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A COMPARISON OF OUTCOMES OF A HOME-BASED CARDIAC REHABILITATION PROGRAM AS AN ALTERNATIVE TO TRADITIONAL OUTPATIENT PHASE II CARDIAC REHABILITATION

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Abstract – A Comparison of Outcomes of a Home-Base Cardiac Rehabilitation Program as an Alternative to Traditional Outpatient Phase II Cardiac Rehabilitation

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Phase II outpatient cardiac rehabilitation (CR) is an intervention offered to patients that have been diagnosed with heart disease, undergone various procedures such as stenting or valve replacement, or to those with claudication diseases. Home-based cardiac rehabilitation (HBCR) is an alternative approach to traditional outpatient phase II CR, that is an emergent area of study with preliminary evidence showing in some outcomes that it approximates traditional CR. As there is current interest in the study of HBCR, this paper examines outcomes of mortality, risk factor modification, exercise capacity, and cardiac function to determine the extent to which this intervention may be a suitable alternative to traditional phase II outpatient CR. In this review, outcomes in HBCR are compared to usual care control groups (participants who are non-participants or non-referrals to CR) to identify outcomes that change following a HBCR intervention. Following comparisons of HBCR and usual care controls, the former is then compared to traditional phase II outpatient CR to present areas of significant improvement between the interventions. After examining the various outcomes in the most relevant 28 manuscripts from a large literary search, preliminary evidence indicates HBCR is, in many respects (e.g. Peak VO_2, 6MWD, METs, resting SBP, RHR, LVEF, TC, HDL, LDL, and mortality), equivalent to traditional outpatient phase II CR in eliciting an exercise response. Traditional phase II outpatient CR has an advantage in adherence and safety due to direct patient monitoring, coverage and reimbursement of health care, and standardized guidelines in terms of outcomes. HBCR is advantageous in situations with barriers to adherence or participation such as travel, frailty due to advancing age, and additional comorbidities or health issues.

Table of Contents:

Introduction

Cardiac rehabilitation (CR) is an intervention method offered to patients that have been diagnosed with heart disease, undergone various surgeries such as stenting or valve replacement, or those who may have claudication diseases such as peripheral artery disease (PAD) so that they may be educated on their overall health, reduce risk for cardiac events, and maintain a higher level of physical activity (Dalal, Doherty, & Taylor, 2015). CR typically has three phases: Phase I referring to inpatient rehabilitation during hospitalization, Phase II for those in outpatient care in a physician supervised environment within 4 months after discharge, and Phase III for unmonitored exercise after graduation from Phase II (McMahon, Ades, & Thompson, 2017). Benefits of CR in patients with coronary heart disease (CHD) and heart failure (HF) are: reduced cardiovascular mortality, reduced risk of hospital readmission, improved exercise capacity and quality of life (QoL) (Dibben et al., 2018). In general, additional benefits to CR are improved survival, fewer recurrent myocardial infarctions (MI), slowed progression of coronary artery disease (CAD), and lower frequency of rehospitalization (Witt, Thomas, & Roger, 2005). Despite the benefits of CR, there are several barriers that may reduce attendance or discourage participation. These include issues with distance or transport to the site of rehabilitation, older age, and additional comorbidities or health issues.

Studies have shown that commute time was a predictive factor for participation in CR, and that participants were more likely to live closer to a facility and own and drive a car than nonparticipants (Daly et al., 2002). Another study in Australia reported that those who attended CR lived closer to a facility than those who declined rehabilitation (15.4 ± 20.6 km vs 40.4 ± 37.5 km, $p = 0.019$) (De Angelis, Bunker, & Schoo, 2008). Rural participants of CR have, in some cases, been known to report distance as a barrier to participation greater than those of their urban counterparts (Shanmugasegaram, Oh, Reid, McCumber, & Grace, 2013). One study in Korea showed data from retrospective analysis that 53.9% of their non-attenders and 35.9% of their attenders of CR did not attend or missed sessions due to travel distance (Chi-square test, $p < 0.001$) (Im et al., 2018). Soroush et al (2018) identified distance to CR as a predictor of referral when adjusted to their overall population ($p = 0.042$).

In conjunction with distance, age has also been found to be a barrier to CR, and older individuals have been known to have greater difficulty traveling and attending CR programs on a consistent basis (Daly et al., 2002). Patients over the age of 65 have been shown to participate at lower rates than those younger than 65 (Witt et al., 2005). In contrast, some studies have indicated that non-attenders of CR appear to be younger than those who attend (Dunlay et al., 2009; Im et al., 2018). Additional findings also indicate that older adults identify more CR barriers than younger patients and that CR participants were significantly younger than nonparticipants; one of these barriers being comorbidities (Grace et al., 2009).

In addition to distance and age, pulmonary and musculoskeletal comorbid diseases have been associated with lesser participation in CR (Witt et al., 2005). In 2009 in the United States, and in 2018 in the United Kingdom there were reports that there has been a decline in those with diabetes taking part in CR (Dunlay et al., 2009; Harrison, Doherty, & Phillips, 2018). Some results have shown that comorbidities and functional status of an individual indicate a higher risk for CR non-attendence, and (Im et al., 2018). Im et al (2018) observed that significant barriers to attendance included, “I find exercise tiring or painful”, “I don’t have the energy”, “Other health problems prevent me from going”, and “I am too old.” Servio et al also reported in 2019 that patients not enrolled in CR reported significantly greater barriers that were related to comorbidities and functional status, perceived need, and personal and family issues (Sérvio et al., 2019).

As an alternative to the traditional CR setting, home-based cardiac rehabilitation (HBCR) could possibly be used to mitigate the effect of barriers for on-site non-attenders and attenders. HBCR is a method of administering an individual's exercise prescription at home, community centers, health clubs, parks, or by home visit or telecommunication (Brouwers et al., 2020; Thomas et al., 2019). Typically, home-based exercise training is recommended by cardiac rehabilitation staff members on days those patients do not generally attend the facility or center. There have been reports in various reviews and meta-analyses that there is some evidence that HBCR and center-based rehabilitation have similar effects regarding measures of exercise capacity, cardiovascular risk factors, and QoL (Blair, Corrigall, Angus, Thompson, & Leslie, 2011; Buckingham et al., 2016; Dalal, Zawada, Jolly, Moxham, & Taylor, 2010; Kate Jolly, Taylor, Lip, & Stevens, 2006).

The purpose of the paper was to identify the factors in which HBCR may improve cardiac patient health, compare the changes seen in these factors with usual care and traditional rehabilitation, and determine if HBCR is as effective as traditional rehabilitation. An examination of the studies will be presented as comparisons of HBCR to usual care, followed by comparisons to traditional CR, and lastly comparisons to both situations should studies exist that compare all three. Factors of interest within this paper include exercise capacity changes (peak VO_2, METs, and Six-Minute Walk Distance), cardiovascular changes (blood pressure, resting heart rate, peak heart rate, and left ventricular ejection fraction), risk factor modifications (cholesterol, glucose, waist-hip ratio, and body mass index), and mortality. The need for examination alongside usual care, is due to low usage of CR, as approximately 25% of hospitals in the States refer less than 20% of eligible participants (Aragam et al., 2015). Ritchey et al (2020) also noted in their examination of 366,000 participants covered by Medicare in 2016 that only 25% participated in CR, and of those who participated, 24% began within 21 days of the cardiac event or surgery, and approximately 27% completed the full 36 sessions of CR. With this information, typical usual care for cardiac patients who do not attend CR involves follow-up with a non-exercise related physician to manage symptoms.

The previously mentioned factors are important as traditional CR has known effects on each of them, as illustrated in Figure 1 below. In terms of exercise capacity, Peak VO_2, METs, and 6MWD have been shown on several occasions to increase through a traditional program (Ades et al., 2003; Ali et al., 1998; Araya-Ramírez et al., 2010; Artham, Lavie, & Milani, 2008; Church, Lavie, Milani, & Kirby, 2002; Gremeaux et al., 2009; Lavie & Milani, 1996a, 1996b, 1997, 2004, 2005, 2006, 1999, 1993, 1994, 1995a; Maniar, Sanderson, & Bittner, 2009; R. V. Milani & Lavie, 1995; R. V. Milani, Littman, & Lavie, 1993; Richard V. Milani & Lavie, 1998, 2003, 2007; Richard V. Milani, Lavie, & Cassidy, 1996; Richard V. Milani, Lavie, & Mehra, 2004; Rejeski et al., 2002; Roberts, Li, & Sykes, 2006; Tallaj et al., 2001; Verrill, Barton, Beasley, Lippard, & King, 2003; Wright, Khan, Gossege, & Saltissi, 2001). Regarding cardiac function, Quindry et al (2021) highlighted in a recent study with a total sample of 31,885 patients that CR can decrease resting systolic and diastolic blood pressure. Resting heart rate (RHR) has been shown on several occasions to decrease post-intervention (Beckie, Beckstead, Kip, & Fletcher, 2014; Missiri, Amin, Tawfik, & Shabana, 2020; Giallauria et al., 2006; Hao, Chai, &

Kligfield, 2002; Lavie & Milani, 1993, 1995, 2006; Tsai, Lin, & Wu, 2005), and left ventricular ejection fraction (LVEF) has been shown to increase after attending CR (Wilcox et al., 2012). With respect to risk factor modification, total cholesterol (TC) has been shown to decrease (Ali et al., 1998; Church et al., 2002; Lavie & Milani, 1994, 1995a, 1995b, 1996a, 1996b, 1997, 2004, 2005; R. V. Milani & Lavie, 1995; R. V. Milani et al., 1993; Richard V. Milani & Lavie, 1998; Richard V. Milani et al., 1996), high-density lipoprotein increases (Ali et al., 1998; Artham et al., 2008; Church et al., 2002; Lavie & Milani, 1997, 2004, 2005, 2006, 1999, 1993, 1994, 1995a, 1995b, 1996a, 1996b; R. V. Milani & Lavie, 1995; R. V. Milani et al., 1993; Richard V. Milani & Lavie, 1998, 2003, 2007; Richard V. Milani et al., 1996, 2004), and low density lipoprotein decreases through CR (Lavie & Milani, 1993, 1994, 1995b, 1995a, 1996a, 1996b, 1997, 2004, 2005; R. V. Milani & Lavie, 1995; R. V. Milani et al., 1993; Richard V. Milani & Lavie, 1998, 2003; Richard V. Milani et al., 2004). Fasting blood glucose (FBG) has been shown to be unresponsive to treatment (Artham et al., 2008; Lavie & Milani, 1997, 2005; Richard V. Milani & Lavie, 2003; Richard V. Milani et al., 2004), and body mass index (BMI) has been shown to decrease with treatment (Artham et al., 2008; Lavie & Milani, 1993, 1994, 1995a, 1995b, 1996a, 1996b, 1997, 2004, 2006; R. V. Milani et al., 1993; Richard V. Milani et al., 1996). Lastly, regarding mortality, there is data that indicates 5-year mortality decreases with CR and decreases further with 25 or more sessions of the intervention (Suaya, Stason, Ades, Normand, & Shepard, 2009).

