al. (1998) reported findings of a study involving 109 patients randomized to an educational mailing intervention (n=55) or standard care (n=54) after hospitalization for heart failure. The intervention was designed to encourage self-management and consisted of a series of mailings at 3 to 4 week intervals that contained a personalized letter and a variety of educational materials (booklets, brochures, fact sheets, resource guides, and a video), as well as compliance aids (medication sheets and a weight chart). Interviews were conducted before and after the three-month intervention to assess compliance and quality of life, and readmissions were monitored for 6 months. The average age of the participants was 71 years, and 52% were women. Results indicated that 27% of the patients in the intervention group were readmitted at least once during the 6-month follow-up period compared with 50% of the patients in the control group ($p=0.025$). Moreover, multiple readmissions were more common in the control group, and the study intervention resulted in 52% fewer total readmissions (43 vs. 21 readmissions; $p<0.01$). Additionally, individuals receiving the study intervention reported better overall health status, greater confidence in self-management, and enhanced compliance with diet, medications, and weight monitoring as compared to control group patients. Furthermore, the investigators reported that although the cost of the education program was $50 per patient, the intervention reduced overall costs, and there was a net return on investment of $8:$1 for the hospital and $19:$1 for third party payers (Serxner, Miyaki, & Jeffords, 1998).

In 1998, Ekman and colleagues evaluated the feasibility of a nurse-monitored, outpatient care program for elderly patients (mean age = 80 years) previously hospitalized with moderate to severe HF (Ekman, Andersson, Ehnfors, et al., 1998). Upon hospital discharge, one hundred fifty
eight patients with NYHA class III-IV HF were randomized to the structured-care intervention (n=79) or standard care (n=79). The structured care program followed established guidelines for medical treatment and principles for care of the patients were based on previously documented experiences (Konstam, Dracup, Baker, et al., 1994; Dracup, Baker, Dunbar, et al., 1994; Rich, Vinson, Sperry, et al., 1993). The main goal of the intervention was that patients would learn to recognize and monitor symptoms of deterioration and be familiar with effects and side effects of the medication they had been prescribed (Ekman, Andersson, Ehnfors, et al., 1998). Patients were instructed to call the nurse if worsening symptoms occurred or if they had questions pertaining to their illness. The nurse was available by beeper during business hours; however, an attending doctor was responsible for medical decisions. Each patient was contacted a week after hospital discharge and offered a visit to the clinic, together with a caregiver. In addition to clinic visits, nurses regularly contacted patients by telephone to follow-up discussions concerning medication, weight, diet, or questions raised by the patient’s apprehension of the illness. During the six month follow-up period, the median number of telephone contacts was four calls per patient. Twenty-two (28%) patients and eighteen (23%) relatives or caregivers made spontaneous telephone contacts; whereas, seven patients (9%) made spontaneous clinic visits due to decompensation, leading to acute admissions. Among the seventy-nine patients randomized to the structured care group, 23 patients (29%) never visited the nurse and this was explained by death (11 patients), fatigue or unwillingness (11 patients), and institutional care (1 patient). Patients who never visited the nurse showed the following characteristics at entry: female sex, advanced age, and need of assistance at home.

Results of the structured-care program did not demonstrate any beneficial effect on the number of readmissions and hospital days. If anything, structured care tended to be associated
with an increase in hospital days (mean difference in hospital days was 8 days; \( p=0.29 \)). Interestingly, these results are in agreement with a previously discussed study, which demonstrated that structured management, with increased access to primary care after hospital discharge, was associated with an increased rate of hospitalizations in severely ill patients (Weinberger, Oddone, & Henderson, 1996). One explanation for these results may be that structured care may lead to the detection of previously unrecognized medical problems, owing to improved communication between caregivers and patients as compared to conventional care. This, in combination with easier access to inpatient care, may increase readmission rates. The authors concluded that the outpatient, nurse-monitored symptom management program was not feasible for the majority of these elderly patients with moderate to severe HF, mainly because of the small proportion of eligible patients and the high dropout rate (Ekman, Andersson, Ehnfors, et al., 1998). Furthermore, management of these patients may have to be more individualized and adjusted to the patient’s home situation.

Based on previous studies, it can be expected that patients who are able to care for themselves effectively will encounter fewer problems leading to rehospitalizations or unnecessary visits to the emergency department (Happ, Naylor, Roe-Prior, 1997; Rich, Gray, Beckham, et al., 1996; Rich, Beckham, Wittenberg, et al., 1995; Vinson, Rich, Sperry, et al., 1990; Gooding & Jette, 1985). However, some authors argue that because of increased access to care and increased knowledge about the illness, it is also possible that education and support leads to an increase in health care resource use (Weinberger, Oddone, & Henderson, 1996; Ekman, Andersson, Ehnfors, et al., 1998). In various multi-faceted interventions, education is an important aspect of the intervention, such as the availability of a heart failure clinic or a heart failure team (Ekman, Andersson, Ehnfors, et al., 1998; Rich, Beckham, Wittenberg, 1995;
The specific contribution of education and support alone to such programs is seldom isolated. Therefore, Jaarsma and colleagues (1999) conducted a trial to determine the effect of patient education and support by a nurse on self-care and resource utilization in patients with severe HF (Jaarsma, Halfens, Huijer, et. al., 1999).

