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Home-Based Cardiac Rehab vs. Center-Based Cardiac Rehab in Rural Areas

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by

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Table of Contents

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Abstract

Cardiac rehabilitation in rural areas can present unique challenges. The main challenge is the locations patients must travel to receive such care. Some patients are expected to travel more then an hour away, on multiple occasions during the week, to undergo therapy. This can be an issue for many patients and something that has been studied and is starting to be addressed in various countries. A literature review was done to see if there was a safe and effective alternative to the traditional center-based cardiac rehabilitation. The electronic search databases PubMed, Embase and CINAHL Complete were utilized to search for articles that addressed the four main topics of the paper: safety and efficacy of center-based cardiac rehab, safety and efficacy of home-based cardiac rehab, keys to successful implementation of home-based cardiac rehab, and projected outcomes of home-based cardiac rehabilitation in rural areas. Dalal et al. (2019) found that home-based cardiac rehabilitation was as safe and effective as the traditional approach and was a more affordable model. Antoniou et al. (2022) stated that "home-based cardiac rehabilitation interventions using wearable sensors can be as effective as center-based cardiac rehabilitation." Banner et al. (2015) stated that the patients who underwent home-based cardiac rehabilitation "demonstrated statistically significant improvement in exercise capacity, along with total cholesterol, LDL and saturated fat intake," to that of the traditional approach. Overall, home-based cardiac rehabilitation could be a safe and effective alternative to the center-based approach and is something that should be researched further.

Key words: home-based cardiac rehabilitation, center-based cardiac rehabilitation, cardiovascular diseases rehabilitation, and rural health

Introduction

The American Heart Association defines cardiac rehab as a "medically supervised program designed to improve cardiovascular health if you have experienced heart attack, heart failure, angioplasty or heart surgery." Currently, there are an estimated 2.3 million individuals in the United States that are participating in a cardiac rehabilitation program. The current rate of cardiac rehabilitation compliance, in rural areas of the United States, is right around 56 %. The traditional method has been having the patients go to a rehabilitation facility to participate, with the facilities typically being in the clinical or hospital setting. In rural America, this has become an issue due to the distance some have to travel to participate. According to Bakhshayeh et. al (2021) some patients must travel up to 2.5 hours to get to a rehabilitation center. Luckily, research has been completed and numerous other studies are currently being done to find a safe and effective alternative.

Home-based cardiac rehabilitation is completed in the patient's own home. This is completed by using different technology to ensure that the patient is meeting health criteria and is always monitored by trained professionals.

Statement of Problem

Cardiac rehabilitation is a crucial step in the treatment of patients with previous heart history; however, access to the traditional rehabilitation centers, in the rural setting, is a significant barrier for many. This is a grave concern for compliance in the completion of such programs. A safe and effective alternative to the traditional approach that provides a safe and effective outcome within a patient's home, then the overall compliance can be increased.

Research Question

For patients in rural areas with coronary artery disease, is home-based cardiac rehab an effective and safe alternative to in-person, center-based cardiac rehab?

Methods

A literature review was conducted using the electronic search databases PubMed, Embase and CINAHL Complete. A keyword search was used, and mesh terms were applied to define home-based and center-based cardiac rehabilitation. Further mesh terms were applied that contained cardiovascular diseases/ rehabilitation and rural health. PubMed revealed a total of 723 results. The studies that were not solely in English were then excluded from the search. This was further refined by limiting to studies that were completed from 2010 to 2022; this narrowed the results to 287. Article types that included clinical trials, meta-analysis, and randomized controlled trials were selected; this brought the total number of results down to 141. A search of Embase and CINAHL Complete found no additional studies. After finding that there were no other studies that were beneficial to this study; PubMed was solely used. Many of the 141 studies were eventually excluded from the literature review because they did not specifically look at either the safety, efficacy, patient satisfaction or implementation of various cardiac rehabilitation programs. Fifteen studies met the criteria and were included in the review. Three of the 15 looked specifically at center-based cardiac rehab, four looked specifically at home-based or virtual cardiac rehab, and the remaining eight compared the two in some capacity. Four meta-analyses were selected to be included in the review and were scrutinized to ensure that there was no overlap of studies used.

Literature Review

Safety and Efficacy of Center-Based Cardiac Rehab

Patti et al. (2021) examined 57 studies and the overall effectiveness of exercise-based cardiac rehab. Fifty-one of the studies were from traditional, center-based cardiac rehabilitation (CBCR) programs and the other six studies were from home-based cardiac rehabilitation (HBCR) programs. Patti et al. (2021) looked at five main areas for this study and the effect that exercise tolerance had on the participants.

