Thomas et al Home-Based Cardiac Rehabilitation: A Scientific Statement From AACVPR, AHA, and ACC
Supplemental Materials
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Table 1 SUMMARY OF CARDIAC REHABILITATION STUDIES

Study	Design	No. of Patients	Patient Population	Interventions	Outcomes	Subgroup Analyses	Unique Strategies, Learnings, Solutions to Address Challenges of Operating Home-Based Program	Notes
Aamot, I. 2014[1,2] **Norway**	RCT stratified on age, gender, & diagnosis Recruited 2009-2011 from CR referrals Examined exercise adherence at 1 year on n=76/90	N=90 Women = 10 Men = 80 Mean age 57 (8) MI: n = 61 CABG: n = 22 ACS: n = 7	MI, CABG, ACS, No HF	High intensity interval training (HIT) in 3 settings: 1) Treadmills (TE) in hospital in small groups of 3-7 patients. Physiotherapist monitored. N=34 2) Group exercise (GE) in hospital in groups of 10-15 instructed by physiotherapist. Circuit & interval training (running, squats, steps, push-ups, sit ups), walking. N=28 3) Home-based exercise (HE) – 2 sessions of instruction by physiotherapist. Up-hill walking or jogging. Then cross country skiing, bicycling, running or indoor treadmills or cross trainers as preferred. Holter ECG recorded first exercise session to ensure safety. N=28 All sessions were 2/week for 12 weeks. 10 min warm up to 50-70% peak HR; contained 4 intervals lasting 4 min each at intensity 85-95% peak HR separated by 4 minutes of activity breaks at intensity 70% of peak HR. Then cool down of 3-5 min at 50% of peak HR. Instructed on using polar HR monitor	Primary Outcomes: at baseline & 12 weeks 1) Peak VO_2 (CPET) – ramp protocol to exhaustion or clinical symptoms Secondary outcomes: 1) HRQoL (MacNew), exercise attendance, resting BP, resting HR, body composition, self-reported PA (IPAQ) Results: Changes in peak VO_2 higher in TE vs. GE (1.6 ml/kg/min, p=.02). No difference between TE vs. GE or GE vs. HE. BUT no differences between groups in "on treatment analyses" (TE vs. GE 1.0 ml/kg/min, p=.28; TE vs. HE 1.3 ml/kg/min^{-1}, p=.13, GE vs. HE 0.2 ml/kg/min^{-1}, p=1.) Target HR achieved in all groups with no between group differences. Minutes in target HR NS between groups. Exercise attendance: higher in TE & GE than HE (p=.04) as 4 in HE did not reach 70% of 24 exercise sessions. Median number exercise sessions = 24 (range 7-24) for TE, 23 (17-24) for GE, & 24 (10-24) for HE. HRQOL: No between-group differences. BP, HR, body weight, body composition improved slightly in all groups. NS Self-reported PA – no change from pretest to posttest. General conclusion: exercising on treadmills in hospital increased peak VO_2 more than exercising at home. However, on-treatment analysis, including only those who trained per protocol, showed NS difference in peak VO_2 between groups. One-year adherence: 76/90 of original participants; TE=29/34; GE=24/28; HE=23/28. CPET: NS difference between groups. HE nearly maintained post-intervention peak VO_2. Self-reported PA: NS group differences. Accelerometer data for 7 days: (n=73) 69/73 met 30 minutes of moderate PA/day. Total energy expenditure: no between group differences. Trend for more moderate PA in HE	None	2014[1]: Safety concerns and population: • Exclusion – HF, other medical conditions contradictive to HIT • Clinically stable, middle-aged, baseline, "quite fit" and "motivated". • Individually instructed in use of HR monitor, reaching target HR – HE two initial sessions, TE and GE – physiotherapist present all sessions HE: After initial sessions, HIT was performed in preferred exercise mode in their home environment – (e.g., uphill walking, skiing, running or indoor equipment). Mode could vary within desired exercise intensity. Exercise attendance – higher in TE and GE compared to HE (p=0.04), "lack of time" main reason for those not reaching 70% of the 24 sessions. However, difference between groups	Exercise-only program. Attendance = number of sessions completed. Completing 70% of exercise sessions = training per protocol 1 patient moved from TE to HE; 7 lost to follow-up; 92% completed 12-week follow-up. Not ITT analysis Non-blinded outcome assessors With high degree of self-administration & no monitoring during CR, the transition from supervised to unsupervised exercise might be enhanced.

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					group. NS group differences in body composition but no regression. No group differences in HRQoL. <u>Adverse events:</u> Short-term: Major adverse events (cardiac arrests or acute MI) - none. Minor adverse events (musculoskeletal): 2 in GE but not in HB & all subjects able to complete intervention Long-term (12 months): 1 MI in patient in TE group. 2 CABG, 1 in TE & 1 in GE, but none in HB. --9 minor orthopedic events: 3 in TE, 3 in GE, 2 in HB.		for peak V02 was not statistically significant. 2016[2]: One year F/U Support/Instruction/Communication strategies: All 3 groups of participants encouraged to exercise either HIT or with any other preferred exercise mode & intensity to meet recommended PA level. Also informed of community rehab options (Phase 3) if unsupervised exercise became difficult-however, none attended. No further contact before 1-yr F/U Measurement: Self-report (IPAQ)– exercised regularly (yes/no); use of HR monitors during the year. One year- Accelerometer- 7 days/24 hrs HE: habitual exercise was more often reported than other groups (p=0.04) and used HR monitors during exercise (p=0.01)	
Arthur 2002[3, 4] **Canada**	RCT & 6-year follow-up	242 HBCR: n=120 (110 men) Mean age 64 (9) CBCR: n= 122 (96 men) Mean age 62.5 (9) Completed 6-year follow-up: HBCR: 70/96 CBCR: 74/100	Post-CABG (35-49 days) Exclusion: angina, abnormal ETT, unable to attend CR 3 times/ week, physical limitations, previously participated in CR	**HBCR:** 6 months of exercise training, 5 sessions/week, phone call every 2 weeks to monitor progress, assess & document adherence, revise exercise prescription, provide support, & education; 10-15-minute warm-up, 40 minutes aerobic training (self-paced walking), 10-15-minute cool-down; HBCR averaged 6.5 sessions/week, 42 minutes/session the first 3 months, & 47 minutes/session the second 3 months; HBCR participated in 10.7 calls (15 minutes each) over 6 months	<u>Primary:</u> peak VO_2 (cycle ergometer): Similar improvements in both groups at 6 months (31% in HBCR & 36% in CBCR, difference NS); 3 month results not reported <u>Secondary:</u> HRQoL (SF-36), social support (ISEL): Physical HRQOL improved in both groups (p<0.0001), but statistically more in the HBCR (6 months PCS: 51.2 vs 48.6, p=0.004; MCS 53.5 vs. 52, p=.13; 18 months PCS: 48.3 vs 47.6, p=.67, MCS 53 vs. 50.2, p=.07); HBCR reported greater total social support than the CBCR at baseline (data not shown), 3 months (36.2 vs 34.0, p<0.0001) & 6 months (36.0 vs 34.6, p<0.05) NS change in weight in either group but reduced waist-hip ratio over 6-month. NS difference in clinical events by 6 years between groups. Total number & distribution of	None	Home-based participants exercised at home and were phoned at varying intervals depending on CR site.	Comprehensive program. HBCR participants exercised at home but had access to services of CBCR (dietitian, psychologist counseling) Lost to follow-up: 20/242 (8%) at 6 months & 24/242 (10%) at 18 months <u>Adherence</u> Exercise/week: HBCR: 6.5 (4.6) CBCR: 3.7 (2.6)