A total of one hundred seventy nine patients hospitalized with NYHA class III-IV HF were randomized to a nurse-led educational intervention (n=84) or to usual care (n=95) (Jaarsma, Halfens, Huijer, et. al., 1999). The average age of participants was seventy-three years and fifty-eight percent were male. The supportive education intervention consisted of intensive, systematic and planned education by a study nurse about the consequences of heart failure in daily life, using a standard nursing care plan developed by the researchers for older patients with heart failure (Jaarsma, Halfens, Huijer, et. al., 1999). Education took place over a ten-day period, beginning in the hospital and continuing through a home visit within a week of discharge; however, all patients were followed for nine months. An investigator telephoned the patients one month after discharge and visited the patient at three months and nine months after discharge for data collection. Data were collected on self-care abilities, self-care behaviors, readmissions, visits to the emergency heart center, and use of other health care resources.

No statistically significant differences were found between the two groups in self-care abilities. The supportive educational intervention was effective, however, in enhancing self-care behavior after discharge. On average, patients were compliant with nine of nineteen items of self-care behavior at baseline. As can be expected, the effects of the intervention were most powerful on short-term behavior, which is reflected in significant differences in self-care behavior between the two groups both at one month and at three months after discharge (14 vs 12; t=3.8, \( p=0.001 \), and 12.2 vs 10.6; \( t=2.9; \ p=0.05 \), respectively). Both control and intervention
patients decreased self-care behavior over time; however, the intervention patients still reported complying with more behaviors than control patients at nine months (11.2 vs. 10.3; \(t=1.6\); \(p=0.11\)). Although the difference between groups at nine months was not statistically significant, the increase from baseline remained substantially significant in the intervention group, but not in the control group. No significant effects on resource utilization were found. The authors concluded that education and support from a nurse in a hospital setting and at home can significantly increase self-care behavior in patients with severe HF (Jaarsma, Halfens, Huijer, et al., 1999). The decrease in self-care behaviors over time suggests that although patient self-management should play an important role in care management strategy, the study design should ensure concomitant outpatient supervision and enforcement of education to achieve success. Additionally, it can be expected that certain aspects, for example those relating to adapting activities, may not be affected by education and support. The data indicated that, due to their poor physical behavior, most patients already rested during the day, spread activities throughout the day, and decreased activities when needed, (Jaarsma, Halfens, Huijer, et al., 1999). Therefore, interventions that encourage regular exercise at the patient’s own pace may be needed, because it has been shown that exercise can improve functional capacity and attitudes (McKelvie, Teo, Roberts, et al., 2002).

Jerant and colleagues (2001) compared the effectiveness of three hospital discharge care models for reducing CHF-related hospital readmission costs: 1) home telecare delivered via a 2-way video-conference device with an integrated electronic stethoscope (n=13); 2) telephone follow-up (n=12), and 3) usual outpatient care (n=12) (Jerant, Azari, & Nesbitt, 2001). Prior to hospital discharge, thirty-seven patients were randomized to one of the three care models using sealed envelopes containing randomly generated numbers and were followed for one year.
Patients assigned to telephone care received scheduled phone calls from the study nurse in the intervening period, whereas, those assigned to the video-based telecare group received scheduled home telecare visits. For urgent questions or problems, the groups in telecare and telephone groups had access to nurse via the medium appropriate to their group assignment. Patients in all groups received a home nursing visit shortly after discharge and a second home nursing visit approximately sixty days later, during which subjects completed the SF-36 questionnaire (Ware & Sherbourne, 1992) and the Minnesota Living with HF questionnaire (Rector & Cohn, 1992). Additionally, during all in-person, telecare, and telephone encounters, the study nurse assessed signs and symptoms, activities of daily living, medication use, and dietary factors, provided education, and developed patient-centered goals for the frequency and content of follow-up visits (Jerant, Azari, & Nesbitt, 2001). Furthermore, a set of algorithms were drawn from national consensus recommendations to help the study nurse better determine the adequacy of HF drug regimens (Advisory Council to Improve Outcomes Nationwide in HF, 1999). Patients randomized to usual care received only the care directed by their primary care physicians in the period between in-person nursing visits (Jerant, Azari, & Nesbitt, 2001). The primary outcome measure was HF-readmission charges during a 6-month period after randomization.