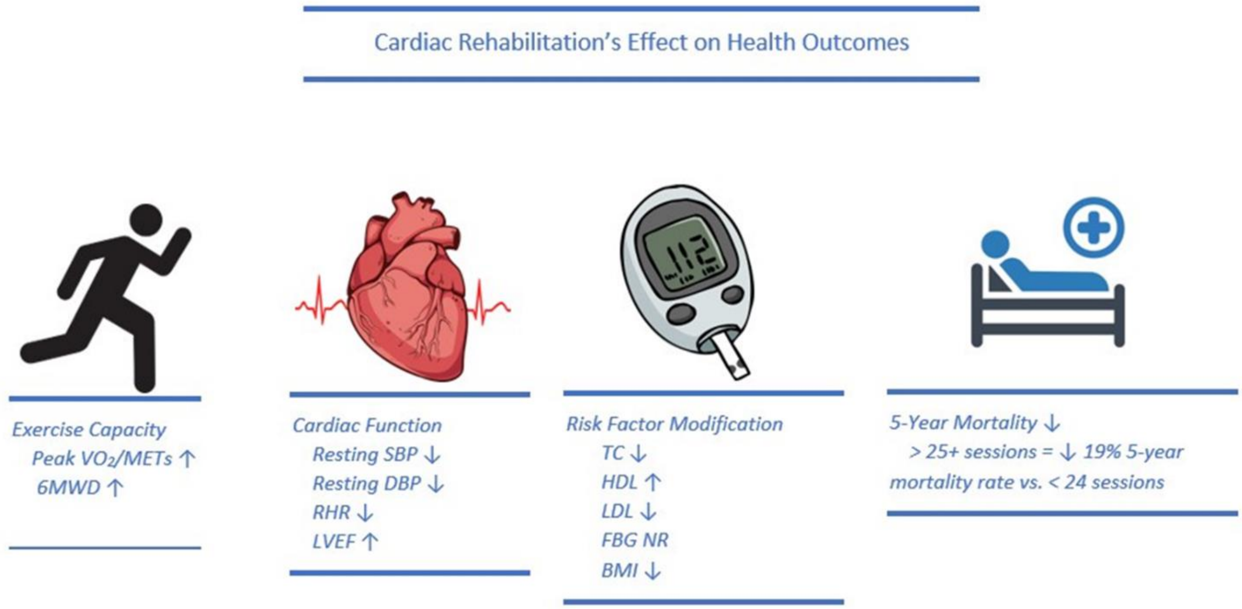

Figure 1. Known health outcomes post-intervention interpreted from information provided by the publications below:
Ades et al 2003; Ali et al 1998; Araya-Ramirez et al 2010; Artham et al 2008; Beckie et al 2014; Church et al 2002; Giallauria et al 2006; Gremeaux et al 2009; Hao et al 2002; Lavie and Milani 1994, 1995, 1995, 1996, 1997, 1997, 1999, 2004, 2005, 2006; Lavie et al 1993, 1999; Maniar et al 2009; Milani and Lavie 1995, 1998, 2003, 2007; Milani et al 1993, 1996, 2004; Missiri et al 2020; Quindry et al 2019, 2021; Rejeski et al 2002; Roberts et al 2006; Suaya et al 2009; Tallaj et al 2001; Tsai et al 2005; Verrill et al 2003; Wilcox et al 2012; Wright et al 2001.
↑ - Increase, ↓ - Decrease, NR – No Response; 6MWD – Six Minute Walk Distance; SBP – Systolic Blood Pressure; DBP – Diastolic Blood Pressure; RHR – Resting Heart Rate; LVEF – Left Ventricular Ejection Fraction; TC – Total Cholesterol; HDL – High-Density Lipoprotein; LDL – Low-Density Lipoprotein; FBG – Fasting Blood Glucose; BMI – Body Mass Index.

The data were gathered via web search on PubMed using the phrase "home cardiac rehab" as a blanket phrase which garnered 2,773 results. Search results were further filtered by toggling the "clinical trial" and "randomized controlled trial" article types (575 results). As not all the results were specific to HBCR and included some outliers, articles were further examined for exercise-related studies with clear outcomes related to mortality, risk factor modification, cardiovascular factors, and exercise capacity. If any studies were unavailable via PubMed, titles or authors were searched on the Maureen and Mike Mansfield Library online database through the University of Montana to gain access via other site locations. After filtering, 52 clinical trials and randomized controlled trials were examined to gather data on the topic for review, which included information comparing HBCR to usual care (n =24) or traditional cardiac rehabilitation (n = 28). As presented in Table 1, the 28 most relevant manuscripts comparing HBCR and traditional cardiac rehabilitation were summarized by participant age and exercise prescription.

TCR vs HBCR Exercise Prescription

Study Lead & Year	**Age TCR (years)**	**Age HBCR (years)**	**TCR Rx**	**HBCR Rx**
Aamot et al 2014	58 ± 8	58 ± 8	HIIT 2 times /wk for 12 wks. WU @ 50-70% PHR for 10 min, and 4 intervals of 4 min each @ 85-95% PHR with 4 min breaks between @ 70% PHR. CD for 3-5 min @ 50% PHR. Conducted in groups of 10-15 under PT.	HIIT 2/wk for 12 wks. WU @ 50-70% PHR for 10 min, and 4 intervals of 4 min each @ 85-95% PHR with 4 min breaks between @ 70% PHR. CD for 3-5 min @ 50% PHR. Two initial sessions with PT, all others at home by preferred exercise method.
Ades et al 2000	58 ± 12	56 ± 9	TM exercise 25-30 min and 5-10 min on other machines (cycle, rowing, and arm ergometers) until total of 40-50 min achieved. ECG monitored first 4-6 sessions exercising @ 65-85% HRmax. Three mo of 36 sessions.	Patients monitored via patient kit containing ECG leads and transmitter, a headset and voice transmitter, and telephone modem. Continuous intermittent exercise of 15-25 min @ 65% HRmax.Guidance of nurse coordinator over the phone lead to gradual increase to 85% HRmax for total of 35-40 min of cycling per session. Additional adult present @ home required during sessions. Three mo of 36 sessions.
Arthur et al 2002	62.5 ± 8.8	64.2 ± 9.4	Supervised sessions 3 times/wk for 6 mo. Exercise sessions began 10-15 min WU of walking and stretching. 40 min aerobic exercise on cycle and arm ergometer, TM, track walking, and stair climbing. 10-15 min CD. Advised to train 5 times/wk via ACSM guidelines and keep exercise log.	Attended 1 hr exercise consultations with specialist @ baseline and 3 mo of training. Advised to train 5 times/wk via ACSM guidelines. 10-15 min WU, 40 min aerobic training, 10-15 min CD. WU and CD consisted of walking and stretching. Advised to keep exercise log with length of time involved and HR. Telephoned every 2 wks by specialist to monitor progress. Logs reviewed monthly.
Avila et al 2020	62.0 ± 7.4	62.2 ± 7.1	Three weekly sessions of 45 min of endurance training @ 70-80% HRR followed by relaxation. Advised to maintain active lifestyle and invited for follow-up visits @ 12 wks and 1 yr.	Individualized exercise Rx recommending 150 min of exercise/wk @ 70-80% HRR at home for 3 mo. Record exercise data and upload on Garmin web application. Receive feedback 1/wk by phone or email.

Batalik et al 2020	57.7 ± 7.6	56.5 ± 6.9	Usage of wrist HR monitor for HR, time, training mode, duration and distance. Three times/wk for 12 wks. 10 min WU, 60 min aerobic walking or cycling @ 70-80% HRR, and 10 min CD.	Two supervised training sessions in outpatient clinic before start. Usage of wrist HR monitor for HR, time, training mode, duration and distance. Three times/wk for 12 wks. 10 min WU, 60 min aerobic walking or cycling @ 70-80% HRR, and 10 min CD. Telephoned once/wk for feedback and advice.
Bravo-Escobar et al 2017	55.64 ± 11.35	56.50 ± 6.01	Exercise sessions 3 times/wk (24 sessions) in a CR unit. Exercised with 15 min WU and 30 min continuous aerobic activity alternating days of TM and stationary bike @ 70% HRR for the first month, and @80% for the second. Ended exercise with a 15 min CD. Resistance training one time weekly with 1-2 sets of 10 reps for brachial biceps, brachial triceps, pectoris major, deltoids, and quadriceps at 20 RM with 2-3 min recovery between reps.	Participated in mixed surveillance with one CR visit/wk. Exercised at home following a walking program for 1 hr @ 70% HRR for the first month, and @ 80% during the second. Exercised with 15 min WU, 30 min aerobic activity, and 15 min CD. Monitored via remote electrocardiographic device (NUUBO) at least 2 d/wk. Encouraged to exercise daily. Resistance training one time weekly with 1-2 sets of 10 reps for brachial biceps, brachial triceps, pectoris major, deltoids, and quadriceps at 20 RM with 2-3 min recovery between reps.
Dalal et al 2007	64.3 ± 11.2R , 62.8 ± 11.5P	60.6 ± 10.1R , 64.5 ± 10.3P	Outpatient classes 1d/wk for 8-10 wks for 2 hrs in groups of 8-10. Comparable with TCR in the UK. Encouraged to exercise at home, building to 5 sessions/wk.	CR nurse issued guidance with the Heart Manual over 6 wks. CR nurse made a home visit 1 week after discharge; followed up with phone calls over 6 wks on wks 2, 3, 4, and 6 to check progress.
Jolly et al 2009	61.8 ± 11.0	60.3 ± 10.5	Four different TCR programs with various lengths: 12 sessions over 8 weeks, and 24 sessions over 12 weeks. Exercised to 65-75% of predicted HRmax for 25-40 min and a WU and CD with unspecified timing.	Consisted of usage of the Heart Manual; 3 home visits at 10 d, 6 wks, and 12 wks; and phone contact at 3 wks. Manual encouraged buildup of exercise to a minimum of 15 min of moderate intensity activity daily.
Karapolat et al 2007	45.27 ± 13.10	35.61 ± 12.91	Exercise sessions 3 times/wk for 8 wks for ~ 1.5 hrs. Exercise included flexibility training and aerobic training for 30 min on TM or stationary bike @ 60-70% VO2max and Borg scale 13-15. After wk 2, strength was added targetting abdominal, upper limb, and lower limb groups with weights of 250-500g.	Exercise sessions 3 times/wk for 8 wks for ~ 1.5 hrs. Exercise included flexibility training and aerobic training for 30 min of walking @ 60-70% VO2max and Borg scale 13-15. After wk 2, strength was added targetting abdominal, upper limb, and lower limb groups with weights of 250-500 g. Taught by PT to perform same exercises as TCR at home.