The first area that they looked at was skeletal myopathy and sarcopenia. They found that increased exercise tolerance can result in an increase in the overall oxidative capacity of muscles thus improving their overall performance by delaying the onset of anaerobic metabolism and limiting muscle fatigue.

The second area that they looked at was the "central" effects. These are the effects at the cardiac and neurohumoral level. Several of the studies that they looked at found that an increased exercise tolerance in patients with heart failure can improve left ventricular ejection fraction by more than 2.6%, which was a statistically significant number with a p value of 0.03.

The third area that they looked at was the effects on functional capacity. They found that peak vital oxygen levels can improve anywhere from 13% to 31%. Furthermore, with the addition of strength training, a patient can have improvement in overall muscle strength, aerobic capacity, and quality of life.

The fourth area that they looked at was the overall outcome of the patient. "In patients with symptomatic heart failure, physical inactivity has been shown to be associated with higher

all-cause and cardiac mortality, while even modest exercise is associated with survival benefit," (Patti et al., 2021). This study cited another meta-analysis by the Cochrane Collaboration Group, and they found that cardiac rehabilitation may make little or no difference in all-cause mortality in the short term but may improve all-cause mortality in the long term (>12 months) compared with no exercise controls.

The fifth area that they looked at was the effects of exercise tolerance on quality of life and depression. "There is a large agreement on the positive effects of exercise tolerance on quality of life and depression metrics" (Patti et al., 2021). Sixteen of the studies that they looked at addressed this very issue and all of them came to the same conclusion: exercise tolerance reduced symptoms of depression, with an antidepressant-type effect.

Patti et al. (2021) went into detail on various criteria and indications for patient referral to an exercise training program. These criteria included the preliminary evaluation of the patient, aerobic interval training vs. continuous aerobic training, the addition of resistance training, and inspiratory training.

Patti et al. (2021) found that exercise tolerance has beneficial effects on multiple levels in patients with heart failure and is recommended by major societies. Exercise tolerance can have significant positive impact on exercise capacity, heart health, quality of life, the reduction of depression and associated symptoms. They also found that there is no overall agreement on a universal exercise prescription for all patients. "The intervention has thus to be individualized after an accurate evaluation of the patients' cardiovascular conditions and functional capacity", (Patti et al., 2021).

There were a couple of issues in this study. The first issue was the lack of information on the overall patient demographics and size of each study. Another area that was lacking was the

criteria that was used to determine a patient's quality of life. There are various scales and qualitative measures that are used to measure a patient's quality of life; none of which were used limited the ability to compare or replicate the studies. This is an important piece to accurately compare studies and the ability to replicate the studies if one chose to. No bias was noted.

Martin et al. (2013) conducted a retrospective study to assess the association between cardiorespiratory fitness and cardiac rehabilitation (CR) outcomes. The study used 5641 patients; 4282 were male and 1359 were female. The study population was from Calgary and Alberta in Canada. All the patients that participated in the study were previously diagnosed with coronary artery disease. The participants underwent a baseline physical examination that included weight, height, waist circumference, blood studies, and preliminary exercise tolerance. They were then classified into three categories: low fitness, moderate fitness, and high fitness. They used peak metabolic equivalents (MET) for these categories. Usually, the patients that were listed in the low fitness also had multiple other co-morbidities including diabetes, hypertension, hyperlipidemia, and pulmonary disfunction. They were enrolled in a CBCR program that consisted of a 12-week comprehensive program that was directly under the supervision of a physician, nurse, and exercise physiologist. All the patients that they looked at were from July 1, 1996, to February 28, 2009.

Martin et al. (2013) looked at all-cause mortality as their benchmark for the results. The variables that they used included overall exercise tolerance and mortality. With every point increase in metabolic equivalent there was a decrease in overall mortality of 13% with a significant p value of <0.001. "This association was even stronger for those who started with a low fitness; those patients had a 30% per point reduction in their overall mortality ($p < 0.001$)". (Martin et al., 2013).

They concluded that the initial classification of the patient was a major determinant into the overall mortality of the patient. Those patients that came into the study with an initial exercise tolerance that was higher did better at the end of the study. Those that came into the study with a low fitness to begin with had a poorer overall outcome. “Baseline cardiorespiratory fitness is highly predictive of long-term mortality in patients with coronary artery disease attending cardiac rehabilitation.” (Martin et al., 2013).

There were areas in the study that left room for improvement. The first area was regarding the patient demographic for the study. Close to 76 % of the participants were male. This will ultimately skew the statistics for the patient population. Another area for improvement would be to add various metrics including the patient’s overall sense of health and quality of life. No bias was noted.