Ninety-two telecare encounters (76%) were limited by at least one technical problem. Video problems were judged to be severe in only five encounters (4%) and heart and lung sound resolution was inadequate in only two encounters (2%). Mean HF-readmission charges were 86% lower in the telecare group ($5,850±$21,094) and 84% lower in the telephone group ($7,320±$24,440) as compared to the usual care group ($44,479±$121,214). However, the between-group difference was not statistically significant ($P=0.262$). Both the intervention groups had significantly fewer HF-related emergency department visits ($P=0.0342$) and charges...
(\(P=0.0487\)) than the usual care group. Trends favoring both interventions were noted for all other utilization outcomes.

Based on these results, video-based home telecare does not appear to offer incremental benefits beyond telephone follow-up in reducing frequent hospital readmissions and emergency department visits for patients with HF (Jerant, Azari, & Nesbitt, 2001). More importantly, these data imply that deployment of distance technologies, such as telephone follow-up, to provide post-hospitalization monitoring could yield substantial reductions in hospital readmissions, emergency visits, and costs of care in select patients with HF.

In 2002, Doughty and coworkers examined the effect of an integrated heart failure management program on quality of life and hospital readmissions in patients with NYHA class III-IV HF (Doughty, Wright, Pearl, et al., 2002). The aim of this study was close liaison between patient, family, general practitioner (GP), and the hospital-based heart failure clinic. One hundred and ninety seven patients admitted to Auckland Hospital with an exacerbation of HF were enrolled in the study. Participants were randomized to the intervention group (n=100 patients, 64 GPs) or usual care (n=97 patients, 68 GPs) using the general practitioner as the unit of randomization. The intervention consisted of an evaluation and an individual education session with the nurse within two weeks of hospital discharge. Subsequently, two group educational sessions (each lasting 1.5 to 2 hours) were offered within six weeks of hospital discharge, and a third session after 6 months. These sessions were led by a cardiologist and a study nurse, and content was based on current HF guidelines (Konstam, Dracup, et al., 1994). Each patient was given a diary for recording medication information and daily weights, and a follow-up plan was devised for each patient aiming for 6 weekly visits alternating between the GP and heart failure clinic (Doughty, Wright, Pearl, et al., 2002). A letter was faxed to the GP on
the same day patient visited the HF clinic to document any changes in the management plan. Patients randomized to usual care continued under standard care of the GP with additional follow-up measures as recommended by the inpatient medical team.

Patients in the intervention group attended the HF clinic an average of four times during the twelve-month follow-up period. Sixty percent of the intervention group attended the first group education session, and forty percent attended the six-month session. The main effect of the intervention was attributable to the prevention of multiple readmissions. Although first readmissions for all causes were similar in intervention and control groups (64 vs 59, respectively), subsequent all-cause readmissions were fewer in the intervention group compared with the control group (56 vs 95, respectively, $2p=0.015$) with an associated reduction in bed days. Additionally, the Minnesota Living with Heart Failure scores showed markedly impaired quality of life at baseline, with mean physical functioning and emotional scores of $25.6\pm12$ and $10\pm7$, respectively. The physical dimension of quality of life showed a greater improvement in the intervention group from baseline to twelve months compared with the control group (-11.1 vs -5.8, respectively; $2p=0.015$); however, there was no significant change in the emotional score in either group (-3.3 vs -3.3, respectively; $2p=0.97$).

These results are in contrast to those previously discussed by Weinberger et al. (1996), who reported higher readmission rates in the intervention group as compared to controls (0.19 vs 0.14 per month, $p=0.005$), implying that a disease-specific protocol of primary with specialist care, as in the current study (Doughty, Wright, Pearl, et al., 2001), may be important requirements for the success of such management programs. Additionally, Cline et al. (1998) reported only modest effects of a nurse-led hospital-based clinic for HF management, with an increase in the time to first readmission but only a trend to fewer hospital admissions in the
intervention. The study design by Cline et al. (1998) differed from this study (Doughty, Wright, Pearl, et al., 2001), as it did not involve a structured approach to integration between the patient and primary and secondary care. Therefore, these authors (Doughty, Wright, Pearl, et al., 2001) suggest that not only is it necessary to have a disease specific protocol, but also a structured, integrated approach between the patient and primary and secondary care.

Previous studies have suggested that multidisciplinary disease management programs can substantially reduce the risk of readmission, with as much as a fifty-six percent reduction in HF readmissions and a forty-four percent reduction for all-cause readmission (Rich, Beckham, Wittenberg, et al., 1995). However, these interventions have generally included medical management components, and consequently, it is difficult to identify the critical factors responsible for success. Additionally, it has been suggested that behavioral factors such as noncompliance with medications and diet, and delay in seeking preventive care may contribute to readmissions and premature mortality (Dracup, Baker, Dunbar, et al., 1994; Happ, Naylor, Roe-Prior, 1997). Therefore, Krumholz and coworkers (2002) evaluated the effect of a formal education and support intervention on the rate of readmission or mortality, and hospital costs for patients with HF (Krumholz, Amatruda, Smith, et al., 2002).