Karapolat et al 2009	45.16 ± 13.58	44.05 ± 11.49	Supervised by physician, 3 sessions/wk for 8 wks for 45-60 min. Flexibility (ROM), aerobic, and breathing exercises (pursed lip). Performed 30 min TM @ 60-70% pVO2, 60-70% HRR, and 13-15 Borg scale. Included 5 min WU and CD.	Trained by PT how to perform at home before starting. Supervised by physician, 3 sessions/wk for 8 wks for 45-60 min. Flexibility (ROM), aerobic, and breathing exercises (pursed lip). Performed 30 min walking @ 60-70% pVO2, 60-70% HRR, and 13-15 Borg scale. Included 5 min WU and CD. Pedometer was used to record distance. Contacted at start of each wk by phone.
Kim et al 2017	56.5 ± 13.8	52.9 ± 12.7	Performed 30-40 min TM, stationary cycling, arm ergometry, and stair climbing for 1 or 3 sessions/wk for 3 mo (12 or 36 sessions) @ 60-70% HRR	One session each mo for 3 mo. Followed a booklet of self-management on medications, fluid management, symptom exacerbation, sodium intake, and moderate intensity activity for 30 min (as tolerated) most days of the wk parallel to the guidelines of the American College of Cardiology and American Heart Association.
Kraal et al 2017	57.7 ± 8.7	60.5 ± 8.8	Training for 12 wks of at least 2 sessions/wk for 45-60 min on TM or cycle ergometer @ 70-85% HRmax. Training supervised by two CR PTs.	Training for 12 wks of at least 2 sessions/wk for 45-60 min @ 70-85% HRmax. Trained for 3 sessions at TCR before transition to home. Usage of HR monitor chest strap to upload to web application. Patients received feedback once/wk on training frequency, duration, and intensity.
Lee et al 2006	59 ± 11 (all patients)		Trained for 24 sessions meeting 2 times/wk. Began with 15 min normal and 5 min fast walking under supervision. First session performed no more than 80% of HRmax. Sessions consisted of 10 min WU, 30-40 min aerobic exercise (cycling, rowing, walking, and stepping) based on RPE. Encouraged to exercise 3 times/wk outside of program.	Patients used the Heart Manual for their exercise program. Part 1 includes six weekly sections for a phased health education program, stress management, and daily incremental fitness plan. Part 2 includes answers to questions commonly asked by patients with MI (medicine, anxiety and stress, and chest pain).
Maddison et al 2019	61.5 ± 12.2	61.0 ± 13.2	Trained for 3 sessions/wk for 12 wks for 30-60 min (including WU and CD) @ 40-65% HRR. Exercise sessions based on patient VO2max.	Comprised of 12 wks of individualized exercise prescription based on VO2max. Patients logged into the program during available monitored hours aligned with TCR. Patients used a smartphone and chest-worn sensor for information on heart and respiratory rate, single lead ECG, and accelerometry. Trained for 3 sessions/wk for 12 wks for 30-60 min (including WU and CD) @ 40-65% HRR.

Moholdt et al 2012	63.6 ± 7.3	61.7 ± 8.0	Exercise intensity set using the Borg scale. Participated in 30 sessions of varying intensities (4 low, 16 moderate, 10 high). 80% of sessions comprised of endurance training.	Received oral instruction on AIT and were asked to complete 3 times/wk for 6 mo. 10 min WU, 4 intervals for 4 min of high intensity @ 85-95% HRmax. Between intervals, exercise at moderate intensity for 3 min @ 70% HRmax. Session totals were 38 minutes, with 16 minutes of high intensity.
Oerkild et al 2011	74.7 ± 5.9	74.4 ± 5.8	A 6 wk program training for 60 min 2 times/wk @ 11-13 Borg scale. Encouraged to exercise at home to meet international recommendations.	PT made home visits 2 times in 6-week intervals to develop a training program. Exercise programs were prescribed after 6MWT and pVO2 data were obtained. Patients exercised for 30 min @ 11-13 Borg scale predominantly by brisk walking and stationary cycling 6 d/wk.
Piotrowicz et al 2010	60.5 ± 8.8	56.4 ± 10.9	Trained with a 5-10 WU, 10-30 min aerobic endurance training, and a 5 min CD. Aerobic training consisted of intervals on a cycle ergometer @ 40-70% HRR (11 RPE) for 10-15 min/session/day exercising intermittently for 1-2-3 min followed by 1-2 min active recovery. Patients were to gradually increase to 30 min/session with intermittent periods of 4 min and 2 min active recovery.	Trained with a 5-10 WU, 10-30 min aerobic endurance training, and a 5 min CD. Aerobic training consisted of continuous walking @ 40-70% HRR (11 RPE) for 10, 15 or 20 min/session/day (based on baseline pVO2). Patients were to gradually increase to 20-30 min/session/d.
Ramadi et al 2015	61.1 ± 10.1	57.9 ± 10.9	Supervised training 2-3 d/wk of aerobic training that includes 5 min WU, 20-60 steady state exercise @ 45-85% HRR (and Borg 12-14), and 5 min CD. Patients encouraged to exercise 1-3 time independently.	Attended 1 session of supervised exercise to receive instructions and advice to exercise on their own with a 5 min WU, 20-60 min @ 45-85% HRR (and Borg 12-14), and a 5 min CD for 3-5 d/wk. Patients were phoned by CR staff every 3 wks.
Scalvini et al 2013	63 ± 11	63 ± 12	Patients exercised for 100 min/day in the mornings (Mon-Fri) and 40 min in the afternoons (Saturdays were morning sessions only). The morning programs included 50 min of calisthenics, a 10 min WU, and 40 min of interval training on a cycle ergometer starting @ 25 W for 5 min and increased to 50 W for 35 min. The afternoons only consisted of the cycle ergometer interval training. CR lasted for 4 weeks face to face.	Patients exercised for 100 min/day in the mornings (Mon-Fri) and 40 min in the afternoons (Saturdays were morning sessions only). The morning programs included 50 min of calisthenics, a 10 min WU, and 40 min of interval training on a cycle ergometer starting @ 25 W for 5 min and increased to 50 W for 35 min. The afternoons only consisted of the cycle ergometer interval training. CR lasted for 4 weeks via video conferencing for monitoring DVD for the intervention. Nurse tutors provided services every 2 weeks at home.

Schopfer et al 2020	65 ± 8	65 ± 8	CR followed AHA protocols with 2-3 sessions/wk Participation assessed by number of sessions attended. 12-36 sessions over 6-12 wks.	Program included 6 weekly and 3 biweekly phone calls from staff to provide coaching and education. Participation assessed by number of weekly phone calls, if they lasted 15 min and included education. 9-12 sessions over 12 wks.
Shagufta et al 2011	56.35 ± 8.07	58.87 ± 7.87	Took part in 45 min exercise session that inclueded ROM exercise, walking, and stair climbing @ 4-6 Borg 10-point RPE scale 3 times/wk for 4 weeks.	Took part in 45 min exercise session that inclueded ROM exercise, walking, and stair climbing @ 4-6 Borg 10-point RPE scale 3 times/wk for 4 weeks. Updated by phone weekly.
Skobel et al 2017	58 (52, 67)	60 (50, 65)	Performed unspecified supervised TCR program near patient-individualized target HR.	Patients used the Gex system to synchronize data collected from patients into a web-based system for medical professionals to prescribe exercise programs and provide feedback about their sessions. Endurance trained 2x/wk for 3 wks for 3 bouts of 10 min for 30 total min @ 11 RPE; endurance and resistance trained2x/wk for 2 wks for 3 bouts of 10 min for 30 total min @ 12-13 min RPE; increased bout times by 5 min for total of 45 min for 2 more wks; increased training to 3x/wk for 2 more wks; and finally began a maintenance period of 12+ wks training 3x/wk for 3 bouts of 20 min for a total of 60 min @ 12-13 RPE.
Smith et al 2004	63.4 ± 8.8	65.1 ± 9.0	Exercise sessions were ~30-50 min 3x/wk @ 60-80% of HRR. Exercises included TM, stationary cycling, arm ergometry, and stair climbing.	Exercise sessions were ~30-50 min 3x/wk @ 60-80% of HRR. Exercise consisted of walking, but could include any exercise equipment in participant possession.
Smith et al 2011	70.3 ± 8.26	70.2 ± 10.7	Exercise sessions were ~30-50 min 3x/wk @ 60-80% of HRR. Exercises included TM, stationary cycling, arm ergometry, and stair climbing. LTF for one 3 hr session @ CR.	Exercise sessions were ~30-50 min 3x/wk @ 60-80% of HRR. Exercise consisted of walking, but could include any exercise equipment in participant possession. LTF for one 3 hr session @ CR.

Stewart et al 2012	73 ± 13	70 ± 15	Performed unspecified supervised hospital rehabilitation, with a dedicated specialist on CHF at their local hospital and coordinated by an experienced CHF nurse. 12-18 mo follow-up	Received home visit from CHF nurse 7-14 days post-discharge. Visit entailed assessment of clinical stability, application of pharmacological and nonpharmacological management, assessment of cognitive status, assessment of home environment, counseling of family or caregivers, assessment of social support and coping skills, review of current and past medication, assessment of food and fluid intake, identification of equipment, assessment of patient mobility, referral to community pharmacist, and contact with family physician. 12-18 mo follow-up
Varnfield et al 2014	56.2 ± 10.1	54.9 ± 9.6	Consisted of 2 supervised and 1 hr education sessions weekly for 6 wks. Followed an individualized circuit program of light to moderate intensity exercise on the Borg scale (6-10 and 11-13 respectively).	Used smartphone monitoring, education, and weekly consultations for ~15 for 6 wks. Exercised at least 30 min of moderate intensity activity (Borg 11-13) most days of the week with walking as the main exercise modality.
Wakefield et al 2014	63.8 ± 5.3	63.7 ± 8.2	Attended a phase 2 CR program based on proximity to home.	Telephoned each week for 12 wks to review program. Individualized programs were given via ACSM guidelines, and participants exercised at least 30 min 3x/wk using RPE.
Wu et al 2006	62.8 ± 6.9	60.9 ± 7.6	Performed 30-60 min aerobic exercise via stationary cycling or TM @ 60-85% PHR along with 10 min WU and CD 3x/wk for 36 sessions.	Performed home exercise @ 60-85% PHR (Borg 11-13) for 30-60 min of aerobic training (fast walk or jog) with a 10 min WU and CD. Exercise was documented for adherence by giving updates by office or phone every 2 wks.

Table 1. The summary of all studies examined in which TCR and HBCR are compared to one another in terms of age group and exercise prescription of each intervention. CR – Cardiac Rehabilitation, TCR – Traditional Cardiac Rehabilitation, HBCR – Home-Based Cardiac Rehabilitation, HIIT – High-Intensity Interval Training, WU – Warm-up, CD – Cool down, PHR – Peak Heart Rate, PT – Physiotherapist/Physical Therapist, TM – Treadmill, HRmax – Heart Rate Maximum, ECG – Electrocardiography, ACSM – American College of Sports Medicine, HRR – Heart Rate Reserve, HR – Heart Rate, ROM – Range of Motion, pVO2 – Peak VO2, MI – Myocardial Infarction, RPE – Rating of Perceived Exertion, AIT – Aerobic Interval Training, BP – Blood Pressure.