Xia et al. (2018) completed a meta-analysis that looked at the overall efficacy of different types of exercise-based CR. They compiled a total of 60 randomized clinical trials in their study, and they were gathered from over 18 countries. In all of the studies combined there were a total of 19,411 patients. They reviewed various types of CR including CBCR, HBCR, tele-based and combined or hybrid-type programs. Eleven of the 37 trials evaluated programs that contained both aerobic exercise and strength training, while the other 26 studies only looked at aerobic exercise. The primary endpoint for their analysis was all-cause death of the patient. They also specifically looked at cardiovascular death, recurrent fatal and non-fatal myocardial infarction, recurrent coronary bypass grafting, and hospital readmission during follow-up. In all the articles that they looked at, the most prevalent comparison was CBCR vs. usual care (no cardiac rehabilitation).

Xia et al. (2018) concluded that CBCR drastically reduced all-cause mortality vs. no CR, with a p value = 0.002. They also found that CBCR was directly associated to a lower overall incidence of cardiovascular death vs. no CR; this also had a significant p value of 0.002. The authors concluded that "Current evidence suggests that center-based cardiac rehab is acceptable for patients. As home-and tele-based cardiac rehab can save time, money, effort, and resources and may be preferred by patients, their efficacy should be investigated further in subsequent studies" (Xia et al., 2018).

The main drawback of this meta-analysis is that it only considered the physical health of the patient and not the mental health. If the overall patient's mental health and quality of life would have been studied than it would have been a well-rounded study. They also did not have a lot of statistical analysis of the other types of CR and mostly just looked at CBCR. No bias was noted.

Safety and Efficacy of Home-Based Cardiac Rehab

Dalal et al. (2019) studied the efficacy and costs of HBCR in patients with coronary artery disease. This study specifically studied patients with reduced ejection heart failure. This is an important study due to the relationship of overall patient outcomes and the associated cost that is associated to it. The study compared the new rehabilitation enablement in chronic heart failure (REACH-HF) intervention to that of the traditional center-based approach. REACH-HF is a "novel home-based cardiac rehabilitation intervention derived from health behavior change theory for people with heart failure and their caregivers, which is facilitated by a health care professional," (Dalal et. al., 2019). The researchers hypothesized that the addition of the REACH-HF would improve a patient's overall quality of life (QOL) and be a cost-effective alternative to the traditional approach.

The study had 216 participants, of which 78% were male. The average age of the participant group was 70 years old. All the participants in the study had to have a reduced ejection fraction (EF) with a mean of 34%. One hundred and eighty-five participants finished the study and were able to provide data. Thirty-one participants did not finish the study for various reasons including personal, family, participant passing away, and the researchers not being able to contact the participants. The participants were randomly allocated to either the REACH-HF group (107) or the control group (109), which consisted of the traditional approach.

The study looked at the Minnesota living with heart failure questionnaire (MLFHQ) to determine the patient's QOL score at 12-months. This questionnaire is comprised of 21 questions around several physical, emotional, and socioeconomic ways heart failure can adversely affect a patient's life. The patient marks 0-5 for each question, with 5 being the highest, for the extent each item adversely affects their QOL; for a maximum score of 106. The researchers found that there was a 5.7 overall point reduction (95% confidence interval -10.6 to -.7) for patients that participated in the REACH-HF group ($p= 0.025$) and a 1.1-point reduction in the control group ($p= 0.01$).

The researchers also looked at secondary outcomes including overall rehospitalization, increased EF, death, and exercise capacity. They found no statistical difference (p value = 0.05). The study also looked at the overall cost of implementation of the REACH-HF protocol. They found the median cost to be 418.39 Euros in the REACH-HF group vs. the control group at 509.21 Euros.

Dalal et al. (2019) stated that "the benefits of an affordable, novel home-based cardiac rehabilitation intervention that offers patients, clinicians and healthcare commissioners an additional option to center-based cardiac rehabilitation is important."

There are a few areas that the study could be improved including the patient's demographics, the current diagnosis, and the overall length of the study. Seventy-eight percent of the participants were male makes it difficult to apply to the general population. The study only looks at participants with reduced EF. Further studies could investigate patients with preserved EF. It would also be beneficial to follow the patients for years to come. This would require a larger staff and more time but something that may be beneficial. There was also a lack of blinding in the study, which the researchers acknowledged. They did not mask participants to the treatments that they were getting, which may have inadvertently led to the responses on the MLFHQ being biased.

Stefanakis et al. (2022) completed a meta-analysis, looking at nine different studies to determine the overall safety of HBCR. They looked at studies from the United States, Poland, Netherlands, Czech Republic, Australia, Spain, and the Dutch. The total sample size of patients that they looked at was 808, ranging from 13-425 per study. All had an intervention group and a control group.