Eighty eight patients aged ≥50 admitted with HF to Yale-New Haven Hospital were enrolled in the study, and randomized to the intervention (n=44) or usual care (n=44). The intervention was designed to empower the patient and improve compliance, and occurred in two phases: 1) the initial phase, and 2) the telemonitoring phase. The initial phase consisted of an initial educational session with a nurse within two weeks of hospital discharge using a teaching booklet. Home visits were performed for forty-five percent of the patients unable to travel to the hospital. Baseline meetings did not include clinical assessments or modification of treatment.
During the telemonitoring phase, a nurse contacted the patient by phone weekly for four weeks, then biweekly for eight weeks, and then monthly for a total intervention period of one year. The purpose of telephone contact was for education, not for modification of current regimens or to provide recommendations for treatment.

The median age of the participants was 74 years; 57% were men and 74% were Caucasian. Among the eighty-eight participants in the study, twenty-five patients (56.8%) in the intervention group and thirty-six patients (81.8%) in the control group had at least one readmission or died during the one-year follow-up. Overall, there were 49 all-cause readmissions in the intervention group and 80 in the control group in the year following discharge ($p=0.06$), indicating a 39% reduction in readmissions. After adjusting for clinical and demographic characteristics, the intervention group had a significantly lower risk of readmission compared with the control group. Although the average cost of the intervention was $530 per patient, hospital readmission costs were higher in the control group by an average of $7,515 per patient ($p=0.02$), yielding an overall cost reduction of $6,985 per patient in the intervention group.

Krumholz et al. (2002) extends previous work on disease management for patients with HF (Rich, Vinson, Sperry, et al., 1993; Rich, Beckham, Wittenberg, et al., 1995; Stewart, Pearson, Horowitz, 1998) by specifically evaluating the impact of education and support without medication management as an outcome for these patients. This intervention differs from other programs, as it focuses on enabling patients to take an active role in managing their illness based on knowledge and education rather than relying on physicians or nurses actively intervening to adjust medical care and regimens (Krumholz, Amatruda, Smith, et al., 2002). In comparison to work by Jaarsma and colleagues (1999), this study demonstrated that a brief education and support intervention by a nurse could increase self-care behaviors among patients who had been
hospitalized with HF (Krumholz, Amatruda, Smith, et al., 2002). However, unlike this study, the nurse in the Jaarsma study made a home visit to every patient and all of the intervention occurred within 10 days of discharge (Jaarsma, Halfens, Huijer Abu-Saad, et al., 1999). Furthermore, in contrast to this study, Jaarsma et al. (1999) found no significant change in resource utilization, although there were trends that favored the intervention group, indicating that a longer follow-up may be necessary. Although it was theorized that the outcomes were achieved through promotion of patient compliance and empowerment, this trial did not explicitly test the mechanism of intervention (Krumholz, Amatruda, Smith, et al., 2002). Future studies may explore the potential mechanisms for maximal benefits of education and support.

The findings of a study by Kasper and coworkers (2002) extend the work of Rich et al. (1995) to a longer intervention period (six months vs. three months) and to a younger population (median age of sixty four years vs. seventy nine years). Additionally, Kasper et al. (2002) emphasized the involvement of the patient’s primary physician, as well as active initiation and titration of medications by nurses. The purpose of the study was to determine whether an outpatient program designed to implement optimal medical therapy, increase patient understanding and compliance and reduce financial barriers to care, coupled with frequent telephone monitoring and clinic follow-up, could decrease mortality and hospital readmissions, as well as improve compliance and quality of life, at no extra cost in patients with HF (Kasper, Gerstenblith, Hefter, et al., 2002). Two hundred patients hospitalized with HF at increased risk for readmission were randomized to a six-month multidisciplinary program (n = 102) or usual care (n = 98). The median age of the study patients was sixty-four years, forty percent were women, and ninety four percent were in NYHA functional class II or III. A cardiologist and a HF nurse evaluated each patient and made recommendations to the patient’s primary physician
before randomization. It is important to note that primary-care physicians were not excluded from HF disease management, but rather were integrated into the team care of their patients. The intervention consisted of an algorithm designed by cardiologists according to available HF guidelines and clinical experience (Konstam, Baker, Dracup, et al., 1994; Williams, Bristow, Fowler, et al., 1995). Nurses adjusted medications according to the algorithm which also included a 2-g sodium restricted diet, as well as a recommendation to exercise by walking for 20 min at least four days per week (Kasper, Gerstenblith, Hefter, et al., 2002). The treatment plan was individualized for each patient. All patients in the intervention group were provided a pill sorter, list of correct medications, list of dietary and physical activity recommendations, contact number available 24 hours per day, and patient education material. Additionally, patients with limited financial resources were provided, if needed, a scale, a 3-g sodium “meals on wheels” diet, medications, transportation to the clinic, and a telephone.