Changes in Exercise Capacity with Home-Based Cardiac Rehabilitation

The standard measure that is used to determine cardio-pulmonary exercise capacity is VO_2max, commonly quantified as peak VO_2. One study examining a home group that performed HBCR for 3 months at 60-80% peak heart rate 3 times per week for 30 minutes on non-consecutive days with biweekly telephone monitoring showed a significant increase in peak VO_2 (28.8 ± 6.4 vs 31.7 ± 8.1 ml/kg/min, $P < 0.05$) while the usual care control showed a significant decrease in peak VO_2 (28.6 ± 6.6 vs 26.8 ± 7.2 ml/kg/min, $P < 0.05$) (Salvetti, Oliveira, Servantes, & Vincenzo de Paola, 2008). Another study followed a similar protocol with the exception being that participants who performed 1 week of traditional CR followed by 3 months of HBCR also showed a significant increase in peak VO_2 in the intervention group (18.2 ± 4.1 vs 20.9 ± 6.6 ml/kg/min, $P = 0.02$) and a significant decrease in the usual care control (18.7 ± 4.2 vs 16.5 ± 3.7 ml/kg/min, $P < 0.01$) (Chen et al., 2018). In 2015, a study had HBCR patients complete initial training in a rehabilitation unit and transitioned to 8 weeks of telemonitored training 5 days per week (Smolis-Bąk et al., 2015). After 3-4 months of training, the HBCR showed a significantly greater peak VO_2 than the control group (17.2 ± 3.9 ml/kg/min vs 13.4 ± 4.2 ml/kg/min, $P = 0.0324$). Piotrowicz and colleagues in 2015 trained participants via Nordic walking based on 40-70% heart rate reserve (HRR) and functional capacity of the participants at baseline until they could reach 45-60 minutes 5 days per week over eight weeks with results showing a significant increase in peak VO_2 in the training group (16.1 ± 4.0 vs 18.4 ± 4.1 ml/kg/min, $P = 0.0001$), no significant changes in the control group (17.4 ± 3.3 vs 17.2 ± 3.4 ml/kg/min), and a significant difference between groups ($P = 0.0004$) (Piotrowicz et al., 2015). Piotrowicz also presented a more recent study after 9 weeks of telerehabilitation (1 week in the hospital and 8 weeks at home). The telerehabilitation portion of the study incorporated exercise training via "tele-ECG" which included an EHO mini device, blood pressure device and a body weight scale that would transmit data via mobile telephone technology. The study consisted of exercise for 5 days per week and showed a significant difference ($P < 0.001$) between the intervention group (16.9 ± 6.0 ml/kg/min to 17.9 ± 6.2 ml/kg/min) and the usual care control group (16.6 ± 6.0 ml/kg/min to 16.7 ± 5.9 ml/kg/min) (Piotrowicz et al., 2020). When compared to usual care, results have been mixed over time as there have been various studies showing no significant differences within or between groups (Claes et al., 2020; Corvera-Tindel, Doering, Woo, Khan, & Dracup, 2004; Dracup et al., 2007; Oka et al., 2000; Oka, DeMarco, & Haskell, 2005; Y. T. Wu et al., 2008).

Primary consideration would be the comparison of peak VO_2 between traditional CR and HBCR. In a study in 2000, intervention participants exercised beginning with a telephone call to a nurse coordinator along with other patients for 15-25 minutes of exercise at 65% heart rate maximum (HRmax) and gradually increased to 85% HRmax to reach a total cycling session of 35-40 minutes while traditional CR participants performed treadmill exercise for 25-30 minutes as well as other machines such as cycle, rowing, and arm ergometers for total session times of 40-50 minutes (Ades et al., 2000). As presented in Table 1, exercise prescription was comparable to the traditional CR control. After 36 sessions, all participants were measured again, and data had shown that there were no significant differences in peak VO_2 between the HBCR and traditional rehab groups. Another study in 2002 took record of patients from baseline to 3 months and 6 months after beginning their home based (telephoned every 2 weeks by an exercise specialist) or hospital programs (Arthur, Smith, Kodis, & McKelvie, 2002). After the home group had followed the American College of Sports Medicine (ACSM) recommendations for exercise as described in Table 1, peak VO_2 was assessed at 3 months and 6 months and both the home group and hospital group showed significant changes in peak VO_2 within their groups (1260.3 ± 306.5 to 1433.4 ± 589.7 ml/min, $P < 0.05$; 1222.1 ± 269.0 to 1497.2 ± 594.3 ml/min, $P < 0.0001$), but did not show significant differences between each other.

In extension to this understanding about improvements in peak VO_2 comparing traditional CR and HBCR, Smith et al recruited individuals 6-8 weeks after CABG to participate in a 6-month home or hospital rehabilitation and a 12-month follow-up investigation (Smith, Arthur, Mckelvie, & Kodis, 2004). Following ACSM guidelines, as presented in Table 1, exercise prescriptions were based on peak 65-70% VO_2, and patients were encouraged to exercise 5 times per week using a target heart rate based on their resting heart rate plus 65-70% of their HRR. Both groups showed increases in peak VO_2 from baseline to discharge, however, there was a drop in peak VO_2 in the hospital group at the 12-month follow-up compared to the home group, leading to a significant difference between groups (1535 ± 426 ml/min vs 1565 ± 437 ml/min, $P < 0.05$). Another study in 2009, as presented in Table 1, showed in heart failure (HF) patients that were being directed at home by a physician 3 days per week that there was a significant increase in peak VO_2 in both hospital and home groups (17.85 ± 4.44 to 19.43 ± 4.59 ml/kg/min and 17.48 ± 6.09 to 18.12 ± 6.00 ml/kg/min respectively, $P < 0.05$ for both), but there were no significant differences between groups (Karapolat et al., 2009). The following year in another study with HF patients, all patients underwent 8 weeks of CR with the HBCR group receiving an EHO device and a mobile phone to send ECG data to the monitoring center and to communicate with center staff (Piotrowicz et al., 2010). In their study, the data had shown that both the standard group and the HBCR group showed significant increases in peak VO_2 (17.9 ± 4.4 to 19.0 ± 4.6 ml/kg/min and 17.8 ± 4.1 to 19.7 ± 5.2 ml/kg/min respectively, both p = 0.0001), but there was also no significance between groups.

With further consideration to improvements in peak VO_2, Oerkild et al in 2011 used an intervention with a physiotherapist making home visits twice with a 6-week interval to create a training program based on the six-minute walk test (6MWT) and exercise capacity test from a cycle ergometer measuring peak VO_2 (Oerkild et al., 2011). Three months after the intervention, the HBCR showed a significant increase in peak VO_2 by 1.2 ml/kg/min ($P < 0.05$), the center group showed no significant changes at 0.4 ml/kg/min ($P = 0.46$), and there were no significant differences between groups. In a six-year follow-up study, Smith et al examined data collected over a six-year period from 196 patients who participated in home or hospital-based rehabilitation for 6 months (Smith, McKelvie, Thorpe, & Arthur, 2011).

The profile data showed no significant differences between groups regarding peak VO_2 at baseline, discharge, or 1 year after rehabilitation, but in the six-year long term follow-up HBCR patients maintained a significantly higher peak VO_2 than hospital patients (1543 ± 444 vs 1412 ± 438, $P \leq 0.05$) despite habitual physical activity scores being lower in the HBCR group than the hospital group (26% vs 19% decline, $P = 0.042$). A study in 2012, as presented in Table 1, set HBCR patients on an aerobic interval training (AIT) program to perform intervals at 85-95% HRmax four times for 4 minutes each with a rest of 3 minutes of moderate intensity at 70% HRmax (Moholdt, Bekken Vold, Grimsmo, Slørdahl, & Wisløff, 2012). Both the HBCR and the residential rehabilitation group showed significant increases from baseline at their six-month follow-up (23.8 ± 5.4 to 27.7 ± 6.5 ml/kg/min and 25.6 ± 4.0 to 30.2 ± 4.3 ml/kg/min respectively, $P < 0.05$) and with no significant differences between groups.

Regarding further observations of improvements in peak VO_2, Aamot and colleagues' intervention was to have a traditional CR group, a treadmill exercise group, and a HBCR group perform high-intensity interval training (HIIT) twice a week for 12 weeks at 85-95% peak HR as detailed in Table 1 (Aamot et al., 2014). After the 12 weeks, peak VO_2 increased in all groups significantly from 34.7 ± 7.3 to 39.0 ± 8.0 ml/kg/min, 32.7 ± 6.5 to 36.0 ± 6.2 ml/kg/min, and 34.4 ± 4.8 to 37.2 ± 5.2 ml/ kg/min in the treadmill, traditional, and HBCR groups respectively ($P \leq 0.001$) with only the treadmill group showing a significant increase between groups ($P < 0.05$). In 2017 Kraal et al had HBCR patients complete 3 months of training with telemonitored guidance with at least 2 sessions per week for a duration of 45-60 minutes at an intensity of 70-85% HRmax (Kraal et al., 2017). The data indicated that both the center and HBCR groups showed significant increases in peak VO_2 at discharge (24.0 ± 5.6 to 26.5 ± 7.1 ml/kg/min and 24.4 ± 6.7 to 27.9 ± 7.5 ml/kg/min respectively, $P < 0.001$) and at a one year follow-up (24.0 ± 5.6 to 27.5 ± 8.1 ml/kg/min and 24.4 ± 6.7 to 27.7 ± 6.9 ml/kg/min, $P < 0.001$), but there was no significant difference between groups at discharge and follow-up ($P = 0.308$ and $P = 0.865$).

With continued evidence of improvements in peak VO_2, Batalik et al in 2020 had participants complete rehabilitation either in a regular outpatient training group or a HBCR group via telerehabilitation with physiotherapists checking in on patients once each week (Batalik, Dosbaba, Hartman, Batalikova, & Spinar, 2020). As presented in Table 1, patients were given a wrist HR monitor and uploaded their HR, time, training mode, duration, and distance of training to a web application. After training 3 times a week for 12 week with a 10 minute warm-up, 60 minutes of aerobic activity at 70-80% HRR, and 10 minutes of cool-down, the data reported that both the regular training group and the HBCR group showed significant increases in peak VO_2 (23.4 ± 3.3 to 25.9 ± 4.1 ml/kg/min, P = 0.02; and 23.7 ± 4.1 to 26.5 ± 5.7 ml/kg/min, P = 0.04) and there was no significant difference between groups (P = 0.59). Despite indications that there are no significant differences in follow-ups post intervention in many of the studies, there are some cases that indicate center-based rehabilitation may have better outcomes (Karapolat et al., 2007; Kim et al., 2017). Another method that used to examine increases in exercise capacity is the six-minute walk test (6MWT).

Corvera-Tindel et al (2004) reported after 3 months from baseline collection with a HBCR group exercising for 5 days per week progressively increasing from 10 minutes at 40% HRmax to 60 minutes at 65% HRmax during the last 6 weeks of the program that there were significant differences in six-minute walk distance (6MWD) between the HBCR group and the usual care control (1219.0 ± 241.5 to 1337.1 ± 272.2 ft and 1273.2 ± 249.2 to 1263.9 ± 254.5 ft respectively, P < 0.008). Another study in the same year targeted older women with diastolic heart failure (DHF) and used a 12-week walking program with a 5-minute warm-up, an individualized endurance training period, and a 5-minute cool-down at 40% intensity based on target HR and gradually increased to 60% intensity by the end of the program (Gary et al., 2004). In a study from Gary et al, there was found to be a significant difference in 6MWD between the HBCR and the usual care control group (840 ± 366 to 1043 ± 317 ft and 824 ± 367 to 732 ± 408 ft, P = 0.02). After a 6-month intervention of exercising at 12-14 on the RPE scale for five days per week over ground (emphasized to not be on treadmill), there was shown to be a significant increase in 6MWD in the HBCR group compared to the usual care control (357.4 ± 97.6 to 399.8 ± 101.6 m vs 353.3 ± 91.9 to 342.2 ± 110.8 m, $P < 0.001$) (McDermott et al., 2013).