All included studies in the meta-analysis used patient exercise hours as the measure for adverse effects. Only one study reported an adverse effect related to exercise in which required emergency services. "The significant finding is that home-based cardiac rehab seems to be a safe alternative, with the incidence of one severe adverse event per 23,823 patient hours of exercise; no exercise-related deaths or hospitalizations were recorded," (Stefanakis et al., 2022). In both HBCR and CBCR, most of the adverse effects noted were related to hypotensive exercise reactions. They concluded, it can be assumed that in the HBCR model, mild adverse effects can be partially prevented by comprehensive baseline education and ongoing telemonitoring.

The researchers also compared HBCR adverse effects to CBCR adverse effects. They found that the rate of adverse events in CBCR was one per 49,565 patient hours of exercise and one per 63,289 patient hours in the HBCR group. Stefanakis et al. ultimately concluded that special care should be taken during the first sessions of CR.

Stefanakis et al. (2022) determined that HBCR could provide a safe and usable alternative to the traditional CBCR. The overall incidence of adverse effects in the selected studies was low and not statistically significant compared to the traditional model. More importantly they found that the HBCR model could be an "equivalent intervention model for stable patients with coronary vascular disease at all levels of risk," and who do not have proper access to services.

The overall size of the meta-analysis would be a limitation. The researchers' methods in restricting the number of studies that were included limited the number of participants in the study. No demographics of the participants were noted making it difficult to compare for each of the nine studies. With not knowing this, it is hard to draw a complete comparison and unbiased view on the actual safety for all patient populations.

A larger group of eligible patients needs to be studied to establish safety. These groups, according to Stefanakis et al. include older adults, patients with multiple diseases, obese individuals, frail patients, socioeconomically impaired patients, ethnic minorities, and rural residents. No bias was noted.

Bravo-Escobar conducted a study in Spain with the control group being treated at Virgen de la Victoria Hospital. The study examined the safety and efficacy of HBCR versus the traditional CBCR approach. This was a real-time study in which there were 28 original participants. All participants were male with a median age of 56 years old. All the participants

had similar conditions and were on similar medications. Fourteen were put in the control group which would attend the traditional CBCR multiple times a week. The remaining 14 were placed in the experimental group. Both the control group and the experimental group would participate in the study for a total of two months. They both started the study five to six months post cardiac event. The control group went to the hospital for the traditional treatment four to five times a week. The experimental group started the first month by reaching 70% of their maximum heart rate four to five times a week and then the second month they reached 80% of their target heart rate. For both groups the body weight and BMI were measured along with blood pressure, exercise capacity in terms of METS, laboratory measurements (cholesterol, HbA1C), and the assessment of overall QOL of the patient. The QOL was measured using a continual medical outcome survey that was given to the patients on a weekly basis (Bravo-Escobar et al. 2017). The results showed that HBCR was as effective and safe as the traditional CBCR model in all the measured categories except one. The QOL measures were greater amongst the control group. No causation was identified for these findings but was felt by the authors to be a notable difference.

The authors concluded “future lines of research should analyze how the design of home-based programs could improve these results; bearing in mind the multi-dimensional nature of quality of life” (Bravo-Escobar et al. 2017).

In this study, control and experimental groups were well matched for age, diagnosis, and use of medication. There was only one drop out of the study and that was in the experimental group due to personal issues. The use of the QOL survey is a very subjective data point and one that could be easily influenced by day-to-day happens in the person’s life. A more objective measurement would strengthen the study. No bias was noted.

Keys to Successful Implementation, in a Rural Setting, of Home-Based Cardiac Rehab

Antoniou et al. (2022) completed a meta-analysis that looked at the effectiveness of wearable sensors in HBCR and compared it to traditional CBCR methods. They looked at a total of 14 randomized control trials from 2010 to 2022. There was a total of 1,263 patients. Aerobic exercise was the primary source of exercise for the HBCR group.

Several different types of wearable sensors were used. They assessed, monitored, and recorded vital signs. The participants were continually monitored for the safety of the exercise sessions. Electrocardiographic monitoring was also used in four different studies during the exercise sessions. Heart rate devices were used in all the studies to record the exercise data and evaluate training duration and intensity. A sphygmomanometer and finger pulse oximeter were provided to the participants to verbally report their blood pressure, heart rate, and oxygen saturation at the beginning and end of each session.

Antoniou et al. (2022) looked for both primary and secondary outcomes in the studies analyzed. The primary outcome of the study was to assess the overall cardiopulmonary function of the participants. Peak oxygen consumption was used to assess cardiopulmonary exercise tolerance. "The random and fixed effects model revealed a significant post-intervention in favor of home-based cardiac rehab on cardiopulmonary function with a medium effect size ($g = 0.22$, 95 %, CI 0.06 to 0.39)," (Antoniou et al. 2022).