Contact with the patient was on a prespecified schedule, and consisted of telephone follow-up and clinic visits. A telephone nurse coordinator made scheduled follow-up calls to patients within 72 hours of hospital discharge, then weekly for one month, twice in the second month, and monthly thereafter, unless a problem occurred that required more frequent contact. The telephone nurse followed a set script and pursued problems as clinically indicated, but did not adjust medications over the telephone. Patients had at least monthly clinic visits with a HF nurse; however, some visits occurred in the home. Patients in the control group were followed as usual. Data were collected at six months, and patients were followed for an additional three months. Telephone calls averaged 9.5 per patient, with duration of $16\pm9$ min per call; whereas clinic visits averaged 8.5 per patient, and the average length of a visit by a HF nurse was $57\pm21$ minutes (Kasper, Gerstenblith, Hefter, et al., 2002). There were 43 HF hospital admissions and 7
deaths in the intervention group, as compared with 59 HF admissions and 13 deaths in the control group \( (p=0.09) \). Additionally, dietary compliance was described to be good or average in patients in the intervention group vs the control group, based on a review of dietary history (65 of 94 patients vs 38 of 85 patients, \( p=0.001 \)). There was no difference, however, in medication compliance. Moreover, quality of life scores, as assessed by the Minnesota Living with Heart Failure Questionnaire (Rector & Cohn, 1992), and percentage of patients on target vasodilator therapy were significantly better in the intervention group. Finally, costs per patient in 1998 US dollars, were similar in both groups (Kasper, Gerstenblith, Hefter, et al., 2002).

These results may not apply to all patients with HF, because the investigators specifically targeted patients thought to be at high risk for readmission. It is likely that not all patients require such an extensive intervention (Kasper, Gerstenblith, Hefter, et al., 2002). Additionally, the program was multidisciplinary in nature and not designed to analyze the relative contributions of its various components. Moreover, it is unclear from these data whether telephonic management alone results in a benefit (Kasper, Gerstenblith, Hefter, et al., 2002). Therefore, further research is needed to identify which of these components is essential and if a briefer, less intense intervention will be as effective in a HF patient population.

Although previous studies evaluating the use of multidisciplinary care management have included telephone follow-up as a component of the intervention (Kasper, Gerstenblith, Hefter, et al., 2002), with the exception of Jerant et al. (2001), no studies have examined whether telephonic management alone results in improved outcomes in patients with HF. However, in the study by Jerant and colleagues (2001), patients also received a home nursing visit shortly after discharge and a second home nursing visit approximately sixty days later. Therefore, Riegel et al. (2002) evaluated the effectiveness of a standardized telephonic care-management intervention
to decrease resource use in patients with chronic heart failure. Three hundred fifty-eight patients were identified at hospitalization and assigned to receive six months of intervention (n=130) or usual care (n=228) based on randomization of their physician. Outcome data were collected at three and six months.

Nurses monitored, educated, and counseled patients by telephone in a standardized fashion guided by a computer program designed by clinical experts to support national guidelines for treatment of HF (Konstam, Dracup, Baker, 1994; Packer, Cohn, Abraham, 1999). The intervention group was telephoned within five days of hospital discharge and thereafter at a frequency guided by the software and case manager judgment based on patient symptoms, knowledge, and needs (Riegel, Carlson, Kopp, et al., 2002). During the calls, the nurses educated patients regarding such topics as medication adherence, diet recommendations, and identification of worsening signs and symptoms, with the goal of improving intermediary factors that would influence important outcomes such as hospitalization. Additionally, printed education material was mailed to patients monthly. Moreover, physicians were sent guidelines for the treatment of systolic HF with their first notification of patient progress (Konstam, Dracup, Baker, et al., 1994), and automated progress reports produced by the software on a regular basis (Riegel, Carlson, Kopp, et al., 2002). Furthermore, physicians were notified of discrepancies between patients’ reports of medications and treatments vs. actual physician orders. Care for patients in the usual care group was not standardized and no formal telephonic case management was in existence. However, these patients presumably received some education regarding HF management prior to hospital discharge (Riegel, Carlson, Glaser, et al., 2002).

The overall sample was elderly (72±12 years), almost equally divided by sex (51% female), and functionally compromised (ninety-seven percent were NYHA class III or IV). The
only significant differences between groups on demographic or clinical descriptors were a higher use of beta-blockers and a lower incidence of chronic lung disease in the intervention group (Riegel, Carlson, Kopp, et al., 2002). Patients received an average of seventeen phone calls at decreasing levels of intensity, length, and frequency over the six month follow-up period (median, 14 calls; interquartile range, 11-22 calls). The HF hospitalization rate was 45.7% lower in the intervention group at three months ($p=0.03$) and 47.8% lower at six months ($p=0.01$). Additionally, heart failure hospital days and multiple readmissions were significantly lower (both $p=0.03$) in the intervention group at six months. Furthermore, inpatient heart failure costs were 45.5% lower at six months ($p=0.04$). A cost savings was realized even after intervention costs were deducted, and there was no evidence of cost shifting to the outpatient setting. Lastly, patients in the intervention group reported significantly higher satisfaction with care than those receiving usual care.