Additional information regarding improvements in 6MWD from the 2015 Piotrowicz et al study revealed there to be a significant increase in 6MWD in the HBCR group alone ($P = 0.0001$) and a significant difference between the HBCR group and the usual care control (428 ± 93 to 480 ± 87 m vs 439 ± 76 to 465 ± 91 m, $P = 0.0483$) (Piotrowicz et al., 2015). Bernocchi et al in 2018 had a HBCR group undergo 4 months of telerehabilitation with weekly phone calls to the patient and started a program at 15-25 minutes of mini-ergometer exercise and 30 minutes of callisthenic exercises 3 times per week and free walking twice per week and gradually rose to 30-45 minutes with an incremental workload of 0-60 W on the mini-ergometer, 30-40 min of muscle reinforcement exercise with 0.5 kg weights and pedometer walking 3-7 days per week (Bernocchi et al., 2018). After 4 months, the HBCR group showed a change in 6MWD by 60 m, the usual care control showed no significant improvements (-15 m), and there was a significant difference between groups ($P = 0.0040$). In the 2018 Chen et al study mentioned above, there was shown to be a significant increase in 6MWD in the HBCR group (421 ± 90 to 462 ± 74 m, $P = 0.03$), but no significant difference in the usual care control (350 ± 107 to 344 ± 121 m, $P = 0.43$).

In extension to the understanding of improvements in 6MWD, a study by Peng et al (2018) had the HBCR group use text-based, audio, and video conversations to have their training conducted under supervision in a 2-month exercise training program with the first 4 weeks focusing on endurance with three 20-minute sessions per week and another 4 weeks incorporating resistance and muscle strengthening in 5 30-minute sessions per week. At the end of the study and 4 months after the program, there was shown to be a significant difference between the HBCR and control groups in both cases (posttest: 407.09 ± 12.27 to 419.23 ± 9.67 m vs 406.05 ± 12.35 to 406.55 ± 12.54 m, P = 0.000). The previously mentioned Piotrowicz study in 2020 also produced results showing a significant difference between a HBCR and a usual care control group (419 ± 100.3 to 450 ± 109.5m vs 409 ± 100.0 to 432 ± 106.7 m, P = 0.01) (Piotrowicz et al., 2020). Despite the evidence, there have been some studies indicating that there is no significant difference between groups (Dracup et al., 2007).

Regarding observations of improvements in 6MWD between HBCR and traditional CR, the HBCR versus hospital-based rehabilitation study by Karapolat et al in 2009 indicated there was a significant increase in both the HBCR and hospital groups (374.34 ± 79.06 to 418.72 ± 50.43 m and 383.97 ± 82.39 to 423.78 ± 76.89m, both P < 0.05), but no significant differences between groups (P > 0.05) (Karapolat et al., 2009). Piotrowicz et al (2010) showed a significant increase in both the HBCR and standard rehabilitation groups (418 ± 92 to 462 ± 91 m and 399 ± 91 to 462 ± 92 m, both P = 0.0001) and a significantly greater increase in the standard group compared to the HBCR group (P = 0.0469). Scalvini et al (2013), as described in Table 1, had a HBCR group perform their exercise training via video conferencing (monitored by physiotherapists once a week) at home for a maximum for 4 weeks (24 sessions maximum) with nurse tutors servicing providing service at home every 2 weeks. Sessions consisted of 100 minutes in the morning and 40 minutes in the afternoon Monday-Friday and Saturdays consisted of only morning sessions. Both the HBCR group and the hospital group of the study showed significant increases in their 6MWD (334 ± 90 to 449 no standard deviation (SD) given and 354 ± 102 to 442 no SD given, P < 0.001), but no significant difference between groups.

In further understanding improvements of 6MWD, Varnfield et al (2014) used a smartphone based HBCR model with moderate intensity walking (11-13 RPE) for at least 30 minutes as the primary exercise mode over 6 weeks with weekly consultations over the phone for approximately 15 minutes and recorded daily weight, blood pressure, sleep duration and quality, exercise, steps, stress, meals, alcohol consumption, and smoking. Results showed both the HBCR and traditional CR groups had a significant increase in 6MWD from baseline to 6 weeks (510 ± 77 to 570 ± 80 m and 537 ± 86 to 584 ± 99 m, $P < 0.05$) which was maintained in both groups after 6 months, but there was no significant difference between groups. Schopfer et al (2020) compared a HBCR group and facility-based group in which the HBCR group were enrolled in a shorter time window than the facility group (25 vs 77 days). Detailed in Table 1, the HBCR group had 6 weekly followed by 3 biweekly telephone calls from staff to provide coaching individually and they completed at least 15 minutes of physical activity and education. The results showed that there was no significant difference at baseline between the HBCR and facility groups (346 m vs 349 m, $P = 0.82$), but there was a significant difference between groups in a 3 month follow up with the HBCR group showing a greater increase in 6MWD (+95 m vs +45 m, $P < 0.001$). With evidence that there could be comparable 6MWD changes with no significance between groups, some have found that there are greater increases in a traditional setting (Oerkild et al., 2011).

An additional method that is used to determine exercise capacity is via Metabolic Equivalents (METs). Senuzun et al (2006) compared a HBCR group with usual care, with the HBCR group completed three 45–60-minute sessions per week for 12 weeks. Both groups were comparable at baseline (10.5 ± 2.0 vs 10.6 ± 1.8 METs, $P = 0.949$), but showed a significant difference in the HBCR versus the usual care control (13.0 ± 1.5 vs 10.6 ± 2.1 METs, $P = 0.000$). Lee et al (2013) reported on a HBCR group compared to a usual care group that completed exercise at home 4-5 times weekly for 50 minutes with 20 minutes of flexibility exercise and 30 minutes of gait exercise. With weekly phone calls and ECG monitoring equipment, exercise intensity was increase gradually from 40-80% HRR with 40% in weeks 2 and 4, 50% in weeks 5 and 6, and so on until 80% was achieved in weeks 11 and 12. Results showed both the HBCR group and the usual care group significantly increased their METs after 12 weeks (7.14 ± 1.86 to 9.61 ± 1.80 METs and 7.07 ± 2.07 to 8.50 ± 2.05 METs, both $P < 0.001$), and there was a significant difference between groups ($P = 0.021$). The previously stated study by Smolis-Bąk et al (2015) reported that there were no significant differences in METs achieved between the HBCR and the control group at 3-4 months (4.15 ± 1.41 to 5.47 ± 1.76 METs and 3.06 ± 1.70 to 4.13 ± 1.80 METs) and at 12 months (5.74 ± 2.22 METs vs 4.62 ± 2.38 METs). Despite the information provided with HBCR versus usual care, there are some that have shown results with no significant differences between the two (Chen et al., 2018; Oka et al., 2000).

In addition to this knowledge of improvements in METs, the previously mentioned study by Arthur et al (2002) comparing HBCR and hospital rehabilitation contained data that showed that in both groups there was a significant increase in METs after 6 months (4.6 ± 0.94 to 5.22 ± 2.1 METs vs 4.3 ± 0.85 to 5.21 ± 2.0 METs, both $P < 0.0001$) with baseline HBCR METs being significantly different from the hospital baseline ($P < 0.05$), but with no significant changes between groups after 6 months. Smith et al (2004) showed in their study that there was a significant increase in METs in the 12-month follow-up only in the HBCR group and not the hospital group (4.66 ± 0.97 to 5.79 ± 1.6 METs vs 4.41 ± 0.86 to 5.44 ± 1.5 METs, HBCR P

<0.001), however, there was no significant differences between groups in at 12 months. Smith et al (2011) showed data that indicated there was a significant difference in peak METs in the long term between the HBCR group, and the hospital group (5.07 ± 0.9 to 5.4 ± 1.3 METs vs 4.5 ± 0.9 to 4.9 ± 1.2 METs, $P \leq 0.01$). Ramadi et al (2015) reported retrospective results from a HBCR group versus a center-based group with the HBCR group attending 1 supervised exercise session for advice to exercise on their own for 20-60 minutes 3-5 days per week to a target HR of 45-85% HRR and 12-14 RPE, as presented in Table 1. The results of the study showed that peak METs achieved by the HBCR and center-based group showed significant increases from baseline to 12 weeks of the intervention (8.56 ± 2.03 to 9.29 ± 2.08 METs and 7.91 ± 1.91 to 8.86 ± 1.96 METs, both $P < 0.05$) and at a 1-year follow-up (8.56 ± 2.03 to 9.24 ± 2.24 METs and 7.91 ± 1.91 to 8.74 ± 2.12 METs, both $P < 0.05$), but there was no significant difference between groups.

Regarding understanding of improvements in METs, Bravo-Escobar et al (2017) compared HBCR to traditional CR after 6 months from discharge with having the HBCR group attending a single mixed surveillance group session once per week. The HBCR group otherwise exercised following a walking program for 1 hour, 30 minutes being treadmill or stationary bike activity alternating each day along with both a 15-minute warm up and cool down, at 70% HRR for 1 month and 80% for a second month for at least 2 days a week with encouragement to exercise daily, as presented in Table 1. Both the HBCR and traditional CR groups showed significant increases in METs (7.55 ± 2.77 to 8.28 ± 2.62 METs vs 7.10 ± 1.97 to 8.45 ± 1.71 METs, both $P = 0.03$), but there were no significant differences between groups.

In summary, comparing HBCR to usual care controls, there were five studies reporting significant differences between groups in terms of peak VO_2 with HBCR showing a greater increase (Chen et al., 2018; Piotrowicz et al., 2020, 2015; Salvetti et al., 2008; Smolis-Bąk et al., 2015), and six studies reporting no significant differences within or between groups (Claes et al., 2020; Corvera-Tindel et al., 2004; Dracup et al., 2007; Oka et al., 2000, 2005; Wu et al., 2008). Seven studies reported HBCR showing a significantly greater increase in 6MWD compared to usual care controls (Bernocchi et al., 2018; Corvera-Tindel et al., 2004; Gary et al., 2004; McDermott et al., 2013; Peng et al., 2018; Piotrowicz et al., 2020, 2015), and only one study reported no significant differences within or between groups (Dracup et al., 2007). Three studies reported HBCR showing significantly greater METs post-intervention compared to usual care controls (Lee et al., 2013; Senuzun et al., 2006; Smolis-Bąk et al., 2015), and two other studies reported no significant difference within or between groups (Chen et al., 2018; Oka et al., 2000). Comparing traditional CR to HBCR, ten studies reported no significant differences between groups in regard to peak VO_2 (Aamot et al., 2014; Ades et al., 2000; Arthur et al., 2002; Batalik et al., 2020; Karapolat et al., 2009; Kraal et al., 2017; Moholdt et al., 2012; Oerkild et al., 2011; Piotrowicz et al., 2010; Smith et al., 2011), one study reported significantly greater peak VO_2 in HBCR (Smith et al., 2004), and two additional studies reported no significant differences within or between groups (Karapolat et al., 2007; Kim et al., 2017). Regarding 6MWD, three studies reported no significant differences between groups between HBCR and traditional CR (Karapolat et al., 2009; Scalvini et al., 2013; Varnfield et al., 2014), two studies reported evidence of traditional CR showing a significantly greater increase (Oerkild et al., 2011; Piotrowicz et al., 2010), and one other study reported a significantly greater increase in HBCR (Schopfer et al., 2020). Finally, regarding METs, four studies reported no significant difference between HBCR and traditional CR (Arthur et al., 2002; Bravo-Escobar et al., 2017; Ramadi et al., 2015; Smith et al., 2004), and only one study reported a significantly greater change in HBCR (Smith et al., 2011).