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		22% diabetic		**CBCR:** exercise training in hospital 3 sessions/week for 6 months, 2 sessions/week outside hospital (5 days/week total); 10-15-minute warm-up, 40 minutes of aerobic training (cycle ergometer, arm cycle ergometer, treadmill, track walking, stair climbing), 10-15-minute cool-down; CBCR group averaged 2.3 sessions/week in hospital CR & 1.4 at home. Both groups had access to dietitian & psychologist counseling	hospitalizations were significantly different between HBCR (n=42) and CBCR (n=79) but median time to first hospitalization was similar (4.49 Years). 6-year follow-up: Peak VO_2 higher in HBCR than CBCR (p<.05). Peak METs also significantly better. At 6 years: 45.8% (n=27) of CBCR & 58.3% (n=28) of HBCR met criteria for exercise maintenance; p=0.244. Physical Activity Scale for the Elderly (PASE): PASE scores were significantly higher among HBCR group than the CBCR group at 1 year & persisted at 6 years. But the decline in scores was greater among HBCR group. Adverse events: None reported			No difference in % patients seeking psychologist consultation Only low risk patients enrolled. Cited as a study limitation.
Bell 1998[5] **UK 5 district hospitals**	RCT	252	Post-MI Excluded age >72 years Mean age 59 (8.9) 77% male	HBCR (n=152) versus CBCR (n=100) **HBCR:** Heart Manual. Duration of exercise 6 weeks, frequency, intensity & duration not reported. 4 phone calls by facilitator, health education & stress management **CBCR:** 12 weeks of 1 session/week or 4 weeks of 2 sessions/week; session duration ≥20 minutes; intensity 3-4 on Borg; education sessions on CHD causes, medication risk factor modification, stress management & exercise.	Primary: peak functional capacity (METs), LDL cholesterol Secondary: total cholesterol, HDL cholesterol, triglycerides, blood pressure, cardiovascular medications, costs, adherence (exercise sessions attended) Follow-up 6-months post-randomization Total follow-up 10.5 months HRQoL Outcomes: Nottingham Health Profile: HBCR vs CBCR Energy 18.6 (28.4) vs 17.3 (30.7) p=0.78 Pain 6.6 (15.3) vs. 7.4 (15.5) p=0.74 Emotional reaction 6.6 (15.3) vs 7.4 (15.5) p=0.74 Sleep 6.6 (15.3) vs. 16.9 (22.8) p=0.0007 Social Isolation 3.7 (13.6) vs. 6.7 (15.0) p=0.18 Physical mobility 6.9 (13.5) vs. 9.1 (15.9) p=.003 No difference in smoking behavior.	None	Safety concerns/population: Low risk post CABG patients; excluded any with physical limitations Support/Instruction/Communication strategies: HBCR: Individual 1 hr exercise consult with exercise specialist at baseline & 3 months of exercise training. Exercise log – activity, time, & heart rates – reviewed monthly by exercise specialist Telephoned every 2 weeks by same exercise specialist to monitor program, assess & document adherence, revise exercise prescription if needed. (Average 10.7 +/- 2.8 over 6 months, approximately.15 min each. Both groups had access to dietitian & psychologist counseling – similar number of consults for both groups (dietician, 53% CBCR, 50%	Comprehensive program Adherence not reported

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							HBCR; psychologist, 51% CBCR; 42% HBCR) Safety concerns: Exclusion – physical infirmity, >75 years, persisting medical conditions. Support/Instruction/Communication strategies: HBCR – instruction: 4 phone calls by facilitator, health education & stress management	
Carlson 2000[6] USA	RCT	80	CABG, MI, angioplasty, CHD HBCR: n=38 CBCR: n=42 Mean age 59 (14); 83% male	CBCR & HBCR. Initial 4 weeks were identical in both groups (orientation, 3 exercise sessions/week with ECG monitoring-warm up, 30-40 minutes aerobic exercise initially 20-30 bpm above resting HR or RPE <13, & after exercise test, 60-85% of aerobic capacity), cool down), encouraged to achieve > 5 aerobic exercise sessions/week for > 30 minutes/session, assessment at baseline, patient education (3 group sessions of nutrition/risk factors, individual counseling before & during exercise sessions on exercise training principles, CVD risk factors, nutrition to maintain ideal body weight, pharmacologic therapy, & identifying target outcomes), groups classes & educational videos. **CBCR:** Weeks 5-12: same as first 4 weeks Weeks 13-25: Phase III program-same as in weeks 5-12, but without ECG monitoring, & staff supervision reduced-rest & post-exercise BP's checked, along with instantaneous ECG. Patients recorded their intensity & duration.	Baseline & 6-month follow-up. Program participation: (Patients who discontinued CBCR exercise by week 7 & failed to complete 6-month evaluation were considered drop-outs.) HBCR 92% vs CBCR 76% (p<0.05). Attendance at all 3 nutrition/risk factor classes: HBCR = 27/48; CBCR = 33/37 Exercise adherence: (Patient self-report for off-site exercise, one session was >30 minutes of exercise; those not returning activity logs or who were absent for 2 consecutive weeks were contacted for off-site exercise information). Weekly average of total exercise sessions (on- & off-site): NS different in weeks 1-6 (HBCR 4.9 vs CBCR 4.6), 7-12 (4.8 vs 4.4) or at 6 months (4.3 vs 3.8); HBCR > CBCR for weeks 13-25 (4.2 vs 3.4, p=0.03) Cardiovascular outcomes: Primary: maximal oxygen uptake, LDL cholesterol NS differences noted (it is possible that the CBCR patients are biased, due to the higher drop-out rate in the CBCR vs the HBCR group) Secondary: Ventilatory threshold, BMI, total cholesterol, HDL cholesterol, triglycerides, resting HR & BP, & submaximal rate-pressure product. NS differences noted. Adverse events: No significant adverse events in either group. Only low or moderate risk patients enrolled. Program cost: Included services typically billed to insurance, including CR sessions, exercise tests, & blood tests; also patient fees for Phase III sessions, & staff time were included.	None		Comprehensive program. Study tests traditional CR vs "hybrid" CR, & does not truly test HBCR alone. HBCR intervention included 3 different interventions: (1) more HBCR vs CBCR exercise, (2) weekly group support meetings, & (3) self-efficacy educational training Cost analyses did not apparently consider clinic visits, re-admission to hospital, time off work, & other similar costs. Attrition bias Differential intervention contact time bias

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				HBCR: Weeks 5-25: Exercise without ECG monitoring, but with HR monitor instead for 3 weeks for on- & off-site exercise sessions. In week 6-on-site exercise reduced to 2 sessions/week & weekly 1-hour education/support group meetings on exercise, nutrition, stress reduction, how to overcome barriers to adopting exercise & nutrition behaviors (based on self-efficacy theory). Week 6-6 months, HBCR could do on-site exercise up to 2 sessions/week, but encouraged to reduce to 1 session/week in weeks 11-17, & 1 session/2 weeks in weeks 18-25.	Total average cost/patient: HBCR $1,519 vs CBCR $2,349 (level of significance not reported); staff time HBCR 87 hours vs CBCR 124 hours (level of significance not reported)		Safety Concerns/population: Post CABG or event- 35-75 years classified as low-moderate risk. Support/Instruction/Communication strategies: First 4 weeks: CBCR – no difference in care Exercise – 60-85% HR – aerobic capacity (GXT); Education Weeks 5-12: CBCR – continue same; Weeks 5-12: HBCR- reduction (2/week) of facility based sessions, ongoing education/support that emphasized independent exercise & nutrition behaviors. Weekly "heart health forums" Weeks 13-25: CBCR – encouraged to attend Phase III CR – 3/week – no telemetry monitoring, less staff supervision HBCR: permitted 2/week onsite, gradual decrease to 1/session/week, then 1 session every 2 weeks. Log books to record off-site exercise	
Cowie 2012[7, 8] UK	Single center, 3-group RCT	N = 60 Mean age 65.8 Age range 35-85 85% male 20% Diabetes Race/Ethnicity not reported	HF with left ventricular systolic dysfunction class II/III stable for 1 month	1) **HBCR** (DVD, booklet, phone calls every 2 weeks from physiotherapist) (n = 20). Exercise: 15-minute warm-up & 15-minute cool down. Aerobic overload: 2 x 15 minute circuits (10 simple, functional aerobic exercises, e.g., knee lifts, side steps); interspersed with low-paced active recovery (toe tapping or slow walking; 90 seconds each	Follow-up at 8 weeks. Primary Outcome: Incremental Shuttle Walk Test: HBCR (+ 44m, p = 0.02), CBCR (+ 71m, p = 0.01), Control (+ 8m, p = 0.42). HBCR vs. control p = 0.03. CBCR vs. control p = 0.01. HBCR vs. CBCR p = 0.59. Secondary outcome: Minnesota Living with Heart Failure Questionnaire: NS differences within or between groups	None		Exercise-only program Adherence (completing 16 exercise sessions) HBCR 77% & CBCR 86% (p = 0.32) 5/20 (25%) CBCR & 5/20 (25%) dropped out.