The reduction in hospitalizations, costs, and other resource use achieved using standardized telephonic case management in the early months after a heart failure admission is greater than that usually achieved with pharmaceutical therapy and comparable with other disease management approaches (The Heart Outcomes Prevention Evaluation Study Investigators, 2000; The Digitalis Investigation Group (1997). The authors (Riegel, Carlson, Kopp, 2002) suggest that the effectiveness of the approach may be a function of the intensity and focus of the intervention, standardization, patient characteristics, or an interaction of these factors. Further study is needed for a clear understanding of specific factors responsible for the improved outcomes (Riegel, Carlson, Kopp, 2002).

McDonald, et al., (2002) addressed the question of whether multidisciplinary care of HF can reduce readmissions when optimal medical care is applied in both intervention and control
groups. Ninety eight patients (mean age, 71±11 years) admitted to the hospital with NYHA functional class IV HF were assigned to multidisciplinary care (n=51) or routine care (n=47). All patients received the same components of optimal inpatient medical care of HF, as defined by specialist-led inpatient care, titration to maximum tolerated dose of ACE inhibitor before discharge, and attainment of predetermined discharge criteria (symptomatically improved, weight stable, off all intravenous therapy, and no change in oral regimen for 2 days). Additionally, those in the multidisciplinary care group received nurse-led education and dietitian consults on three or more occasions during the index admission, followed by close follow-up for three months. Telephone follow-up occurred three days after discharge and weekly thereafter until twelve weeks. Moreover, patients and their next of kin attended the HF clinic at weeks two and six. Education topics included daily weight monitoring, salt restriction, and disease and medication understanding. The primary study endpoint was re-hospitalization or death for a HF-related issue at three months. At three months, four people (7.8%) had events in the multidisciplinary care group compared with twelve people (25.5%) in the routine care group (P=0.04). Additionally, readmission for HF was more frequent in the routine care group at 25.5%, compared to 3.9% in the multidisciplinary care group. Furthermore, patients in the multidisciplinary care group exhibited a greater understanding of HF, medications, and importance of sodium restriction upon hospital discharge as compared to the routine care group. The superior knowledge noted at discharge was sustained at 3 months.

These data demonstrate for the first time the intrinsic benefit of multidisciplinary care in the setting of protocol-driven, optimal medical management of HF (McDonald, Ledwidge, Cahill, et al., 2002). Moreover, the event rate of 7.8% at three months as the lowest reported rate
of such a high-risk group, underlines the value of an integrated inpatient and outpatient multidisciplinary approach to the management of HF.

Both randomized and nonrandomized controlled studies have linked HF case management to decreased readmissions (Rich, Beckham, Wittenberg, et al., 1995; Fonarow, Stevenson, Walden, et al., 1997; Stewart et al., 1998), cost savings (West, Miller, Parker, et al., 1997; Cline, Israelsson, Willenheimer, et al., 1998; Tilney, Whiting, Horrar, et al., 1998), and improved functional status (Fonarow, Stevenson, Walden, et al., 1997) in mostly homogeneous settings. Therefore, Laramee et al. (2003) conducted a study to test the effect of hospital-based nurse case management on ninety-day readmission rate in a heterogeneous population of HF patients (Laramee, Levinsky, Sargent, et al., 2003).

A total of 287 patients admitted to a five hundred fifty bed academic medical center with the primary or secondary diagnosis of HF, left ventricular dysfunction of less than forty percent, or radiologic evidence of pulmonary edema for which they underwent diuresis were randomized to the intervention (n=141) or usual care (n=146). The intervention consisted of four major components: early discharge planning, patient and family HF education, twelve weeks of telephone follow-up, and promotion of optimal HF medications. Patients in the study received post-discharge care locally from their own cardiologists, internists, or family practitioners. The dispersed outpatient setting was characterized by considerable variation of follow-up care; therefore, the objective of the study was to evaluate the effect of hospital-based nurse case management on readmission rates in a heterogeneous setting (Laramee, Levinsky, Sargent, et al., 2003).

Patients or family members received telephone calls at one to three days following hospital discharge, weekly for the first month, and every other week in the second and third
months. The telephone calls surveyed HF symptoms, medications, self-care activities, adherence to the treatment plan, and provided opportunity for patients and families to ask questions. Data, including demographics, NYHA classification, and readmission rates, were collected at enrollment and twelve weeks. Additionally, adherence to the treatment plan, as measured by self-report, and patient satisfaction were assessed at four and twelve weeks.