Changes in Cardiac Function with Home-Based Cardiac Rehabilitation

First regarding observations in resting blood pressure, the previously disclosed study by Senuzun et al (2006) examined HBCR and usual care and showed that after CR there was a significant difference in both resting systolic and diastolic blood pressures between groups (SBP: 139.0 ± 11.0 to 129.5 ± 15.6 mmHg vs 140.0 ± 18.7 to 136.2 ± 3.4 mmHg, $P = 0.036$; DBP: 86.2 ± 8.6 to 79.3 ± 7.6 mmHg vs 85.3 ± 9.5 to 85.5 ± 6.0 mmHg, $P = 0.041$). Salvetti et al (2008) compared HBCR and a usual care control showing that resting SBP significantly decreased only in the HBCR group after 3 months (133 ± 15 to 125 ± 12 mmHg, $P < 0.05$). Oerkild et al (2012) reported with a study design of HBCR patients completing exercise with two home visits by a physiotherapist in a 6-week interval to alter the program. Exercise programs were individualized with 30 minutes per day including a 5-10 min warm-up and 10-minute cool down at a frequency of 6 days per week at an intensity of 11-13 RPE. While there was data on both a 3 month and 12 month follow up after the program, only during the 3 month follow up did any significant changes occur with the HBCR group showing a significant decrease in resting SBP (Δ 0-3 months -12.9 mmHg; CI 95%; -24.2, -1.6; $P < 0.05$). In HBCR and usual care comparisons, there have been several studies that found no significant differences in resting SBP or DBP within or between groups (Heron et al., 2017; Houle et al., 2011; Lee et al., 2013; Oka et al., 2000, 2005; Wang, Jiang, He, & Koh, 2016; Wu et al., 2008; Xu et al., 2016).

With comparisons of HBCR to traditional CR, Oerkild and colleagues in the 2011 study reported a significant decrease in resting DBP in the HBCR group after 3 months (Δ 0-3 months – 4.2 mmHg; CI 95%; -8.1, -0.3; P < 0.01) with no significance between groups (Oerkild et al., 2011). In the same study, there was shown to be a significant difference between groups after 12 months (Δ 12 months 6.0 mmHg; CI 95%; 0.3, 11.6; P < 0.05), but not within groups. Varnfield et al (2014) study reported a significant decrease in resting DBP in the HBCR group (74.2 ± 8.7 to 71.7 ± 8.9 mmHg, P = 0.05) and a significant difference in resting DBP between groups (Adjusted mean difference CI 95%, 4.19 mmHg, 0.44 to 7.93, P = 0.03).

With further consideration to improvements in resting BP, Jolly et al had a design with a HBCR group and a center-based group with the HBCR group having a manual, 3 home visits (at 10 days, 6 weeks, and 12 weeks), and a phone call at 3 weeks with the manual instructing patients to gradually build to achieving a minimum of 15 minutes of moderate intensity exercise daily, as described in Table 1 (Jolly et al., 2009). Outcome measures between baseline and 12 months revealed that both resting SBP and DBP significantly increased in both the HBCR and center-based group (SBP: 124.0 ± 17.3 to 133.8 ± 18.3 mmHg and 124.1 ± 18.8 to 132.5 ± 21.5 mmHg, P < 0.001; DBP: 72.3 ± 11.2 to 75.0 ± 9.8 mmHg and 72.3 ± 10.5 to 74.3 ± 10.7 mmHg, HBCR P < 0.001, center P = 0.008) and there was a significant difference between groups with mean SBP being lower at 12 months in the HBCR group than the center-based group (P < 0.01). Skobel et al (2017) used a web-based system to give HBCR patients feedback on safety of exercise and used the frequency, intensity, time, and type (FITT) principle after a cycle ergometer exercise test to determine individual exercise prescription. The findings showed at a 6 month follow up that the traditional CR control had a significant decrease in DBP from baseline to 6 months (77 (70,83) to 72.6 ± 9.5, P = 0.03) and a significant difference in the change in DBP between the HBCR and control group was found (1.8 ± 9 mmHg vs -5 ± 9 mmHg, P = 0.01). There was also found to be a significant difference in the change in SBP between groups (6 ± 16 mmHg vs -8 ± 12 mmHg, P = 0.003). Several studies reported no significant changes within groups or between groups (Bravo-Escobar et al., 2017; Dalal et al., 2007; K. W. Lee, Blann, Jolly, & Lip, 2006; Maddison et al., 2019; Wakefield et al., 2014).

Comparing HBCR and usual care in terms of resting HR (RHR), Houle et al (2011) had patients randomized into either a HBCR or usual care control group, with the HBCR group possessing a pedometer, diary, and information on physical activity after acute coronary syndrome. Patients walked at moderate intensity according to the RPE scale with type, duration, and intensity of exercise being recorded in the diary along with a target number of steps per day. Patients received a follow-up phone call within 2 weeks after discharge and 5 face-to-face consultations at 6 weeks as well as 3, 6, 9, and 12 months in an outpatient setting for 30-60 minutes, as presented in Table 1. Following the program, the HBCR group showed significant changes from baseline to 6 months compared to the control group (69 ± 11 to 60 ± 7 bpm vs 66 ± 9 to 63 ± 8 bpm, P = 0.048), but not from base line to 12 months (69 ± 11 to 61 ± 8 bpm vs 66 ± 9 to 65 ± 9 bpm, P = 0.064). In the Lee study (2013), the findings indicated that both the HBCR and usual care groups showed significant decreases in RHR from baseline to 12 weeks (78.20 ± 11.84 to 70.76 ± 7.89 bpm vs 78.62 ± 10.93 to 73.14 ± 11.81 bpm, both P < 0.05), but there were no significant differences between groups. Peng et al (2018) showed after their 4-month post-test that the HBCR group had a significantly different RHR (80.51 ± 4.21 to 77.52 ± 3.65 bpm vs 80.52 ± 4.34 to 80.54 ± 4.41 bpm, P = 0.046). Despite the evidence of HBCR compared to usual care, there are several studies that indicate no significant differences between groups post-intervention (de Mello Franco et al., 2006; Dracup et al., 2007; Piotrowicz et al., 2015; Wu et al., 2008; Xu et al., 2016).

Regarding comparisons to traditional CR, Arthur et al found that both the HBCR and hospital groups showed significant decreases in RHR from baseline to 6 months (80.6 ± 16.0 to 74.0 ± 15.8 bpm and 84.2 ± 15.9 to 77.8 ± 14.8 bpm, both $P < 0.0001$) with no significant differences between groups (Arthur et al., 2002). The Aamot study in 2014 showed a significant decrease in RHR only within the HBCR group (59 ± 9 to 54 ± 7 bpm, $P < 0.05$) with no significant differences between groups. Skobel et al (2017) showed in their study that RHR significantly changed in both the HBCR and traditional CR groups (72 (46, 107) to 64 ± 10 bpm vs 71.7 (44, 103) to 64 ± 10 bpm, $P = 0.007$ and 0.004 respectively), but not significant difference between groups ($P = 0.1$). Wu et al (2006) examined all three scenarios with a traditional group, an HBCR group, and a usual care control. The HBCR group exercised at an intensity of 60-85% of peak HR (PHR), that was determined via stress test and RPE 11-13, 3 times per week with each session including a 10-minute warm-up, 30-60 minutes of aerobic training by fast walking or jogging, and a 10-minute cool-down, which was all documented in a record book to be given to the office or discussed by phone consultation every 2 weeks for 12 weeks, as presented in Table 1. Results indicated that all groups (traditional CR, HBCR, and the control group) showed significant decreases in RHR (86.1 ± 6.2 to 76.1 ± 6.8 bpm vs 85.4 ± 6.5 to 78.5 ± 5.4 bpm vs 87.2 ± 7.2 to 83.9 ± 6.0 bpm, all $P < 0.05$) with only the traditional CR group and the control group showing significant difference between one another ($P < 0.05$).

Despite the evidence, there are some studies that show no significant difference either before or after both traditional CR and HBCR (Shagufta, Moiz, & Aggarwal, 2011; Varnfield et al., 2014).

In examining HRmax and PHR comparing HBCR and usual care, Lee et al found after exercise training, the HBCR group of their study showed a significant increase in HRmax (121.96 ± 16.38 to 128.56 ±16.47, $P < 0.05$), however, there was no significant differences between groups (Lee et al., 2013). Piotrowicz et al found a significant increase before and after training in their HBCR group (113 ± 16 to 122 ± 18 bpm, $P = 0.0001$) and a significant difference between HBCR and the usual care control (113 ± 16 to 122 ± 18 bpm vs 120 ± 19 to 117 ± 14 bpm, $P = 0.0088$) (Piotrowicz et al., 2015). Other methods to record a higher HR were via PHR. In studies comparing HBCR and usual care PHR, there were none that showed any significant differences within or between groups (Oka et al., 2000, 2005; Wu et al., 2008).

In measures of HRmax between HBCR and traditional CR, Bravo-Escobar et al showed a significant difference between the two groups as HRmax increased in the HBCR group and decreased in the traditional group after intervention (107.23 ± 32.58 to 123.84 ± 22.61bpm vs 132.84 ± 16.11 to 123.88 ± 17.38 bpm, $P = 0.009$) (Bravo-Escobar et al., 2017). Kraal et al reported that the only significant change was a significant increase in HRmax in their center-based group at their 1-year follow-up with no significant differences otherwise between groups (142.6 ± 16.7 to 149.6 ± 23.8 bpm, $P < 0.01$) (Kraal et al., 2017). Examining PHR, Arthur et al reported that in the hospital group from baseline to 6 months there was a significant increase (126.4 ± 20.6 to 136.7 ± 24.3 bpm, $P < 0.0001$), but there were no significant differences in the HBCR group or between groups (Arthur et al., 2002). Wu et al examining PHR in traditional CR, HBCR, and a usual care control found that all showed a significant increase in PHR from baseline to their 12 week follow up (123.2 ± 9.5 to 143.0 ± 9.7 bpm vs 125.6 ± 10.1 to 139.8 ± 10.7 bpm vs 125.3 ± 11.1 to 132.6 ± 12.6, all $P < 0.05$), and there was only a significant difference between traditional CR and the control group ($P < 0.05$) (Wu et al., 2006). Oerkild et al showed no significant differences within or between groups by HRmax, and Shagufta and Avila showed no significant differences within or between groups by PHR (Avila et al., 2020; Oerkild et al., 2011; Shagufta et al., 2011).