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				exercise). Gradually increased time in aerobic overload relative to active recovery. Educated on HF symptoms; used HR monitors to guide training intensity. Encouraged to work at 12-14 on Borg Scale. 2) **CBCR** (2 supervised sessions per week for 1 hour each – 2 x 15 minute circuits). (n = 20) 15-minute warm-up & 15-minute cool down. Same instructions as HBCR. 3) Control. (n = 20). Duration: 8 weeks.	SF-36: NS within-group differences. NS CBCR vs. HBCR differences Adverse events not reported			
Dalal[9, 10] 2007 **Rural South West England**	RCT with patient preference arms N=104 randomized (HBCR: n=40/60 participated; CBCR n=32/44 participated) N=126 given their preference (HBCR: n=51/72 participated; CBCR: n=47/54 participated)	Recruited 2000-2003. Screened n=815, n=279 eligible, n=104 randomized & n=126 preference arm. N overall: 230 at baseline; 170 participated; 184 provided 9-m data N women: 42 at baseline Mean age: Total: 62 (15) Women: 68.5 Men: 61.8 Age range: 49.1-82.7 (older women chose HBCR) % Diabetics: 13.5	Uncomplicated MI; English speaking	1) **HBCR** (1 randomized group, n=40; 1 preference group, n=51): Provided Heart Manual (developed by NHS) to use over 6 weeks; guide to exercise, stress management, & education; home visits in first week after discharge by CR nurse followed up by 4 telephone calls at 2, 3, 4, & 6 weeks. HB exercise frequency not reported. 2) **CBCR** (1 randomized n=34 & 1 preference group n=47); 8-10 weeks of weekly classes of 2 hours in groups of 8-10 in local hospital (1-5 sessions/ week) or in 2 community centers; encouraged to exercise at home. Exercise modality not reported. Input from dietician, psychologist, occupational therapist & pharmacist	Primary outcome(s): 9-month follow-up (83% of HBCR & 77% CBCR provided follow-up data). Preference arms: 79% provided 9-month data. Primary outcome: HADS depression scale, MacNew QOL questionnaire; total cholesterol. NS between group differences for randomized or preference groups. Secondary outcomes: exercise capacity (Bruce Protocol - METs), self-reported smoking, BP, BMI, use of cardiovascular drugs, coronary events, all-cause & cardiovascular mortality. No difference in smoking behavior. NS between group differences in secondary outcomes. METs increased from 3 months to 9 months in both CB groups from 7.36 to 7.68 & from 8.69 to 9.66 in HBCR group. Adherence of HBCR defined as completion of 4/6 week of the self-completion diaries in Heart Manual. Satisfactory adherence to CR in the preference arms was comparable with that seen in randomized arms: 38/51 (75%) compared with 29/40 (73%) respectively for the HBCR group. Clinical endpoints: 9-months follow-up 1) Composite outcome(s): NR 2) Heart attack/MI: NR 3) Stroke (hemorrhagic, non-hemorrhagic, TIA): See mortality data 4) Revascularization procedure (PCI, bypass): Randomized groups: p=.31 HBCR: 32/60 (53%) CBCR: 19/44 (43%)	None	Safety concerns/population: HF – clinically stable for 1 month; on optimized medications, monitored at home by HF nursing service Support/Instruction/Communication strategies: CBCR – physiotherapist led class HBCR – DVD & booklet; Telephone every 2 weeks; completed diary detailing intensity during every session. Followed by HF nurse.	Comprehensive program. Intent-to-treat analysis. Random allocation with concealment. Blinded outcome assessors. Adherence to randomized & preference arms were similar (73%-75%). HBCR was as effective as CBCR. No difference in adherence No significant difference in cost of either program

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		% Caucasian: NR			Preference groups: p=.054; NS HBCR: 25/72 (35%) CBCR: 28/54 (52%) 5) Death/mortality: Total Mortality: Randomized groups: (n=5) HBCR:4/40 CBCR:1/32 Preference Groups: (n=3) HBCR:2/51 CBCR:1/47 *6 were cardiac deaths; 1 stroke, 1 trauma 6) CHF: NR 7) PVD: NR No differences in deaths/or rehospitalizations, revascularizations, cardiac investigations or primary care consultations as per prior analysis in which no differences in mortality were detected			
Daskapan 2005[11] **Turkey**	Single center RCT	N = 29 Mean age 52 (SD 8) 76% male Diabetes not reported. Race/ethnicity not reported.	HF, EF < 40%, Class II/III	1) **HBCR** exercise training with walking exercise with introductory instructional session, weekly phone calls. (n = 15 randomized, 11 completed). 2) **CBCR** exercise training on treadmill 3 times/week. Monthly phone calls. (n = 14 randomized, 11 completed) Intensity: goal 60% peak HR for 30 minutes Frequency: 3 exercise sessions per week for 45 minutes per session Duration: 12 weeks No education or counseling reported	Follow-up at 12 weeks: VO_2 max (ml/kg/min): HBCR 19.85 ± 7.6 → 23.3 ± 6.8 CBCR: 21.9 ± 5.8 → 23.6 ± 7.4 No significant difference p>0.05 Peak exercise duration (s): HBCR: 626.9 ± 255 → 836.1 ± 167.1 CBCR: 574.1 ± 203 → 700.3 ± 232.4 NS difference p>0.05	None	Safety Concerns/population AMI only; excluded HF, other significant comorbidity. GXT assessment 3-4 most post enrollment at 9-10 mos. Support/Instruction/Communication strategies: All participants received CR nurse counseling pre hospital discharge CBCR: 1/week (2 hours) outpatient classes 8-10 weeks and encouraged home exercise – building to 5/wk. HBCR: Received "Heart Manual" prior to discharge – use over 6 weeks; Home visit in 1st week post discharge, telephone calls over 2 weeks (2, 3, 4, 6 weeks)- 5-10 min to check progress and reinforce plan. Adherence described as completion of 4/6 weeks of self-completion diaries in Heart Manual. (75% - CBCR; 73% - HBCR)	Exercise-Only Adherence of sessions attended HBCR 81% & CBCR 97% Drop out CBCR: 3/11 (27%) HBCR: 4/11 (36%)

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Gordon 2002[12] **Community** **USA**	3 group RCT	Community HBCR group n=49 randomized, 45 completed CBCR**:** N = 52 randomized, 45 completed (3 sessions/ week x 12 weeks)	Community intervention**:** Mean age 60 (9) 78% male Low to moderate risk Prior MI: 16% Prior CABG: 40% Prior PCI: 47% Diabetes not reported. Ethnicity not reported. **Control:** Mean age 60 (9) 76% male Prior MI: 16% Prior CABG: 38% Prior PCI: 53%	**Community HBCR**: Shopping mall kiosk or retail program site in hospital outpatient clinic. Duration: 12 weeks Managed by exercise physiologist using computerized tracking system. On site or telephone counseling 2x/week for weeks 1-4, 1x/week for weeks 5-8, every other week for weeks 9-12. Counseling lasted 15 min & included education: written materials, audiotapes, counseling. Individualized home exercise prescription updated at each counseling session (30-60 minutes of aerobic exercise, 60-85% peak HR). Individualized plans for nutrition, weight, stress, & smoking as needed. Medication changes done by referring physician. **CBCR**: 12 weeks, 3 times/week (36 sessions); intensity 30-60 minutes aerobic exercise, 60-85% peak HR, continuous ECG telemetry during exercise; written materials, audiotapes, education on risk factors & lifestyle modification	Clinical Adverse Events: CBCR: 3 hospitalized (TIA, chest pain, PCI) Community program: 1 hospitalized (pneumonia) Adherence to scheduled visits: No difference CBCR: 81% Community HBCR: 86% Efficacy Outcomes: Improvement in BP, lipids, weight, & VO_2 max similar in both groups. No adverse medical events in low/moderate risk patients.		Safety Concerns/population: Stable medication dosages Exclusion comorbidities: valvular disease, exercise-induced arrythmias, symptomatic myocardial ischemia (<3 months; beta-blocker Rx GXT pre-exercise Individual training & session – monitored BP, HR & RPE; Support/Instruction/Communication strategies: Both groups – 3/week; 60% peak HR, 30 min. HBCR: instructional session: count pulse rate, monitor HR, RPE (12-14) Exercise logs: daily for HR, RPE, durations, and any symptoms- returned biweekly. Weekly phone calls for monitoring progress, adherence, answering questions, provide individual counseling. Drop out reasons: - 4 in HBCR; 3 in CBCR) health related (n=4) & personal reasons (n=3).	Comprehensive program. 4/49 (8%) withdrew: 1 CABG, 1 for unrelated medical problem, 2 for personal reasons 7/52 (13%) of those randomized to CBCR did not complete: 2 did not enroll for personal reasons, 5 withdrew (1 unrelated medical problem, 4 for personal reasons)
Gordon 2002[12] **Supervised** **USA**	RCT	N = 54 randomized, 52 completed physician supervised HBCR arm CBCR Control as above	Mean age 61 (10) 73% male Low to moderate risk Prior MI: 29%	Supervised by physician & nurse case manager Duration: 12 weeks Office visit with physician after baseline testing & at 6 weeks Phone visits with nurse at 2, 4, 8, 10 weeks. Above visits included education: written materials, audiotapes, counseling.	Clinical Adverse Events: Supervised HBCR: 0 hospitalizations Adherence to scheduled visits: Supervised HBCR: 83% Outcomes: Improvement in BP, lipids, & weight similar to CBCR. VO_2 max improved less in HBCR group		Compliance monitored by weekly telephone calls; HR monitoring via chest-strap device; &exercise logs used	2/54 (4%) withdrew for personal reasons