The ninety-day readmission rates were equal for the care-managed and usual care groups, with both at 37%. Total inpatient and outpatient median costs and readmission median cost were reduced fourteen percent and twenty-six percent, respectively, for the intervention group. Patients in the care-managed group were more likely to be taking HF medication at target doses, but dosages did not increase significantly throughout the twelve weeks. Although both groups took their medications as prescribed equally well, the rest of the adherence to treatment plan was significantly better in the care-managed group. Subgroup analysis of patients who lived locally and saw a cardiologist revealed significantly fewer HF readmissions for the intervention group as compared to the usual care group, at 2% and 14%, respectively ($P=0.03$). These results suggest several limitations to the generalizability of the HF care managed improved outcome link in a heterogeneous setting. One explanation is that the lack of coordinated system supports and varied accessibility to care in an extended, non-networked physician setting limits the effectiveness of the case management (Laramee, Levinsky, Sargent, et al., 2003).

In summary, the randomized trials provide strong support for the observational studies that multidisciplinary care management programs are efficacious in select patients with HF. Both randomized and nonrandomized controlled studies have linked HF care management to decreased readmissions (Rich, Beckham, Wittenberg, et al., 1995; Fonarow, Stevenson, Walden, et al., 1997; Stewart et al., 1998; Knox & Mischke, 1999; Serxner et al., 1999; Doughty et al.,
Based on available evidence, significant benefits have consistently been observed following implementation of multidisciplinary programs for patients with HF (refer to tables 3-6). However, despite the consistency of these findings, several important limitations must be recognized and there is considerable opportunity for additional research in this area.

First, most of the studies to date have been conducted as single-center trials at academic medical centers and in mostly homogeneous settings (refer to tables 1 and 3). Additionally, many studies recruited hospitalized patients, thus definite conclusions regarding the effect of the intervention on an outpatient population cannot be drawn. For these reasons, the generalizability of these findings to routine care of HF patients in the community remains uncertain. Therefore, there is a need for further studies evaluating HF disease management programs in larger and more diverse populations and practice settings, particularly the inner city, community hospitals and physician offices, and rural environments.

Secondly, because of the complexity of the HF syndrome and large number of topics that are important to discuss, a team approach has proven extremely useful in providing care and helping patients to understand and retain information about the treatment regimen (Fonarow, Stevenson, Walden, et al., 1997; Rich, Beckham, Wittenberg, et al., 1995). Indeed, physicians and a multitude of other clinicians including: advanced practice nurses, home health nurses,
dietitians, physical therapists, exercise physiologists, pharmacists, other professionals, and support groups may all play important roles in this process as shown by numerous studies (refer to Tables 1 and 2). However, many nonacademic centers may lack the necessary personnel to assemble an effective HF care management team. Additionally, it is unlikely that a single “cookbook” approach will be effective in a wide range of clinical environments and diverse patient populations. Therefore, more research should be done to determine the feasibility of translating disease management teams into clinical practice in various settings. Furthermore, a variety of HF care management models should be considered, and modified as needed to accommodate a given clinical environment.

A third limitation relates to the diversity of the components of the care-managed programs used in clinical trials. Interventions have included simple telephone follow-up, video monitoring, home visits, clinic visits and preemptive hospitalization. Programs have ranged from simple telephone follow-up by a nurse coordinator to extensive interventions with multiple components and comprehensive management teams. The efficacy of each strategy is largely unknown, and published studies have not been of sufficient size to determine the contribution of specific components. Additionally, despite the demonstrated benefits of exercise in patients with heart failure, the value of exercise in the context of a comprehensive heart failure management program has not been adequately studied.

Another limitation relates to individualization of the treatment plan to fit the needs of each patient. Table 7 displays the key components of a comprehensive nonpharmacologic heart failure program as recommended by the AHCPR guideline panel (Konstam, Dracup, Baker, et al., 1994). Because not all components of the program are appropriate for all patients, treatment must be individualized and adapted to accommodate the needs and circumstances of each patient.
Several studies indicate that factors related to patient behavior (such as knowledge of the HF syndrome, worsening symptoms, and compliance with treatment) account for the large numbers of hospital admissions (Konstam, Dracup, et al., 1994; Rich, Vinson, et al., 1993; Dracup, Baker, et al., 1994; Happ, Naylor, et al., 1997; Kasper, Gerstenblith, et al., 2002; Rich, Beckham, et al., 1995). Other barriers to effective care include the cost of medications and special diets (Kasper, et al., 2002). Due to the high rate of noncompliance with treatment, future studies should examine patient knowledge of HF, and interventions based on patient readiness to change (or adopt) specific lifestyle behaviors.