The secondary outcomes included physical activity, QOL, training adherence, cardiovascular risk factors, laboratory factors, stress, overall patient satisfaction, and muscle strength. Physical activity was assessed using questionnaires and accelerometers to assess steps per day. QOL was measured using various questionnaires. Cardiovascular risk factors and laboratory parameters were measured by overall glycemic control and low-density lipoproteins.

In all the secondary outcomes there was no significant difference between the intervention group and the control group.

Antoniou et al. (2022) concluded that "home-based cardiac rehabilitation interventions using wearable sensors can be as effective as center-based cardiac rehabilitation". The authors acknowledge a few limitations in their study. The first limitation was overall small sample size; most of the studies had fewer than 100 participants in them and most of the patients in the studies were male. "Moreover, information about the socioeconomic background, educational level, or place of residence was also missing," (Antoniou et al. 2022). All the studies were also conducted in first-world countries, so it is difficult to generalize the results to all patients.

Bakhshayeh et al. (2021) wanted to study barriers to CBCR and the overall attitude towards HBCR. The researchers had a total of 204 participants in the study. They were a mix of 88% male and 12% female. The study took place in 2017 in Iran. All the individuals in the study had previously been enrolled in CBCR but had since stopped for various factors. These factors were investigated using the modified CR barriers scale. The patients were then enrolled in a HBCR program, and their attitudes towards HBCR were collected using a pre-validated researcher-made questionnaire.

Bakhshayeh et al. (2021) found that the major barriers to CBCR were transportation, travel costs, distance to the rehabilitation center, and overall lack of insurance coverage for the required treatment. They generally found that if a patient lived more than 30 minutes away from the rehab center, then they were less likely to attend the sessions that they needed.

Researchers found that the overall sentiment towards HBCR was favorable. Improvement in the overall patient stress level, patient satisfaction, and QOL were noted with a p value of 0.002. The patients in the study did note that they expected proper communication with the

specialist, training before entering the CR program, and periodic visits to the rehabilitation center to maintain adherence to the HBCR program. “Logistical factors were the major barriers to participation in rehabilitation programs,” (Bakhshayeh et al., 2021). They also stated that “alternative models such as home-based cardiac rehabilitation programs, can be used to overcome these barriers”.

There were a few limitations to his study. The most obvious limitation was the demographics of the patient population. The socioeconomic background of the patients was also not discussed in depth and may lead to possible bias in the results.

Field et al. conducted a study in Australia. They stated, “Morbidity and mortality from heart disease continues to be high in Australia with cardiac rehabilitation recognized as best practice for people with heart disease,” (Field et al., 2018). This study aimed to find the barriers that were associated to non-compliance of patients enrolled in CR in rural areas. The researchers reviewed 16 studies that were a mix of qualitative and quantitative studies. All were from peer-reviewed journals from 2007-2016. Five themes were found to be common between the studies and they were: referral to CR and continuing along the health pathway, cultural and geographic factors necessitating alternative programs, professional roles and influence, psychosocial factors, and financial costs.

Field et al. (2018) found that the major factors that impacted the compliance of CBCR were the general discharge process currently in place, the need for improved accessibility of services, and the geographical restraint for patients travel to treatments. They also found that it was vital for the health professionals to understand, value, and support the patients in their mental health, travel costs, medications, health consultations, and involvement in the patient’s course of treatment. “This study found weak systems with low referral rates and poor access to

cardiac rehabilitation in rural and remote areas," (Field et al., 2018). They also noted that "the findings demonstrate the need for improved models of referral and access, greater flexibility of programs and professional roles."

This study primarily looked at Australia and the Indigenous people that lived there and due to that can be considered a limitation. The studies were small in sample size and hard to reproduce around the world. The sponsor of the study was the Rural and Remote Health Organization which may bias outcomes.

Kikuchi et al. (2021) set out to evaluate the overall feasibility and safety of a remote monitoring system that could be used to monitor a HBCR program. "Cardiac rehabilitation is a widely recommended evidence-based intervention for patients with cardiovascular disease. However, the participation rate has been reported to be low globally, mainly due to barriers in access to the cardiac-rehabilitation center," (Kikuchi et al., 2021). This study was a prospective, interventional study that took place in Osaka, Japan during the winter and spring of 2018. The researchers specifically looked at elderly patients with the diagnosis of heart failure. There were 10 participants in the study: 6 males and 4 females. The median age of the group was 76 years old.