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			Prior CABG: 37% Prior PCI: 42% Diabetes not reported. Ethnicity not reported.	Patients received individualized home exercise prescription updated at each of above visits. Received individualized plans for nutrition, weight, stress, & smoking as needed. Medication changes done by supervising or referring physician at baseline & 6 weeks.	(+0.9 ml/kg/min) than CBCR & community above (+1.6 ml/kg/min). No difference in smoking behavior.			
{Arthur, 2002 #48;Cowie, 2012 #79;Dalal, 2007 #80;Grace, 2016 #101;JM, 1998 #115;Jolly, 2007 #117;Marchionni, 2003 #127;Wu, 2006 #185}[13-15] 2016 Canada	RCT with 3 arms: n=169	CBCR mixed sex (n=59) CBCR female only (n=55) HBCR (n=55) 144/169 (87.8%) enrolled	PCI, MI, CABG, Valve, angina Limited to women Low to moderate risk Mean age 63.6 (10.4) 62.5% white HTN 75% PAD 1.5% Obese 42% Diabetic 33%	All had baseline exercise test & received individualized exercise prescriptions. Programs lasted 4-6 months. Patients encouraged to exercise 150 min/week at target HR. **CBCR** patients exercised on site 1-2 times per week for up to 1 hour. **HBCR** patients had 3 on site visits & then exercised at home. HBCR patients were phoned weekly or biweekly Provided same education materials to all groups on initial visit. No details provided.	Primary outcome: Adherence Overall 96/169 (56.8%) complete interventions; of these 62 (64.4) had exit CPET & 58/169 (60.4% had both pre-& post-CR CPET) CBCR mixed (n=59) 13 (22%) did not attend 6 (10%) attended one of other 2 models 40 (68%) attended 19 (32%) with pre & post CPET CBCR female only (n=55) 8 (15%) did not attend 12 (22%) attended one of other 2 models 35 (64%) attended 21 (38%) with pre & post CPET HBCR (n=55) 6 (11%) did not attend 25 (46%) attended one of other 2 models 24 (33%) attended 18 (33%) had pre & post CPET Across all models, mean of 23 (15) sessions prescribed with mean attendance of 55%. After excluding those attending no sessions, the mean attendance was 64%. NS difference in attendance by ITT but HBCR had higher attendance in the as- treated-analysis. 6 participants did not complete for medical reasons, but group of assignment not reported. Secondary Outcome: Functional Capacity **Very high dropout rate & rate of participants who had pre & post CPET results. No difference in VO$_2$ after intervention among the 3 groups in ITT analysis. In as-treated-analysis, post intervention peak VO$_2$ is:	All women	Adherence defined as regular exercise 3 or more days per week, regardless if in facility and/or at home	Comprehensive programs with education. Women participants preferred CBCR more than HBCR & women-only over mixed sex. Much cross-over between arms 144/164 completed pre-CR surveys & 66 remitted a pre-CR pedometer (39.1%) Concealed allocation Selection bias – low response rate; non-adherence to randomization; retention bias; masked outcome assessment Did not measure HRQoL.

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					CBCR Women only: 18.7 CBCR Women mixed-sex: 19.7 HBCR: 15.5 HBCR peak VO$_2$ was significantly lower than women in mixed-sex group in the as-treated-analysis. NS between group differences in anxiety & depression although PHQ 2 scores improved in all groups. No between group differences in social support scores. NS differences in physical activity or dietary behavior scores between the 3 groups. Step counts, self-reported physical activity, diet, & medication adherence scores were all considered equivalent. Adverse events not directly assessed -Low/moderate risk patients.			
Jolly[16] 2007 BRUM Birmingham rehabilitation Uptake Maximisation UK	Pragmatic, 2-arm, multi-center RCT (4 hospitals) N=1997 screened N=1207 eligible 6 m FU: HBCR-247/263 CBCR-240/262 12 m FU: (91.5%) HBCR-239/263 CBCR-236/262 24 m FU: HBCR-228/263 CBCR-223/262	N overall: 525 English & Punjabi HBCR: 263 CBCR: 262 Diagnosis: MI:258 PCI: 211 CABG: 56 Mean age: 61(10.8) Male: 77% (n=404) Female: 23% (n=121) White: 80.2% Asian: 17% (n=89) Diabetics: 13.3% Previous CR: 11.8%	Post-MI, PCI, CABG in prior 12 m	**CBCR**: 4 centers Hospital 1 (n=93): 2 x weekly; 12 weeks; walking up to 25-30 minutes fixed cycling, rowing, 60-75% max HR; relaxation voluntary part of session; education during each CR session (optional). Hospital 2 (n=107): weekly, 9 weeks; circuit training with 6 stations (1-2 minutes per station & walking), relaxation included in each session, weekly education part of CR session. Hospital 3 (n=39): 12 sessions, 8 weeks; 45-minute circuit training, 65-75% max HR, monitored own pulse rate, weekly relaxation part of session, 8 sessions education. Hospital 4 (n=23): Twice weekly/6 weeks; 1 hour with warm-up, 40 minutes exercise on fixed bikes & treadmills, 65-75% max HR, monitored own pulse, relaxation part of session, 30 min education per session. All participants seen by CR nurse prior to hospital discharge, provided information about their	Primary study outcome(s): 6, 12, 24 months Smoking cessation (cotinine validated) BP HDL-Cholesterol Exercise capacity (incremental shuttle walk test) Hospital Anxiety & Depression scale (HADS) No clinical/statistical significant differences at 6, 12, or 24 m when adjusting for age, sex, diagnosis, ethnicity or center. Secondary outcome(s): Self-reported diet, physical activity (Modified Godin), cardiac symptoms, HRQoL= EQ-5D, SF-12, Global Mood Score NS differences at 6 m,12 m, 24 m Health service resource use/costs (self-report): hospital admission, primary care visits, nurse consultants, medications: NS difference at 6, 12, 24 months HBCR more expensive than CBCR but cost would have been equivalent if patient costs were included. HBCR: staff, telephone, consultations, staff travel (198 UK/patient vs 157/patient for CBCR) Higher event rate on HBCR (16.2%) than CBCR (12.1%) in first 12 m both adverse events (MI & death) & revascularization procedures but NS. No differences at 24 m. Adherence to physical activity of CR programs at 6,9,12 weeks:	Subgroup analyses conducted for diagnosis, age, sex, ethnicity & rehabilitation setting, adherence, diagnosis. All NS.	Community based program had frequent follow up & abundant education. Used a computerized system to track participant progress.	Comprehensive Program. Strengths: Randomly allocated stratified by diagnosis, age, sex, ethnicity & hospital of recruitment HBCR nurses attended 2-day training. Follow-up assessment by blinded assessors 11 HBCR patients crossed over to CBCR but analyzed on ITT as HBCR Sensitivity analyses conducted on missing data at 12 m. Weaknesses: Godin PA response rate at 6 m (70%), 12 m (68%), and 24 m (65%) Although both groups received exercise, education & stress

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				condition & counseled about risk factors. **HBCR**: Patient daily, manual 6-week program, nurse contacts in hospital, at home at 10 days, 3, 6, & 12 weeks; daily exercise encouraged from hospital discharge. Home exercises working up to daily walking, then on to other enjoyable PA, relaxation tapes provided & use encouraged, 6 weekly chapters in Heart Manual covered risk factors, lifestyle changes, medications. Heart manual introduced individually either in hospital or on home visit. Home visits, 1, 6, & 12 weeks after recruitment, telephone call at 3 weeks. Final visit encouraged maintenance of lifestyle changes & continued exercise. 5+ contacts with CR nurse received by 96% participants in home-based arm & only 56% of participants in center-based arm attended this many CR sessions	HBCR reported significantly more hours of PA at each time point & higher PA scores at 9 weeks. Minorities & elderly scored better in HB arm. CBCR attendance ranged from 42-72%. 28% did not start CBCR. Younger patients attended fewer sessions. NS differences between groups in attendance Clinical endpoints: 1) Composite outcome(s): Any event:12 months HBCR: 19.2% CBCR: 14.5% (NS) Any event by 24 months: HBCR: 20.1% CBCR: 20.5% (NS) 2) Admissions for MI by 12 months: 1 X MI HBCR: 3.2% CBCR: 1.4% (NS) 2 x MI HBCR: 0.9% CBCR:0.5% (NS) Admissions for MI by 24 months: 1 X MI HBCR: 4.0% CBCR: 2.0% (NS) 2 x MI HBCR: 1.5% CBCR: 0.5% (NS) 3 x MI HBCR: 0% CBCR: 0.5% (NS) 3) Stroke (hemorrhagic, non-hemorrhagic, TIA): NR 4) Revascularization procedure (PCI, bypass): by 12 months; 1 x Revascularization: HBCR: 14% CBCR:12.1% (NS) 2 x Revascularization: HBCR: 2.8% CBCR: 0.5% (NS) Revascularization procedure (PCI, bypass): by 24 months: 1 x Revascularization: HBCR: 13.4% CBCR:15.4% (NS) 2 x Revascularization: HBCR: 5.0% CBCR: 2.6% (NS) CABG: HBCR: 2.0% CBCR:3.1% 5) Death/mortality: 12 months: HBCR: 1.1% CBCR: 1.1% 12 months: HBCR: 2.3% CBCR: 1.1% 6) CHF: NR 7) PVD: NR			management, the nature & amount of intervention between groups was different Blinded outcome assessments