Lastly, although several studies indicate that factors related to patient behavior account for the large numbers of hospital admissions (Konstam, Dracup, et al., 1994; Rich, Vinson, et al., 1993; Dracup, Baker, et al., 1994; Happ, Naylor, et al., 1997; Kasper, Gerstenblith, et al., 2002; Rich, Beckham, et al., 1995), it has also been suggested that one reason for unsuccessful treatment may be the patient’s lack of understanding of the treatment plan, owing to the differing perspectives of the health-care professionals and the patient (Dracup, Baker, Dunbar, et al., 1994). Moreover, other barriers to effective care include a lack of coordination among various providers (Kasper, et al., 2002). Therefore, it has been suggested that not only is it necessary to have a disease specific protocol, but also a structured, integrated approach between the patient and primary and secondary care (Doughty, Wright, Pearl, et al., 2001).

Furthermore, despite the availability of published HF treatment guidelines, physician implementation of established guidelines remains suboptimal. Therefore, future studies should examine the reasons for the lack of guideline implementation and determine ways to promote greater adherence to established treatment guidelines.

**SUMMARY**
Heart failure develops as a response to an insult to the cardiovascular system. This insult results in a series of cardiac, circulatory, and muscular alterations with short- and long-time constants. These compensatory adaptations may initially be remarkably effective in normalizing cardiocirculatory function. Yet, the compensatory changes which are thought to be beneficial at rest appear to become restrictive during an acute bout of exercise. Furthermore, most compensatory changes exact a price and eventually give rise to many of the clinical syndrome of heart failure, including marked exercise intolerance and chronic fatigue.

The management of patients with heart failure is frequently confounded by a host of medical, behavioral, psychological, social, and economic factors. A considerable amount of the cost associated with heart failure care is attributable to repeated exacerbations that frequently require hospitalization. These exacerbations are often secondary to nonadherence to diet, medication, and activity regimens, inadequate symptom self-assessment and management, inadequacies in patient and care-giver education, and poor discharge planning and follow-up. Consequently, the use of a multidisciplinary team approach appears warranted for adequate management of these patients. In fact, a recent AHA Scientific statement examined the team management of heart failure patients (Grady, Dracup, et al., 2000) and indicated that components of successful healthcare delivery models for heart failure include staff skilled in the understanding of the pathophysiology of heart failure, patient assessment and evaluation of symptoms, education and counseling (focusing on symptoms and medication compliance), dietary consultation, and physical activity and exercise recommendations (see Table XII and XIII).

Multidisciplinary heart failure disease management programs recognize the complexity of medical, psychosocial, behavioral, and financial issues that are faced by many patients with
heart failure and their caregivers, and attempt to provide a relatively structured mechanism for overcoming many of the barriers to effective care. Although the optimal approach to heart failure disease management remains to be defined and may vary depending on the practice environment and patient characteristics, it is clear that such programs substantially improve the overall quality of care for heart failure patients and that they are likely to reduce costs. Although the trials differ in terms of design, duration, clinical personnel, patient characteristics, settings and outcome measures, the value of multidisciplinary programs has been consistently shown. Research has shown consistently that systematic follow-up and early treatment of symptoms can avert problems before they occur and reduce complications, readmissions, and costs.

Of particular relevance to the management of heart failure is the implementation of an adequate and tailored physical activity program. Evidence clearly indicates that patients with stable heart failure should participate in exercise training. The guidelines for and components of exercise training are similar to other clinical populations. However, the exercise prescription should be tailored to each patient’s unique demands and goals. As a result of training many of the peripheral abnormalities improve. These improvements translate to increased exercise tolerance, reduced activity-related symptoms, and improved quality of life. Finally, exercise training increases survival time and decreases health care costs in these patients.

Finally, it is clear from the literature that despite the overwhelming evidence of the efficacy of multidisciplinary programs and the position stand of the American Heart Association, there continues to be a lack of guideline implementation. Thus future studies need to continue to develop ways to promote the use of these strategies and to determine ways to enhance greater adherence in both clinicians and patients to established treatment guidelines.
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VITA

Tracie Rena Parish, the youngest daughter of Winston and Sandra Parish, was born September 27, 1971, in Jackson, Mississippi. She attended the University of Southern Mississippi, where she was a student athletic trainer and earned a Bachelor of Science in Human Performance and Recreation. Upon graduating from the University of Southern Mississippi she worked as a certified athletic trainer for Rehabilitation Center and Mississippi Sports Medicine, and attended Mississippi College on a full scholarship as a graduate assistant athletic trainer. Tracie completed her Masters in Education in 1997 before she progressed to Louisiana State University for doctoral studies. Whilst at Louisiana State University, Tracie initially served as the Training Room Supervisor at the LSU Recreational Sports Complex, then received a graduate assistantship through the Department of Kinesiology, and finally a doctoral fellowship from the Center of Disease Control and Prevention and Association of Teachers of Preventive Medicine. She also served as an athletic trainer and an instructor in the Department of Kinesiology from 2001 to 2003, before becoming a mother to Bailey Robin Parish in April of 2003. She is currently a doctoral candidate and works as an instructor at Mississippi College, where she will continue her teaching and research interests to help mold and develop a new generation of students to love exercise science as much as she does.