Left ventricular ejection fraction (LVEF) is an important measure that is examined in cardiac function of heart patients. In a study from Xu et al with a HBCR group and usual care control, the HBCR group was in an inpatient phase for 1 week and an outpatient phase for 4 weeks with the inpatient phase being exercise estimated at 2-4 METs and the outpatient phase being a 5-minute warm-up, 20 minutes of aerobic exercise, and a 5-minute cool down, as presented in Table 1 (Xu et al., 2016). There were no significant differences between the HBCR and usual care control groups in LVEF at baseline (52.5 ± 7.7 vs 53.3 ± 10.9 %, $P = 0.752$), but at the end of the trial at 4 weeks, there was shown to be a significant difference between the groups (56.6 ± 9.2 vs 51.6 ± 8.6, $P = 0.008$). Despite the previous information, there is only one study showing significant difference in LVEF following HBCR, while other evidence shows there is no significant difference between HBCR and usual care (Chen et al., 2018; de Mello Franco et al., 2006; Dracup et al., 2007; Peng et al., 2018).

Comparing HBCR and traditional CR regarding LVEF, Karapolat et al found a significant increase in LVEF in both groups (29.24 ± 11.11 to 31.16 ± 10.14 % vs 27.05 ± 6.93 to 29.00 ± 9.26 %, both $P < 0.05$), but there was no significant difference between groups ($P > 0.05$) (Karapolat et al., 2009). Smolis-Bąk et al found a significant increase in both the HBCR and center-based groups from baseline to the 12-month follow-up in their study (25.3 ± 7.4 to 28.9 ± 9.1% and 24.9 ± 7.2 to 31.7 ± 10.6, P = 0.0213 and P = 0.0001 respectively) and found no significant difference between groups at baseline or 12 months (P = 0.8320 and P = 0.3273 respectively) (Smolis-Bąk et al., 2015). Scalvini et al found no significant difference within or between groups in LVEF in their study (Scalvini et al., 2013). Only two studies indicated that HBCR can increase LVEF in a similar way to the traditional method.

To summarize comparisons between HBCR and usual care controls, only three studies reported a significant decrease in resting BP in the HBCR group (Oerkild et al., 2012; Salvetti et al., 2008; Senuzun et al., 2006), and eight studies reported no significant differences within or between groups (Heron et al., 2017; Houle et al., 2011; Lee et al., 2013; Oka et al., 2000, 2005; Wang et al., 2016; Wu et al., 2008; Xu et al., 2016). Regarding RHR, only one study reported a significant decrease in HBCR (Peng et al., 2018), and five studies reported no significant differences within or between groups (de Mello Franco et al., 2006; Dracup et al., 2007; Piotrowicz et al., 2015; Wu et al., 2008; Xu et al., 2016). Concerning PHR, only one study reported a significant increase in HBCR (Piotrowicz et al., 2015), while four studies reported no significant differences within or between groups (Lee et al., 2013; Oka et al., 2000, 2005; Wu et al., 2008). Regarding LVEF, only one study reported a significant increase in HBCR (Xu et al., 2016), and four studies reported no significant difference within or between groups (Chen et al., 2018; de Mello Franco et al., 2006; Dracup et al., 2007; Peng et al., 2018).

To summarize comparisons between HBCR and traditional CR, two studies reported a significant decrease in BP in HBCR (Jolly et al., 2009; Varnfield et al., 2014), one study reported a significantly greater decrease in traditional CR (Skobel et al., 2017), and five studies reported no significant differences within or between groups (Bravo-Escobar et al., 2017; Dalal et al., 2007; K. W. Lee et al., 2006; Maddison et al., 2019; Wakefield et al., 2014). With respect to RHR, four studies reported no significant differences between groups (Aamot et al., 2014; Arthur et al., 2002; Skobel et al., 2017; Wu et al., 2006), and two other studies reported no significant differences within or between groups (Shagufta et al., 2011; Varnfield et al., 2014). Regarding PHR, one study reported a significant increase in HBCR (Bravo-Escobar et al., 2017), three studies reported no significant differences between groups (Arthur et al., 2002; Kraal et al., 2017; S. K. Wu et al., 2006), and three additional studies reported no significant differences within or between groups (Avila et al., 2020; Oerkild et al., 2011; Shagufta et al., 2011). Finally, regarding LVEF, two studies reported no significant differences between groups (Karapolat et al., 2009; Smolis-Bąk et al., 2015), and only one study reported no significant differences within or between groups (Scalvini et al., 2013).

Risk Factor Modifications in Home-Based Cardiac Rehabilitation

Modifiable risk factors are an outcome target for cardiac rehabilitation interventions throughout the world. Among these risk factors are cholesterol profiles. Exercise capacity can affect modifiable risk factors such as total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides. Senuzun et al showed no significant differences at baseline for TC, HDL, and LDL, but after the HBCR intervention they reported a significant difference between HBCR and usual care in all three (TC: 187.7 ± 30.2 vs 197.2 ± 49.7 mg/dl, $P = 0.0004$; HDL: 42.2 ± 7.1 vs 38.4 ± 5.2 mg/dl, $P = 0.001$; LDL: 93.3 ± 23.4 vs 109.7 ± 29.3, $P = 0.039$) (Senuzun et al., 2006). Senuzun and colleague’s study was the only study to report significant differences in TC, HDL, or LDL in HBCR versus usual care. All other studies found comparing HBCR and usual care showed no significant differences within or between groups (Claes et al., 2020; Houle et al., 2011; Oerkild et al., 2012; Wang et al., 2016).

In comparing HBCR and traditional CR regarding improvements in blood lipids, Jolly et al showed a significant difference within groups for both the HBCR and center-based group in TC and HDL at 12 months (TC: 4.76 ± 1.28 to 3.99 ± 0.90 mmol/l and 4.83 ± 1.31 to 3.90 ± 0.83 mmol/l, both $P < 0.001$; HDL: 1.17 ± 0.28 to 1.30 ± 0.39 mmol/l and 1.20 ± 0.34 to 1.27 ± 0.34, both $P < 0.001$), but no significant difference between groups (Jolly et al., 2009). Oerkild et al reported only one significant difference between the HBCR and center-based CR with center-based CR having a greater decrease change in TC from 0-3 months (Δ 0-3 months HBCR 0.2; -0.2, 0.5; Center -0.3; -0.6, 0.001; Δ 3 months between home and center 0.5; 0.02, 0.9; $P < 0.05$) (Oerkild et al., 2011). Varnfield et al stated that only the TC significantly decreased from baseline to 6 weeks in the traditional CR group and not the HBCR group (3.59 ± 1.13 to 2.96 ± 0.66 mmol/l vs 3.48 ± 1.16 to 3.22 ± 0.81 mmol/l, $P = 0.04$ and $P = 0.07$ respectively) (Varnfield et al., 2014). Wakefield et al (2014) used a telerehabilitation method with HBCR patients completing 12 weeks of rehabilitation with a workbook to record exercise, diet, instructions on equipment use and exercised according to ACSM guidelines for at least 30 minutes three times per week using the RPE scale, as presented in Table 1. Patients were called weekly to assess progress and adjust their exercise prescription.

The HBCR group showed significant improvements in TC and LDL (169 ± 42 to 150 ± 34 mg/dl and 101 ± 31 to 83 ± 28 mg/dl, both $P \leq 0.01$), and there were no significant differences between HBCR and the traditional CR group (TC: $P = 0.15$, HDL: $P = 0.49$, LDL: $P = 0.87$).

Ramadi et al reported a significant change in both the HBCR and center-based groups of their study in TC at 12 weeks (3.46 ± 0.92 to 3.58 ± 0.92 mmol/l and 3.51 ± 0.99 to 3.53 ± 0.87 mmol/l, both $P < 0.05$) and at 1 year (3.69 ± 0.93 mmol/l and 3.74 ± 0.93 mmol/l, both $P < 0.05$), but no significant differences between groups (Ramadi et al., 2015). The researchers also reported a significant change in HDL in both HBCR and center groups at 12 weeks (1.15 ± 0.36 to 1.22 ± 0.37 mmol/l and 1.15 ± 0.31 to 1.21 ± 0.31 mmol/l, both $P < 0.05$) and at 1 year (1.26 ± 0.37 mmol/l and 1.24 ± 0.32 mmol/l, both $P < 0.05$), but no significant differences between groups. Regardless of the reported evidence, there are still some studies that report no significant differences within or between groups for TC, HDL, or LDL (Aronov, Bubnova, Iosseliani, & Orekhov, 2019; Avila et al., 2020; Bravo-Escobar et al., 2017).

Regarding information highlighting fasting blood glucose (FBG), no studies within the group of investigations found significant differences within or between groups before or after HBCR compared to usual care in FBG (Claes et al., 2020; Houle et al., 2011; Wang et al., 2016). There were also no studies showing significant differences within or between groups in FBG comparing HBCR and traditional CR (Avila et al., 2020; Bravo-Escobar et al., 2017; Ramadi et al., 2015; Skobel et al., 2017). There were no studies that found significant differences within or between groups comparing waist-hip ratio (WHR) in HBCR and usual care (Claes et al., 2020; Oerkild et al., 2012). In comparing HBCR and traditional CR however, Smith et al observed that in HBCR patients only that there was a significant improvement in WHR from discharge to the 12-month follow up (0.91 ± 0.06 to 0.90 ± 0.06, $P < 0.05$) (Smith et al., 2004). Smith and colleague’s study was the only one to indicate that HBCR specifically could improve WHR, as other studies have not found any significant differences within or between groups when comparing to traditional CR (Bravo-Escobar et al., 2017; Oerkild et al., 2011; Smith et al., 2011).

Regarding potential improvements in body mass index (BMI) between HBCR and usual care, Senuzun et al found after 12 weeks of exercise that the HBCR group showed significant improvements (25.9 ± 2.7 to 25.5 ± 2.5 kg/m^2, $P < 0.05$), but no stated significant difference between HBCR and usual care (Senuzun et al., 2006). In a study by Wang et al, a HBCR program was given 40 minutes of education with a research assistant and received a Heart Recovery Education Booklet (HREB) and together set goals with each participant, as presented in Table 1 (Wang et al., 2016). Following directions in the booklet, participants altered their behaviors and received weekly phone calls for 4 weeks to reinforce compliance. After the study, the findings indicated that at the 16-week follow-up the HBCR group showed significant improvement over the usual care control group (23.62 ± 3.67 kg/m^2 vs 25.53 ± 2.69 kg/m^2, $P = 0.04$). No other studies showed any significant differences within or between groups between HBCR and usual care (Xu et al., 2016). Regarding HBCR and traditional CR, Smith et al reported throughout their study that HBCR patients reported significantly lower BMI ($P = 0.041$) (Smith et al., 2011). The previously mentioned study was the only one with such results, as no other study comparing HBCR and traditional CR showed significant differences within or between groups (Avila et al., 2020; Bravo-Escobar et al., 2017; Kraal et al., 2017; Oerkild et al., 2011; Skobel et al., 2017; Smith et al., 2004; Wakefield et al., 2014).

To summarize comparisons between HBCR and usual care controls regarding cholesterol: one study reported decreases in TC and LDL, and increases in HDLin HBCR (Senuzun et al., 2006); and four studies reported no significant differences within or between groups (Claes et al., 2020; Houle et al., 2011; Oerkild et al., 2012; Wang et al., 2016). All three studies found regarding FBG reported no significant differences within or between groups (Claes et al., 2020; Houle et al., 2011; Wang et al., 2016). In comparing WHR, both studies found reported no significant differences within or between groups (Claes et al., 2020; Oerkild et al., 2012). Regarding BMI, one study reported a significant decrease in HBCR (Wang et al., 2016), and one other study reported no significant differences within or between groups (Xu et al., 2016).