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Karapolat 2009[17] Turkey	Single center RCT	N=74 37 CBCR, 37 HBCR	HF patients with LVEF <40% & stable for 3 months, NYHA II-III Mean age 45 years, 63% male 10% diabetes, 30% HTN, 50% ischemic & 50% dilated cardiomyopathy	**CBCR**; n=37. Exercised in rehabilitation unit. **HBCR**: n=37. Exercised at home. Both groups had physician supervised exercise plan was individualized for each patient. Exercise consisted of flexibility exercises, aerobic exercise, & breathing exercises CBCR aerobic exercise performed for 30 min on treadmill at 60-70% of peak VO_2, 60-70% of HR reserve, & level 13-15 on Borg scale. Both groups 3 sessions/week for 8 weeks. HBCR aerobic exercise walking program (60-70% of VO2 max, 60-70% HR reserve, level 13-15 on Borg scale. HR monitor & pedometer used by both groups. HBCR trained by a physiotherapist on how to perform exercises. HBCR contacted weekly to assess exercise motivation.	Outcome Follow-up: 8 weeks Peak VO_2 (Modified Bruce - treadmill) HBCR 17.48 ml/kg/min (SD 6.09) to 18.12 (SD 6.0) CBCR 17.85 ml/kg/min (SD 4.44) to 19.43 (SD 4.59) NS between groups 6 Minute walk test (m): HBCR distance from 384 (82) to 424 (77) CBCR distance from 374 (79) to 419 (50) NS between groups SF-36: HBCR Physical function from 55 (27) to 59 (25) General health from 40 (25) to 47 (23) Vitality from 62 (26) to 67 (20) SF-36: CBCR Physical function from 57.5 (24) to 70 (21) General health from 45 (27) to 54 (25) Vitality from 62 (24) to 70 (17) NS differences between groups Beck Depression Inventory (BDI): HBCR from 14 (8) to 12 (10) CBCR from 13 (11) to 7 (8) NS difference between groups LVEF: HBCR from 29% (11) to 31% (10) CBCR From 27%(12) to 29% (9) NS differences between groups No improvement in State Anxiety Inventory or any other parameters measured. Attendance was 90% in CBCR & 88% in HBCR – NS Adverse events: none during any of the training sessions.		Adherence measured by pedometer, self-monitoring & phone calls Education similar across all groups, except women in the HBCR group received some sex-specific education (e.g., osteoporosis & arthritis). HBCR contacted by telephone every week or two. Women only program model did not result in greater adherence	Exercise-only program. 5/37 (14%) withdrew from CBCR 1/37 (3%) withdrew from HBCR Randomization with concealment No long-term follow-up
Kassaian 2000[18] Iran	RCT, single center	N = 125 Mean age 55 (SD 9.5) 100% male	MI or CABG in last 2 months	1) HBCR 2) CBCR: 3 sessions/week x 50 minutes, treadmill exercise, intensity: 60-85% (not reported what relative to) Duration: 12 weeks	12 weeks-post-randomization Systolic BP, diastolic BP, HR, functional capacity (METs), BMI, cholesterol. Standardized mean difference in effect size Exercise capacity: -1.24 (-1.63, -0.86) favoring CBCR. Total Cholesterol:	Comparison of functional capacity, submaximal systolic BP, diastolic	Heart manual uses cognitive behavior techniques to benefit those in a home program. Used in multi-ethnic study	Exercise-Only Program 100% completion – unclear Significant risk for bias

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					0.05 (-0.29, 0.39) HDL Cholesterol: -0.13 (-0.20, -0.06) favoring CBCR. LDL Cholesterol: -0.41 (-0.71, -0.11) favoring CBCR. Triglycerides: -0.47 (-0.75, -0.19) favoring CBCR. Systolic BP: -7.00 (-10.54, -3.46) favoring CBCR. Diastolic BP: -4.00 (-6.09, -1.91) favoring CBCR.	BP, & HR in patients with left ventricular dysfunction versus good function		
Kraal[19] 2014 Netherlands	RCT	55 patients (26 in CBCR & 29 in HBCR) 3 pts dropped out	MI, UA, PCI or CABG Only those deemed low to moderate risk by Dutch CR guidelines Required internet access 84% men in CBCR & 88% men in HBCR.	HBCR versus CBCR. 12 week programs **Both groups:** Exercise training 40-60 min at 70-85% max HR. **CBCR** on treadmill or cycle ergometer 2 times/week (group based, supervised) 60-minute session of warmup & cool down & 2 20 minute bouts on treadmill or cycle ergometer. **HBCR** started with 3 supervised sessions to discuss home exercise regimen & process; instructed on using wearable HR monitor. Exercised 61 min/session with 41 min in prescribed exercise intensity zone. HBCR received therapist coaching in weekly phone calls. Emphasis on motivational dynamics, barriers & facilitators. Required basic computer & Internet skills to use software.	Outcomes at 12 weeks: Peak VO$_2$ increased significantly in both groups: 23.7±6.4 to 26.1± 7.6 in CBCR vs. 22.8±4.2 to 26.0 ±5.9 in HBCR, with NS difference between groups (p=.4) HRQoL (Dutch version of MacNew questionnaire) increased significantly in both groups (no difference between groups). Improvement was similar in all subscales of the questionnaire tool (physical, emotional, social & total score) Training Adherence: 86% adherence in CBCR (range 6-25 sessions);100% adherence in HBCR (range 13-41) No adverse events in either group.	None	Focus on heart failure Used VO$_2$max & 6 min walk test Used telephone follow up	Comprehensive Program. Emphasis on motivational training techniques with feedback by coaches & monitoring over the internet. ***That all other modalities but exercise training (e.g., lifestyle change therapy, relaxation, stress management, education) took place in a common outpatient clinic may confound results. Outcomes not assessed blinded.
Marchionni 2003[20] Italy	RCT; single blind, factorial (3 age groups & 3 interventions)	N=270 post-MI 67.8% male Age range from 46 to 86 years	3 age groups: 45-65 years 57 (.6); 66-75 years 10(.3); >75 years 80 (.3)	CBCR (n=90) vs HBCR (n=90) vs control (n=90) **CBCR:** 40 exercise sessions (24 sessions; 3/week) of endurance training on cycle ergometer (5-minute warm-up, 20- minute training at constant workload, 5-minute cool down, 5-minute post-exercise monitoring plus 16 (2/week) 1-hour sessions of	Baseline, end of 2-month program, 6 & 12 months later Primary outcome: Total work capacity on cycle ergometer Secondary outcomes: HRQoL (Sickness Impact Profile). CBCR: 79/90 complete data at 14 months HBCR: 74/90 Control Group: 79/90	The oldest (>75 years) group had lower overall improvement in physical function	Patients taught to take their pulse rate	Comprehensive program. Groups may have mixed during monthly support group meetings. Blinded assessors. 2 months may be too short to obtain optimal physiological benefits in those > 75 years. Most improvement in CBCR was lost by 1 year.

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				stretching & flexibility exercises. ECG monitored. Exercise intensity = 70% to 85% of HR on baseline GXT. CVD risk factor counseling 2/week & invited to monthly support group with family members. **HBCR:** 4 to 8 supervised instruction sessions in CR unit. CVD risk factor counseling at each in-hospital session & invited to join monthly family support group. Exercise prescription similar to CBCR, wristwatch HR monitor, cycle ergometer, log book. PT made home visits 2/month for 2 months. **Control Group:** Received single structured education session of CVD risk factors with no exercise prescription & referred to family physician.	**Adverse events:** not reported by group Deaths: 10 (1 sudden death, 2 re-infarctions, 3 neoplasms, 1 pulmonary embolism, 1 post-CSBG, 2 undetermined) Nonfatal events: 7 Refused to continue: 21 Drop-out rate greater in HBCR (16/90) than in the CBCR (11/90) or control (11/90) No treatment- or age-associated difference in the cumulative incidence of new events. <u>Adherence exercise sessions:</u> HBCR: 37.3 (3.4); CBCR:34.4(4.4); p<.0001 Overall 14% drop-out over 14 months. <u>14 months:</u> HBCR & CBCR resulted in similar improvements in work capacity. Less improvement in older age group. With CBCR work capacity remained higher than baseline over entire study only in middle-aged patients whereas on old patients it returned to baseline at 6- & 12-month follow-up. In HBCR, work capacity remained higher than baseline over study in all age groups. <u>HRQoL:</u> in middle-aged & old patients improved significantly over study regardless of treatment assignment whereas in very old patients, HRQoL improved significantly with either active treatment but not in control group. HRQoL improved spontaneously with or without intervention in 2 younger age groups. Improved in older age group only in treatment interventions. <u>Cost:</u> Program & healthcare utilization CBCR: $21,298 HBCR: $13,246 CG: $12,433 Fewer office visits & rehospitalizations in HBCR			HBCR better preserves self-management of exercise program. Restricted eligibility: only those safe to exercise at home. *** HRQoL was significantly different between groups in 45-65 age group & in >75 age group at baseline: 45-65 age: CBCR: 8.4 (1.1) HBCR: 5.6 (0.7) Control: 5.5 (0.8)
Miller 1984 Brief[21] USA	RCT, single site	198 - all men HBCR: N=66 (33 in brief & 33 in extended) CBCR: n=61 (31 in brief & 30 in extended) 179 remained in the study for the initial	Uncomplic ated MI patients aged ≤70 years. Exclusion: unable to do ETT, HF, unstable angina, valve disease,	4 arms: 1. Exercise tolerance test (ETT) (3 weeks post-MI & then exercise training (ET) at home for 8 weeks followed by ETT at 11 weeks 2. ETT (3 weeks post-MI) & then ET at a gym for 8 weeks followed by ETT at 11 weeks 3. ETT (3 weeks post MI) without subsequent training followed by ETT at 11 weeks 4. ETT (26 weeks post-MI)	Outcomes: 23-weeks post-randomization Exercise capacity Mortality Cardiovascular morbidity <u>Adverse events:</u> 15 minor cardiac events (higher in controls vs. ETT groups), non-specified No training-related cardiac events NS differences in HBCR vs. CBCR.	Brief & extended	Weekly phone calls with HBCR patients included behavioral change strategies using goal setting and motivational interviewing; patient progressed toward goals based on weekly training data.Barrier identification & management strategies also applied.	Exercise-Only Program. Emphasis on safety in this early study. Attributed efficacy of ET to biweekly phone calls of nurse which was conducted primarily to check telemetry Significant risk for bias (random sequence generation, allocation concealment, blinding,