The intervention of this study was a 12-week HBCR program that used an integrated telerehabilitation platform that allowed for real-time supervision of the patients. The platform consisted of an ergometer (exercise device), tablet, and an electrocardiographic monitoring device. The researchers spent 30 minutes setting up the equipment at the participants house and another 60 minutes on instructions. All the participants underwent an initial assessment consisting of baseline labs, electrocardiogram, 6-minute walk test, lower extremity muscle strength, and a cardio-pulmonary exercise test. A New York Heart Association functional

classification and exercise habits test were also obtained. The participants were then grouped into three categories: good, fair, and poor pre-intervention health.

The primary outcome was the overall feasibility and safety of the program. Feasibility was assessed by the overall participation rate. There were three sessions each week for a total of 36 sessions. Safety was monitored by adverse events during the sessions. The secondary outcome was the change in exercise tolerance of the participants.

Primary outcomes were as follows: median participation rate was 94.4% with an overall positive experience from both the participant and the clinic staff. Regarding adverse effects, four participants had fatigue during exercise, one had a common cold, and one participant had heart palpitations. No serious cardiac events were noted during exercise that led to heart failure exacerbations, need for emergency services, or hospitalization.

Secondary outcomes of the study were as follows: 6-minute walk distance was drastically increased from 383 to 432 feet, a p value of 0.003, lower extremity muscle strength increased from 17.2 to 20.3 with a p value of 0.022, systolic and diastolic blood pressure decreased from 114 to 107 and 68 to 66 with p values of 0.126 and 0.330 respectively. As far as lab values there was no significant difference between pre and post.

Kikuchi et al. (2021) concluded that “home-based cardiac rehabilitation under real-time supervision was feasible and safe among elderly heart failure patients”. An integrated platform is a suitable option for patients who cannot participate in a CBCR program for various issues including geography or social economic status. “A prospective randomized study in a larger cohort is required to prove the efficacy of the concept and system,” (Kikuchi et al., 2021).

The author notes the limitation of the study including the patient size and the overall demographics of the population. Since the authors used software that they created it led to inevitable bias within the study.

Projected Outcomes of Home-Based Cardiac Rehab in Rural Patients

CR is important for individuals that suffer from a myocardial infarction or other major cardiac conditions. It not only helps to strengthen the heart but helps to educate the patient on ways to live a fulfilled life. The American Association of Cardiovascular and pulmonary rehabilitation, the American Heart Association and the American College of Cardiology compiled various studies from around the world and completed a meta-analysis. Their purpose was to "identify the core components, efficacy, strengths, limitations, evidence gaps, and research necessary to guide the future delivery of home-based cardiac rehab in the United States," (Thomas et al., 2019). This meta-analysis was a comprehensive search of various research databases and pulled a total of 23 studies from January 1980 to January 2017. The review compared the overall design of the studies, the participants, length of follow-up, adherence, and health outcomes. A total of 2951 patients participated in the trials ranging anywhere from 20 to 525 patients per trial. The studies followed the patients anywhere from six months to six years. Four of these studies exclusively looked at patients with heart failure. The remaining studies used patients with uncomplicated myocardial infarction as the primary diagnosis. Thomas et al. (2019) looked at five core components of HBCR; these were the patient assessment, exercise training, dietary counseling, risk factor management (smoking, lipids, blood pressure, weight, and diabetes mellitus), and psychological intervention.

Thomas et al. (2019) found key factors in the successful implementation of HBCR. The first included the patient's overall motivation towards home delivery of therapy, self-efficacy,

and the patient's engagement. A few of the studies pointed to the six-stage transtheoretical stages of change model as a determinant of successful implementation. This model looks at the readiness to change a lifestyle habit. A person with a higher value was more likely to be successful. The second factor in successful implementation that the study found at the provider-level. They found that the provider had three very vital roles in the implementation process; these were referring eligible patients, encouraging patient participation, and communicating the importance of long-term lifestyle changes. The last factor for successful implementation is at the system-level including overall endorsement of HBCR by the American health system and the reimbursement for services.

Thomas et al. (2019) found very strong evidence that HBCR is a safe and effective alternative to the traditional CBCR in the mild to moderate patient risk categories. The authors concluded that there are definite hurdles that must be overcome in the United States before see large scale adoption. These hurdles include the overall cost and reimbursement, participation and adherence of the patient population, effective communication, and social support along with the overall standardization of care. If these items are addressed and solutions are found, then they believe this is a very viable option in the future.

One drawback of the Thomas et al. study was lack of comment regarding overall safety of HBCR. Most of their studies looked at patients in the mild to moderate cardiac risk categories and not severe risk categories. For the mild to moderate risk categories, they found that there was no statistical significance in overall safety between HBCR and CBCR. Since they did not investigate the severe risk category, this limits the studies overall application to this patient population, and thus no definite conclusion can be drawn on the overall safety. No bias was noted.