In summary of HBCR and traditional CR in regard to cholesterol profiles, one study reported a significant decrease in TC in HBCR (Oerkild et al., 2011), one study showed a significant decrease in TC in traditional CR (Varnfield et al., 2014), three studies reported no significant differences between groups (Jolly et al., 2009; Ramadi et al., 2015; Wakefield et al., 2014), and three additional studies reported no significant differences within or between groups (Aronov et al., 2019; Avila et al., 2020; Bravo-Escobar et al., 2017). Concerning FBG, all four studies found reported no significant differences within or between groups (Avila et al., 2020; Bravo-Escobar et al., 2017; Ramadi et al., 2015; Skobel et al., 2017). Regarding WHR, only one study reported a significant improvement in HBCR (Smith et al., 2004), while three other studies reported no significant differences within or between groups (Bravo-Escobar et al., 2017; Oerkild et al., 2011; Smith et al., 2011). Lastly, with respect to BMI, only one study reported a significant decrease in HBCR (Smith et al., 2011), and seven studies reported no significant differences within or between groups (Avila et al., 2020; Bravo-Escobar et al., 2017; Kraal et al., 2017; Oerkild et al., 2011; Skobel et al., 2017; Smith et al., 2004; Wakefield et al., 2014).

Hospitalization and Mortality in Home-Based Cardiac Rehabilitation

With respect to improvements in mortality in cardiac patients, Dracup et al (2007) randomized patients with systolic HF to a usual care control or HBCR group with the HBCR group performing low-level exercise four times weekly by aerobic training starting at 10 minutes at 40% HRmax and gradually increased up to 45 minutes at 60% HRmax for the remainder of the program. After 6 weeks of aerobic training, 2 sets of 10 repetitions were added at a workload of 80% 1 RM and was completed three times weekly on days the participants did not train aerobically. Nurses made home visits weekly for the first 2 weeks and then monthly to assess adherence to protocol. At the 1-year follow-up there was shown to be a significant difference between HBCR and the usual care control for hospitalizations per patient (0.56 ± 0.8 vs 0.99 ± 1.5 per patient/1 year, $P = 0.024$) and in total number of hospitalizations in patients having ≥ 2 rehospitalizations (0.60 ± 0.89 vs 1.05 ± 1.5, $P = 0.002$). The lower incidence of multiple hospitalizations came to be 12.8% in the HBCR group and 26.6% in the control ($P = 0.018$).

With further consideration to improvements in mortality, Wang et al (2016) found that there was no significant difference between the HBCR and usual care control groups on unplanned cardiac-related hospital readmissions ($P = 0.602$), but they did find significant differences on unplanned cardiac-related emergency room (ER) visits (1 vs 9 total visits $P = 0.036$) and medical consultations (9 vs 22 total consultations $p = 0.046$) at the 16-week time point with the HBCR group reporting significantly fewer ER visits and medical consultations than the control. Bernocchi et al comparing HBCR and a usual care control found that the time from hospitalization/death was significant between groups (113.4 vs 104.7 days, $P = 0.0484$) and further increased in the next two months ($P = 0.0387$) (Bernocchi et al., 2018). Total hospitalizations were 21 in the HBCR group (11 for CVD, 6 for respiratory diseases, and 5 for other causes) and 37 in the control group (25 CVD, 11 respiratory, and 1 other cause). According to hospital records, Chen et al found that readmission rate for HF within 1 year was 34%, and 14% within 90 days from 2011-2012, and at the 3- month follow-up, the HBCR group showed a significant reduction (no P value given) in readmission within 90 days with an average of 5% instead of 14% (Chen et al., 2018). Despite the evidence presented in the case of HBCR versus usual care, there are some studies that show no significant difference between the two groups and rehospitalization (Dalal et al., 2019; Piotrowicz et al., 2014).

In comparing HBCR and traditional CR improvements in mortality, Smith et al (2011) reported a significantly lower number of hospitalizations in the HBCR group compared to the hospital-based CR (42 vs 79 hospitalizations, P = 0.001) and a significantly different distribution between HBCR and hospital by number of hospitalizations (1 hospitalization: 29 vs 22; 2 hospitalizations: 5 vs 15; 3+ hospitalizations: 9 vs 1; P = 0.025). Stewart et al (2012) reported on a multicenter trial with CHF patients and compared HBCR and clinic-based CR by unplanned hospitalization or death, as presented in Table 1. During the 18 month follow-up, there was no significant difference between HBCR and clinic-based CR in unplanned hospitalization or death (71% vs 76% of patients, p = 0.861); no significant differences in ≥ 1 unplanned hospitalizations (62% vs 55%, P = 0.194); a significantly lower number length of days in the hospital for unplanned hospitalizations in HBCR (median: 4.0, IQR: 2.0 to 7.0 days vs 6.0, QR: 3.5 to 13 days, P = 0.004); a significantly lower number of total hospitalizations in HBCR (938 days less, P = 0.003); significantly fewer days of cardiovascular-related hospitalization in HBCR (588 days less, P = 0.025), but not CHF-related hospitalization (257 days less, P = 0.218). The data had also shown there were significantly greater days alive out of hospital from unplanned hospitalization in HBCR (452 ± 158 days vs 418 ± 173 days, $P = 0.019$); and significantly greater all days out of hospital in HBCR(451 ± 158 days vs 414 ± 172 days, $P = 0.009$).

To summarize mortality comparing HBCR and usual care controls, one study reported HBCR had a lower total number of hospitalizations in patients having ≥ 2 hospitalizations (Dracup et al., 2007), one reported significant differences in unplanned cardiac-related ER visits and medical consultations in HBCR (Wang et al., 2016), one reported significantly greater time from hospitalization to death (Bernocchi et al., 2018), and another reported a significantly reduced readmission rate within 90 days (Chen et al., 2018). There were two studies that reported no significant differences within or between groups (Dalal et al., 2019; Piotrowicz et al., 2014). In summarizing comparisons of HBCR and traditional CR, one study reported significantly lower hospitalizations in HBCR and a significantly different distribution between HBCR and traditional CR by number of hospitalizations (Smith et al., 2011). Lastly, one other study reported no significance between groups in unplanned hospitalization or death and no significance in ≥ 1 hospitalization, but also reported a significantly number of days in the hospital from unplanned hospitalizations, a lower total number of hospitalizations, fewer days of cardiovascular-related hospitalization, greater days alive out of hospital from unplanned hospitalization, and greater all days out of hospital (Stewart et al., 2012).

Summary of TCR vs HBCR Studies					
	# TCR studies with improvement	# HBCR improvement	when both improve, <, >, =?		
			TCR < HBCR	TCR > HBCR	TCR = HBCR
Mortality	2/2	2/2			2/2
Risk Factor Modification					
Total Cholesterol	4/7	3/7			3/3
HDL	2/7	2/7			2/2
LDL	1/6	1/6			1/1
FBG	0/4	0/4			
WHR	0/4	1/4			
BMI	0/8	1/8			
Exercise Capacity					
Peak VO_2	10/14	11/14			8/8
6MWD	6/7	5/7	2/5		3/5
METs	4/6	6/6			4/4
Cardiac Function					
Rest SBP	1/8	2/8			1/1
Rest DBP	1/9	1/9			
RHR	4/6	5/6			4/4
PHR	3/8	1/8			1/1
LVEF	1/2	1/2			1/1

Table 2. The summary of all studies in which TCR and HBCR are compared to one another. The first columns summarize the number of studies in which TCR and HBCR showed improvements out of the total number of studies that each outcome was measured. The latter columns indicate out of the number of studies in which both TCR and HBCR showed improvements whether there were significant improvements in favor of HBCR (<) , in favor of TCR (>), or whether there was no significance between interventions (=). TCR – Traditional Cardiac Rehabilitation, HBCR – Home-Based Cardiac Rehabilitation, HDL – High-Density Lipoprotein, LDL – Low-Density Lipoprotein, FBG – Fasting Blood Glucose, WHR – Waist-Hip Ratio, BMI – Body Mass Index, 6MWD – Six Minute Walk Distance, SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure, RHR – Resting Heart Rate, PHR – Peak Heart Rate, LVEF – Left Ventricular Ejection Fraction.

Conclusions

In contrast to the majority of patients who receive usual care (no exercise intervention, e.g. non-participants or non-referrals to CR); less than 20% of eligible participants are referred to CR (Aragam et al., 2015). Evaluating outcome measures in exercise-based CR, HBCR is equivalent, with respect to Peak VO_2, 6MWD, METs, resting SBP, RHR, LVEF, TC, HDL, LDL, and mortality to a traditional outpatient phase II CR program in eliciting a response due to exercise. As indicated in Table 2, this evidence is preliminary in nature. By virtue of this finding, HBCR has distinct advantages which are related to barriers to participation in a phase II outpatient CR program. The advantages that HBCR possess include overcoming participation barriers regarding distance or transportation, frailty due to advancing age, and additional comorbidities and health-related issues.

Nonetheless, traditional phase II outpatient CR maintains its inherent advantages such as adherence and safety due to direct patient monitoring, coverage and reimbursement of health care, and standardized guidelines. Constant supervision provides a safer environment for which patients can exercise with the knowledge that, should a cardiac event occur, help is more readily within reach. A HBCR program could be at a disadvantage due to the intervention being administered off-site. If a patient lives further away, it will still take time for medical professionals to arrive if a cardiac event were to occur and is magnified if a patient lives in a rural community. Regarding adherence, some individuals might not have the motivation to participate in a HBCR due to lack of supervision to ensure exercise in a safe environment.

In the United States, while some insurance programs such as Medicare and Medicaid may cover up to 36 sessions of traditional CR, coverage does not include HBCR programs unless offered with home health services (Feinberg et al., 2018). Patients who receive HBCR are those who are unable to leave home without a sizable effort and are typically under the supervision of a visiting nurse or therapist. A traditional program is advantageous, as patients could take up to the full 36 sessions of CR to further reduce risk of mortality. As traditional CR has been well-established over several decades (Balady et al., 2007; Hamm et al., 2011; Thomas et al., 2010), there is no primary standard that has been established for a HBCR program. Knowing that a multitude of different methods by which HBCR can be administered to the patient population, there is not one standard of care given by this intervention other than to mimic a traditional outpatient phase II CR program. The reason HBCR likely has no standard of care is due to the lack of evidence for this intervention until the most recent decades.

In conclusion, there is emergent evidence which indicates that HBCR is equivalent to a traditional outpatient phase II CR program in eliciting an exercise response in outcome measures of exercise capacity, cardiac function, risk factor modification, and mortality (e.g., Peak VO_2, 6MWD, METs, resting SBP, RHR, LVEF, TC, HDL, LDL, and mortality). Traditional outpatient phase II CR has several advantages regarding adherence and safety due to direct patient monitoring, coverage and reimbursement of health care, patient education, and standardized guidelines. HBCR may possess advantages in situations regarding barriers to adherence or participation such as travel, frailty due to advancing age, and additional comorbidities or health issues.

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