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		analysis (benefits at 11 weeks) 160 remained in the study for extended analysis (benefits at 26 weeks)	atrial fibrillation, CABG, history of CVA, orthopedic limitations, PAD, COPD, obesity. Mean age 52±9 years B-blockers, oral nitrates, anti-arrhythmics : 11%;17%; 6%, respectively	**HBCR: 8 weeks** stationary cycling & walking 30 min 5 d/week at exercise intensity 70-85% of peak HR on ETT. Twice weekly nurse telephoned patients to assess telemetry. **CBCR training 8 weeks** supervised training for 30-35 patients in gym, 60 minutes 5 days/week, intensity 70-85% HR max. No education or psychological intervention reported.	HR at submaximal workload decreased significantly in all groups Functional capacity increased significantly in both ETT groups vs. group 3 (ETT without ET) & vs. group 4 (controls) Axdherence: NS differences HBCR: 50/70 (72%) CBCR: 28/40 (71%)			incomplete data, unbalanced groups at baseline)
Miller 1984 Expanded[21] **USA**	Subgroup of ET arms (HBCR & CBCR) extended 26 weeks, & with all (those with & without continued ET) getting 3rd ETTs at 26 weeks.		Same as above but with analysis to see if extended training yielded greater benefits	Subdivision of those in the HBCR & CBCR groups at 11 weeks to compared continued structured intervention vs. those who received no intervention before reassessment at 26 weeks Same criteria as above, with ETT assessments for groups 1,2, 3, 4 at 26 weeks	13 cardiac events (higher in controls vs. ET) No training related cardiac events Functional gains persisted but did not increase significantly in the extended exercise arms. Functional capacity was NS greater in extended ET home or group (2.1 ±1.4, 2.0 ±1.4) vs. brief home or group ET (1.8 ±1.0 & 1.7±1.3) respectively.	Brief & extended interventions	Improvements were similar between home & hospital program. Improvements were also similar in middle-aged &d old persons but smaller, although still significant, in very old patients. Home program was lower cost	Exercise-only Program.
Moholdt 2012[22] **Norway**	RCT	30	Post-CABG Mean age (63(7.7))	HBCR Aerobic High Intensity Training (HIT) vs 4 week CBCR (residential) **CBCR**: n=16; 81% male; 2 drop-out 4 weeks 30 exercise sessions (4 low intensity, 16 moderate- intensity, 10 High-Intensity-Borg 15-17). Outdoor walking, cross-country skiing, indoor cycling, ball games, strength training. Diet counseling, smoking cessation, lectures on healthy lifestyle. Advised to keep exercising at home. Did not receive training diary & advice	Baseline & 6 months Primary: NS between groups Peak VO2 on treadmill, HRR Secondary: HRQoL (MacNew) Glucose HbA1C (increased in both groups: unexplained) Lipid profile Triglycerides Similar improvements were found between groups. CONSORT diagram shows loss to follow-up 4/30 (13%) at 6 months	None	• Home training was as effective as group training for improving functional capacity, • ECG tracings were transmitted from home program patients to enhance safety for these patients in addition to use of portable HR monitors. • No women included in study which limits generalizability of findings.	Comprehensive Program. HBCR 6 months versus 1 month CBCR (differential contact time). Difficult accrual & data collection No evidence of equal treatment effect due to small sample size. While used high intensity exercise, few patients

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				about how to exercise at discharge. **HBCR**: 6 months, aerobic intensive training. N=14; 79% male; 2 drop-out. Given 60 minutes of theoretical instruction why HIT is effective & practice guidelines on how to do this on their own. Exercised 3/week for 6 months. Sessions: warm-up 10 minutes, 4 intervals of 4 minutes of HIT (HR 85-95% of max HR). After each interval, exercised at moderate-intensity for 3 minutes (70% of max HR). Total exercise time 38 minutes (16 minutes HIT). Could choose walking, jogging, swimming or cycling. Received written guidelines, healthy lifestyle & training diary.	Adverse events: 1 patient died during the warm-up of a low-intensity session in the residential group.			actually followed the protocol as designed
Oerkild 2011[23] **Denmark**	RCT, single site	75 HBCR: n=36 Men 52.8% mean age: 74 (6) CBCR: N=39 Men 67% Mean age: 75 (6) MI, PCI, CABG	CHD (MI, PCI, CABG); mean age 75 years	6 weeks of HBCR vs CBCR **HBCR:** PT home visit twice with 6-week interval; telephone call in between 2 visits. Exercise: 30 minutes/day for 6 days/week; intensity of 11-13 on Borg. Self-paced brisk walking & stationary bike. Offered dietary counseling & if needed smoking cessation (no details & optional). **CBCR:** 6-week intensive program – group-based supervised exercise training 1 hour twice a week; encouraged to exercise at home. PT tailored exercise programs. Offered 6 education lectures, 2 dietary counseling, 3 practice cooking classes, & smoking cessation. Cardiologist counseled patients both in HBCR & CBCR all time points. At 4 & 5-month phone call made to answer questions. Both interventions ceased at 3 months	Baseline, 3, 6, & 12 months Mortality: 7 Drop-out: 4 Primary: Peak VO_2 (bicycle ergometer) & 6 MWT. No difference between groups at 3 months & significant decline on both groups by 12 months. 33% in both groups did not improve in either program. Secondary: (NS between group differences) Self-reported level of activity BP Lipid profile Smoking status BMI WHR HRQoL (SF-12) Hospital Anxiety & Depression Scale (significant increase in anxiety score in CBCR group at 3 months followed by decrease at 12 months. Charlson Comorbidity Index No group differences in readmissions or adverse events. No difference in smoking status. The number and length of admissions and adverse events (admission for MI, progressive angina, decompensated HF, severe bleeding, new	None	-Training diaries for compliance -Patients instructed to contact PCP or CR center for any symptoms -No education or dietary counseling -1 Hour of instruction of how to implement HBCR before starting HBCR	Comprehensive program. No sustained effect by 12 months in either group Small sample size Non-blinded outcomes

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				but encouraged to exercise 30 min 6 days/ week.	malignant disease & performance of PCI) were equally distributed at 12-month follow-up (data not shown). Improvements were modest & similar between groups.			
Piotrowic z 2010[24-26] **Poland**	RCT, single site. Patients recruited from 2005-2008	152; 117 men & 8 women	HF patients, NYHA II & III; 95% males in CBCR & 85% male in HBCR. Mean age: CBCR: 60.5 (8.8) HBCR: 65.4 (10.9)	**HBCR with remote telemetry monitoring** (n=77) vs **CBCR** in supervised setting (n=75). Both groups supervised by nurses & PT. Duration of interventions: 8 weeks. First 5 days both groups had daily individual meeting with psychologist. For remaining 8 weeks CBCR patients could meet with psychologist held 3/week on the same day as training sessions. Patients in HBCR could receive psychological support individually via telephone. Patients completing either program had 2 meetings with a psychologist. **HBCR:** Warm up: breathing & light resistance exercises, calisthenics; Duration: 5-10 min. Aerobic endurance training: Continuous walking training; Intensity: 40-70% of HR reserve; perceived exertion level – score of 11 on the Borg scale. Start at: 10 min /session 2 times/ day if baseline peak VO_2 < 14 mL/kg/min;15 min/session 2 times/day if baseline peak VO_2 14-20 mL/kg/min 20 min/session if baseline peak VO_2 over 20 mL/kg/min. Gradually increase to 20-30 min/session/day Cool down**:** Relaxation exercise for 5 min **CBCR: n=75** Warm up: breathing &light resistance exercises, calisthenics for 5-10 min. Aerobic endurance training:	NYHA class: both groups improved Functional assessment at 8 weeks: Treadmill test with VO_2 peak (no difference between groups post-intervention but both groups improved) Adherence: 59/75 (79%) completed CBCR; 77/77 (100%) HBCR; p<.001 Drop outs (only in CBCR- N=20%, mostly due to financial constraints & commuting difficulties for patients) HRQoL= SF-36 (no difference between groups post-intervention but both groups improved). No difference in PCS or MCS scores. An improvement in the social functioning subscale at program completion was observed only in the CBCR group. No adverse events in either group from CR. No worrying signs or symptoms observed during training. 3 episodes of PAF in the BTCR group, including 1 that was asymptomatic & only diagnosed through ECG monitoring. In the CBCR group, an episode of PAF. These arrhythmias not related to ET & occurred during routine daily activities.	None	Physiotherapist home visit every six weeks, otherwise spoke with patient by telephone	Comprehensive program 2 HBCR & 3 CBCR did not have follow-up data. CONSORT shows 19/75 (25%) of CBCR group & 2/77 (3%) of HBCR group failed to provide 8-week data