Chen et al. (2008) conducted a prospective randomized study where a total of 75 individuals participated from June 2013 to March of 2014 in Taichung Veterans General Hospital. The patient's used in the study had an EF that was less than 50%. The study split the 75 individuals into two groups: the control group with 40 participants and the interventional group with 35 people. The median age of the two groups was 60.5 with a standard deviation of 16. The n values for the control group were 18 and the intervention group was 19. The control group were patients that received only 1 week of out-patient CR. The interventional group received the initial 1 week of out-patient CR followed by 3 months of monitored HBCR. These individuals were expected to exercise three times a week for 30 minutes at a time. They were expected to reach a peak heart rate of 60 to 80 percent of the expected.

The results of the study showed that there was a statistically significant patient improvement in the ones that received HBCR. Major findings included an improvement in vital oxygen levels with and without exercise. The QOL of the individuals with HBCR were also significantly improved over the control group. The QOL was measured using a survey that was provided to the participants pre and post experiment. The 6-minute walking distance was also significantly improved in the patients who received HBCR. The total difference was 41 meters which is a considerable change in distance. There was no significant difference in change of the left ventricular EF between the two groups, however more research needs to be done on this according to Chen et al. (2008).

The limitations of the study, according to Chen et al. (2008) were the limited number of subjects that were tested, the high rate of loss follow-up, and a predominantly male subject pool. Of the original 75 individuals that started the study only 37 completed it for various reasons: 17 for the interventional group and 18 for the control group. This limited size is concerning for the

reproducibility of the study. The higher proportion of male subjects may limit reproducibility of the study findings to that of female patients.

Banner et al. (2015) completed 16-week mixed methods randomized control study that looked at the impact of what a virtual CR program had on a patient's overall health and satisfaction. The study was set up to be similar in nature to a standard CBCR program. This included an online intake process that included a patient's medical history, risk factors, and current lifestyle. It also included a one-on-one online session with a program case manager, exercise specialist, and dietician, weekly educational session, and collecting data from the exercise tests that the participants participated in. Seventy-eight patients participated in in the study with 38 being in the intervention group and 40 being in the control group. The interventional group received initial orientation into the program and baseline lab work and vitals. The participants were then given a list of activities to complete for the week; in total the study lasted for 16 weeks. At the end of the study a semi-structured interview was completed to obtain the qualitative results.

Banner et al. (2015) data showed a good participation rate in program activities, website logins, and individual chat sessions with the trial manager, dietician, and exercise specialist. Researchers also found that the interventional groups "demonstrated statistically significant improvement in exercise capacity, along with total cholesterol, LDL and saturated fat intake," (Banner et al, 2015). The data that they collected revealed some common core themes which included: accessibility, making health choices, surveillance, barriers to participation, and perception of the program.

The study showed that many of the participants were "satisfied" with how the program was structured and the fact that they could complete CR in their own home, at their convenience.

There was no need for travel which contributed to the satisfaction of the participants that did not live close to the rehab center.

Some of the participants did report low-to-moderate levels of involvement, however. This was due to several reasons including the patient's lack of time, access issues to the internet, overall lack of motivation of the patient, and overall poor computer competency of the patients. The authors concluded that "the virtual cardiac rehabilitation program was an accessible, convenient and effective way to deliver services," (Banner et al, 2015).

There were some limitations of this study. The first area that was of concern was the patient's demographics. The research failed to give the breakdown of the demographics, just stating that they covered a vast variety of patients. We also did not know what the patient's initial diagnosis or if they have completed a previous CR program. There was also no mention or documentation of what the end of study survey contained. The authors did not disclose any limitations or note lack of bias.

Discussion

Cardiac rehabilitation has proven to increase exercise tolerance, mental health, and reduce overall mortality in patients with cardiovascular disease. Unfortunately, many of the rehabilitation centers are not easily accessible for patients in rural areas. This literature review was completed to determine if there is an acceptable alternative to the traditional CBCR approach.

Dalal et al. (2019) conducted the REACH-HF study that has been widely cited in various medical journals. They found that the overall QOL of the patients that participated in a HBCR program was increased compared to that of the traditional CBCR approach. Due to the fact that this study was completed in Europe we need to be cautious to draw a complete comparison. The

fact that the overall cost per patient was decreased in the HBCR approach, was also statistically significant. Another study by Brave-Escobar et al. (2017) showed that HBCR programs, if administered correctly, were as effective and safe as the traditional CBCR programs.

Stefanakis et al. (2022) completed a meta-analysis that looked at the overall safety of various HBCR programs. They concluded that HBCR programs could "provide a safe and usable alternative to the traditional center-based rehabilitation," and that it was "equivalent intervention model for stable patients with CAD at all levels of risk," (Stefanakis et al., 2022).