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				Interval training on cycle ergometer at 40-70% of HR reserve; perceived exertion - 1 on the Borg scale. 10-15 min/session/day (Intermittent periods of exercise 1-2-3 min, followed by 1-2 min of active recovery). Gradually increase to 30 min/session/day (intermittent periods of exercise 4 min, followed by 2 min of active recovery) Cool down: Relaxation exercise for 5 5 minutes. All patients & partners participated in education program: how to measure HR, BP & body weight; evaluate signs & symptoms; level perceived exertion & how to perform exercise. Patients received psychological support.				
Sparks 1993[27] **USA**	Single center RCT	20 male patients CBCR n=10: Mean age: 53.3 (7.3) HBCR: n=10; mean age 50 (8.5)	Post-MI, PCI, CABG	Patients received same instructions about diet, medications, symptoms that would contraindicate continuation of exercise, anticipated benefits of long term exercise & explanation of exercise training protocol. Instructions given during initial assessment. Education materials distributed to all via handouts before treatment assigned. Educational discussions conducted during the exercise sessions based on handout material. **CBCR:** 36 sessions Exercise training for both groups: 12 weeks, 3 days/ week & 1 hour/day. Warm up: 5 min light stretching & 3-5 min easy cycling followed by exercise for 35 min maximum at 75% of Max HR. Exercise prescription determined from ETT results of both HR responses & functional capacity by end of 3 weeks. Intensity	Outcomes: 12-week post-randomization VO_2 peak, BP, pressure-rate product (PRP) & workload obtained by testing on cycle ergometer. Both groups showed significant improvement in cardiovascular endurance & METs. Within groups Max O_2 consumption increased ant PRP decreased. NS differences between groups pre- or post-training. Compliance with exercise: CBCR: 88% HBCR: 93% Dropout: HBCR – 1 patient dropped out after 6 weeks to return to work. Adverse events: Trans-telephonic exercise monitoring (TEM) group developed new arrhythmias while exercising that required medication changes; however, no medical emergencies arose in either exercise group.	None	3-lead telemetry transmitted thru mobile device to monitoring center; ECG strips transmitted at identified intervals and analyzed for safety and efficacy. Questions asked through mobile device before each session to screen for safety; document adherence. Mobile device also used for psychological support. Patients and partners participated in education program addressing measuring vital signs and symptoms and proper exercise training.	Exercise-only program with education materials on diet, medication, risks & benefits of exercise

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				determined by functional capacity if patients were taking β-blockers. A modified RPE scale (1-5) used to determine exercise tolerance. Exercise intensity & duration increased as long as a rating of ≤ 3 was reported. Cool down: 5 min of no-load pedaling, followed by light stretching & rest until HR returned to resting level. Subject monitoring continued until resting HR re-established. Both groups trained on the Fitron cycle ergometer. **HBCR monitored trans-telephonic system in real-time.** Patients communicated with study personnel. On first day of exercise, study personnel present for HBCR patients. Insurance charged for both groups.				
Varnfield [28] 2014 Australia	RCT – 4 CR centers	835 screened & 120 randomized after being recruited through CR referral Mean age (SD): Intervention: 54.9 (9.6) Control: 56.2 (10.1) Percent men: Intervention: 91% (n=48) Control: 83% (n=34) Total:87% (n=82) Ethnicity: NR	Post-MI	HBCR N=60: The Care Assessment Platform-6 weeks with 6-month maintenance Delivered by web portal & smartphone (diary application for recording exercise & health information & delivering motivational & educational messages, accelerometer) – targeted weekly themes. Data from smartphone synchronized to web portal where participants uploaded data on weight, BP, sleep duration/ quality, exercise (recommended 30 min most days of week), stress, diet, alcohol & smoking (patients entered daily). Mentors accessed information when speaking with participants during weekly telephone consultations (weekly for 6 weeks & 15 minutes long). Received 1-hour face-to-face training on how to use intervention. Provided smartphone, wellness diary app, activity monitoring app, weigh scale, BP monitor.	Primary outcome(s): 6 weeks, 6 m Total Cholesterol (TC) HDL cholesterol (HDL-C) LDL cholesterol (LDL-C) Triglycerides BP Diet: Dietary Habits Questionnaire HRQOL: EQ-5D Psychological distress Scale Depression, Anxiety and Stress Scale 21 6MWT Uptake: attending baseline assessment + 1 gym session for CBCR group & upload of exercise data for HBCR group. (CBCR: 37/60 vs HBCR 48/60; p<.05) Adherence: (attendance to 4 weeks (8+ gym sessions) for HBCR or uploading of 4 weeks of exercise data for HBCR group. (HBCR: 45/48 vs CBCR: 25/37) Completion: attendance at 6-week assessment for each group. CBCR: 28/60 (47%) attended 6-week FU; 26/60 attended 6 m FU HBCR: 48/60 (80%) attended 6-week assessment; 46/60 attended 6 m FU (P<.05)	None	Use of transtelephonic exercise monitoring (TEM). Both groups showed significant improvement in cardiac function. No sig differences between groups pre- or post-training were seen.	Comprehensive program. High risk of bias by not blinding participants & not blinding assessment of outcomes. High risk of attrition bias (40% drop-out rate). Reporting bias: Reported primary outcome differed from primary outcome measure described in study protocol. ITT only for uptake & completion. Adherence only analyzed those who undertook program. Large drop out of HBCR intervention

Study	Design	No. of Patients	Patient Population	Interventions	Outcomes	Subgroup Analyses	Unique Strategies, Learnings, Solutions to Address Challenges of Operating Home-Based Program	Notes
				CBCR control (n=60): 2 supervised exercise & 1- hour education sessions/ week for 6 weeks at 1 of 4 community centers. Exercise: individualized, supervised, circuit-based exercise program of light (6-10) to moderate (11-13) intensity on Borg scale. Cardiovascular & strengthening routines involved treadmill, rower, resistance bands, weights, squats & modified push-ups. Both groups encouraged to maintain lifestyle changes.	Secondary outcomes: Physical activity Nutrition Psychosocial functioning BP HR, BMI Waist circumference Lipid profile HRQOL No between group differences except for improved Diastolic BP (p=.03) & EQ-5D-Index favoring HBCR & triglycerides favoring CBCR. Between-group differences for changes in 6MWT, EQ5D-Index or k10 were not significant at 6 months. HRQoL: significant improvement between groups at 6 weeks (adjusted mean difference -0.08, 95% CI -0.14 to -0.02, p = .01). This improvement not maintained at 6 months. Adverse events: Not reported.			
Wu 2006[29] **Taiwan**	Single center RCT	All male CBCR: N=18 mean age 62.8 (7) HBCR: n=18 mean age 61 (8) Control n=18 Mean age 62 (10) N=12 diabetic	CABG, no History of MI or prior CABG	**CBCR:** N=18. 30-60 min aerobic exercise session (stationary bicycle or treadmill jogging). Intensity=60-85% of the peak HR achieved during baseline ETT. 10 min stretching pre & post exercise. Monitored by cardiopulmonary exercise therapist during session. Frequency: 3 x per week; total of 36 sessions. **HBCR:** N=18 Individual exercise prescription -updated by office or phone consultation every 2 weeks by nurses managing program. Intensity of 60-85% of the peak HR achieved during baseline ETT. Advice to exercise at least 3 x/week. Each session included 10-min warm-up, 30-60 min aerobic exercise (fast walking or jogging) & 10 min cool down. Subjects & families asked to document exercise in record book. **Non exercising control:**	12 week outcomes: Exercise stress test pre & post- intervention on cycle ergometer. All 3 groups significantly improved resting HR, peak HR, workload, V0$_2$ peak & HR recovery. CBCR & HCBR improved more than control group. NS difference between CBCR & HBCR on any outcomes. Resting HR: CBCR: 76 (9) HBCR: 78.5 (5.4) Peak HR: CBCR: 143 (9.7) HBCR: 140 (11) Workload, W CBCR: 132.5 (15.8) HBCR: 126.5 (19.7) Peak V0$_2$: CBCR: 24.2 (4.4) HBCR: 22.9 (3.6)	None	Unique use of a smart phone technology in delivery of CR. CAP-CR had significantly higher uptake (80% vs 62%), adherence (94% vs 68%) and completion (80% vs 47%) rates than traditional rehab (p<0.05). In addition, no difference between 2 treatments in terms of physiological and psychological results.	Exercise-only Program. Unclear random sequence allocation, allocation concealment, attrition bias, no intent to treat analysis Blinded outcome assessment Exercise adherence not reported No CONSORT diagram

Study	Design	No. of Patients	Patient Population	Interventions	Outcomes	Subgroup Analyses	Unique Strategies, Learnings, Solutions to Address Challenges of Operating Home-Based Program	Notes
				No intervention or instruction provided.	HR Recovery CBCR: 19.1 (6.2) HBCR: 16.2 (4.8) Adverse events: Not reported			
							.Used diaries to record compliance. 2 week telephone contacts	

Note: ACS, acute coronary syndrome; BMI, body mass index; BP, blood pressure; CBCR, center-based cardiac rehabilitation; CPET, cardiopulmonary exercise test; CR, cardiac rehabilitation; CVD, cardiovascular disease; HR, heart rate; MI, myocardial infarction; NR, not reported; NS, not significant; RCT, randomized controlled trial; CABG, coronary artery bypass graft; CBCR, center-based cardiac rehabilitation; CHD, coronary heart disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CPET, cardiopulmonary exercise test; CVA, cardiovascular accident; ECG, electrocardiogram; ET, exercise training; ETT, exercise treadmill test; FU, follow-up; HBCR, home-based cardiac rehabilitation; HDL, high-density lipoprotein; HIT, high-intensity training; HR, heart rate; HRR, heart rate recovery; HRQoL, health related quality of life; ITT, intention to treat; LDL, low density lipoprotein; METs, Metabolic equivalents; LVEF, left ventricular ejection fraction; MCS, mental component score; MI, myocardial infarction; NHS, National Health Services; NS, not significant; PA, physical activity; PAD, peripheral artery disease; PCI, percutaneous coronary intervention; PCS, physical component score; PT, physical therapist; RCT, randomized controlled trial; PRE, rate of perceived exertion; 6MWT, 6 minute walk test.