These three studies and meta-analyses demonstrate that if the HBCR programs are administered correctly and under proper guidance, they can be as safe and effective as the traditional model. More importantly is the fact that the HBCR model can drastically improve the patient's overall QOL.

There are various barriers that were addressed in terms of CR in the rural settings. Bakhshayeh et al. (2021) found that some of the main barriers for patients to participate in CBCR programs were transportation to and from the center, travel costs, distance to the rehabilitation center, and the overall insurance coverage for the treatment. Fidel et al. (2018) added to this by finding that there was a general need for improved accessibility to services in geographical distant areas. They also concluded that "the findings demonstrate the need for improved models of referral and access, greater flexibility of programs and professional roles," (Fidel et al., 2018).

The above studies found that there is indeed a barrier to CBCR for patients in rural areas and technology can help to remove this barrier. Kikuchi et al. (2021) completed a 12-week long study that looked at the integration of a telerehabilitation platform that allowed patients to stay in their own homes. The participants were directly monitored using an app on a tablet and the

addition of an ergometer. They found that "home-based cardiac rehabilitation, under real-time supervision, was feasible and safe among elderly heart failure patients," (Kikuchi et al., 2021).

Antoniou et al. (2022) completed a meta-analysis that looked at the overall effectiveness of wearing sensors in HBCR programs and compared it to the CBCR methods. They looked at a total of 14 different studies that used various types of wearable sensors in HBCR settings. They concluded that "home-based cardiac rehabilitation interventions using wearable sensors can be as effective as center-based cardiac rehabilitation".

Banner et al. (2015) also completed a 16-month randomized study that looked at the overall effectiveness and satisfaction that patients had that participated in HBCR programs. They found that almost all the participants in HBCR were "satisfied" with how the program was structed and the outcomes. "The virtual cardiac rehabilitation program was an accessible, convenient and effective way to deliver services," (Banner et al, 2015).

The evolution of telemedicine has given us the opportunity to utilize technology to increase the overall effectiveness of various programs. If we continue to put emphasize on technology and use an open-minded healthcare philosophy, we will continue to advance patient experience and outcomes.

These studies demonstrate that there are various ways HBCR programs can be implemented from simple wearable sensors to more sophisticated technology under direct supervision. The programs can be tailored to the patient so that they can complete the program easier, faster, and with better outcomes.

The last thing that was looked at was the expected outcomes of HBCR programs. Thomas et al. (2019) found that the initial implementation cost of the program and the reimbursement that hospitals will receive needs to be addressed before it is feasible to roll out nationwide. Other

barriers included overall participation and adherence to the program from the patients, effective education, communication, and the social supports needed to ensure that it remains an effective and viable option.

All these studies and results point to the fact that HBCR programs are alternatives to CBCR. They are as effective in overall safety and efficacy and are even found to be superior in overall patient satisfaction and overall QOL.

The largest barrier to implementation of HBCR in rural areas is for large health care entities to invest into the program and understand that initial investment upfront will have significant benefits downstream. Staffing is a significant issue for most hospitals around the country. By allowing patients to stay at home and be "monitored" via camera means that the overall staff needed to administer the program can be minimized. Another area that hospitals can save money by implementing a HBCR programs, is not having to have the floor space dedicated to the traditional program; instead, they can repurpose the space.

Money drives most of the decisions that are made in healthcare. Proper reimbursement strategies for hospitals needs to be figured out before they will implement a program. No hospital system will utilize a program that loses large amounts of money, or that they do not get properly reimbursed for. There needs to be a push at the legislative level and a look at making changes to insurance reimbursements and Medicare.

Thomas et al. (2019) also found that we need to ensure that proper education and training is given to the patients for them to be successful in the program. There is also an argument that can be made to properly train CR staff to implement HBCR.

Further research is needed on feasibility of HBCR programs in the United States. Since most of these programs require high-quality internet as a requirement, we need to ensure that

proper infrastructure is in place in rural areas of the country. The studies also need to determine what advances in technology are necessary to make the equipment more accessible and affordable for the patients.

Conclusion

There is strong evidence that shows HBCR, with proper supervision, is safe and effective in decreasing a patient's mortality and improving overall health. HBCR programs also have been found to be more effective in improving a patient's overall satisfaction and QOL then the traditional CBCR. With proper support from health care entities, insurance companies, patients, and clinicians, HBCR programs can be a safe and effective alternative to the traditional CBCR approach.

Applicability to Clinical Practice

Due to the overall low participation rate of CR, in rural America, we must find an alternate means for patients to participate in a program that gives them flexibility and ensures that we increase the overall compliance. Compliance will then increase overall health in our patients.

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