Table 2: Outcome Metrics in Center-based CR (CBCR) and those used in Home-based CR (HBCR) studies included in this paper.

AACVPR Core Components of CR Programs[30] (Balady et al, 2007)	AACVPR/ACC/AHA Performance Measures (Set B)[31] (Thomas et al, 2007))	*AACVPR CBCR Quality/Performance Outcome Metrics	HBCR Outcome Metrics reported	HBCR Measurement Tool reported
Patient assessment	**Assessment & reassessment** Clinical status (*e.g., symptoms, medical history)* to identify high-risk conditions for adverse CV events; CV risk factor status.			
Nutritional counseling	Individualized based on assessment of specific CV risk factors (*e.g., weight, HTN, DM, lipids)*		Self-reported diet[16, 29]	Dietary habits questionnaire[29]
Weight management	**Goal:** BMI 18.5 to 24.9 kg/m² and waist circumference: Men <40 inches; Women <35 inches **Assessment:** Height, weight, calculate BMI; waist circumference		Weight[1-4, 12] Body composition[1, 2] Waist/hip ratio[3, 4, 24] BMI[6, 9, 10, 19, 20, 24, 29] Waist circumference[19, 20, 29]	
Blood pressure management	**Goal:** <140/90 mmHg or <130/80 mm Hg with DM or CKD **Assessment:** BP to identify HTN diagnosis or untreated HTN	**Outcome**: Optimal BP control **Metric:** Recommendations for proper measurement and cuff size [(Pickering et al, 2015)]	BP[1, 2, 6, 12, 16, 19, 20, 23, 24, 29]	
Lipid management	**Goal:** Optimal control **Assessment:** Lipid profile to Identify optimal or suboptimal control		Lipids[5, 6, 9, 10, 12, 16, 19, 20, 23, 24, 29]	
Diabetes management	**Goal:** HbA$_{1c}$ < 7% **Assessment:** HbA$_{1c}$ or fasting blood glucose to identify DM or IFG (110-125 mg/dl)		Glucose[23]; HbA1C[23]	
Tobacco cessation	**Goal:** Complete cessation of tobacco **Assessment:** Ascertain tobacco use status: • Never • Recent (<6mos) • Current	**Outcome:** Tobacco cessation **Metrics:** For tobacco users, provide at least one intervention: brief tobacco relapse counseling, pharmacotherapy, refer to specialist or program	Smoking status[9, 10, 16]	Self-reported[9, 10] Cotinine validated[16]

Psychosocial management	**Goal:** Identify presence or absence of depression **Assessment:** Screen for depression using valid and reliable depression screening tool.	**Outcome:** Depressive symptom improvement **Metrics:** Validated and reliable depression screen tool. Recommended based on evidence review: PHQ-9, BDI-II, PRFS, or HADS[32-35]	HRQoL[1-5, 7-10, 17, 18, 21, 23-27, 29] Social support[3, 4] Depression and/or Anxiety[9, 10, 16, 17, 24, 29]	Mac New [1, 2, 9, 10, 18, 23] SF-36[3, 4, 7, 8, 17, 25-27] SF-12[24] Nottingham Health Profile[5] Minnesota HF[7, 8] Sickness Impact Profile[21] EuroQol-5D[29] ISEL[3, 4] HADS[9, 10, 16, 24] BDI[17] Spielberger's State Anxiety[17] Psychological distress scale[29]
Physical activity counseling	**Goal:** 30+ min, minimum 5 d per week. **Assessment:** Identify optimal PA habits and suboptimal PA habits		Physical activity[1-4] Exercise adherence/attendance [1, 2, 5, 6, 11-21, 24-27, 29]	Self-reported PA (IPAQ)[1, 2] Accelerometer (7 days)[1, 2] Physical activity scale for the elderly (PACE)[3, 4] Modified Godin[16] Self report[19, 20, 24] Primarily self-report
Exercise training	**Goal:** Develop individualized exercise prescription **Assessment:** Symptom limited exercise tolerance test	**Outcome:** Functional capacity improvement **Metrics:** GXT-symptom limited [(ACSM, 2014)], Estimated exercise session peak METs [(ACSM, 2014)], 6MWT [(ATS, 2002)]	Peak VO2[1-4, 6, 11, 13-15, 17-20, 23-28] Max Mets[5, 9, 10, 21, 22] Sub-max[7, 8, 16, 29]	CPET[1-4, 6, 11, 13-15, 17-20, 23-28] GXT[5, 9, 10, 22] Shuttle Walk Test[7, 8, 16] 6-min walk[17, 29] Cycle ergometer[21]
Other	**Structure-based measurement:** Physician-director oversight of CR program policies/procedures consistent with evidence-based guidelines, safety and regulatory standards, *including provision of alternative programs services, such as HBCR*.		Clinical adverse events[3, 4, 9, 10, 12, 21, 22, 24] Cost[5, 6, 19-21] Health service resource use[16, 21] All cause &CV mortality[9, 10, 24] Use of CV drugs[9, 10]	# hospitalizations[3, 4] Tests, exercise sessions, patient fees, Staff time[6]
	Use of guideline-based preventive medications: **Goal:** Medication adherence **Assessment:** Prescribed medication list, adherence status			

Table 3: HRQoL in HBCR versus CBCR

Author (year)	Follow-up	Instrument	HBCR	CBCR	Between Group differences
Aamot (2014)[21]	3 months	MacNew	Median (range)	Median (range)	
		Global	6.4 (4.7-6-8)	6.3 (4.5-6.7)	=
		Emotional domain	6.1 (3.9-6.7)	6.2 (3.6-6.9)	=
		Social domain	6.8 (4.9-7.0)	6.5 (5.0-7.0)	=
		Physical domain	6.4 (4.0-6.9)	6.4 (5.2-7.0)	=
	15 month	MacNew	Mean (SD)	Mean (SD)	
		Global	6.1 (0.6)	6.1 (0.5)	=
		Emotional domain	6.0 (0.6)	5.9 (0.8)	=
		Social domain	6.3 (0.7)	6.5 (0.5)	=
		Physical domain	6.2 (0.7)	6.3 (0.4)	=
Kraal (2014)[33]	3 months	MacNew	Mean (SD)	Mean (SD)	
		Global	6.1 (0.5)	5.8 (0.7)	=
		Emotional domain	5.9 (0.8)	5.6 (0.9)	=
		Social domain	6.4 (0.6)	6.1 (0.7)	=
		Physical domain	6.1 (0.6)	5.7 (0.8)	=
Varnfield (2014)[30]	6 weeks	EQ-5D	Median (IQR)	Median (IQR)	
		Global Index	0.92 (0.9-1.0)	0.82 (0.7-0.9)	H > C

Data presented as mean and standard deviation unless otherwise specified. HBCR, home-based cardiac rehabilitation; CBCR, center-based cardiac rehabilitation

Table 4. Costs and Healthcare Utilization of HBCR and CBCR

Study	HBCR Cost/ patient	CBCR Cost/ patient	Costs Included	Other Analyses
Carlson [13]	$1519	$2349	Billing to health insurance and patient for sessions, diagnostic testing	Staffing hours HBCR 87 vs. CBCR 124.
Cowie[34, 44]	£197	£222	Staff, DVDs, and heart rate monitors	Hospitalization costs per patient HBCR £7716 vs. CBCR £7208 vs. control £9832.
Dalal [19, 43]	£170	£200	Staff, staff travel, Heart Manual	No significant differences in costs or non-rehabilitation healthcare utilization. No significant difference in QALYs. No change in conclusions with inclusion of patient travel costs.
Jolly[20]	£198	£157	Staff, staff travel, Heart Manual	Inclusion of patient travel costs increased cost of CBCR to £181/patient, with difference in costs no longer statistically significant. No significant differences in non-rehabilitation healthcare utilization. No significant difference in QALYs. No significant difference in time off work.
Marchionni[32]	$1650	$8841	CR program (not itemized)	Non-rehabilitation healthcare utilization costs were HBCR $11,596, CBCR $12,457, and control $12,433. There were fewer medical visits and re-hospitalizations in HBCR compared to CBCR and control.

CBCR, Center-based cardiac rehabilitation, HBCR, Home-based cardiac rehabilitation, CR, cardiac rehabilitation; QALY, Quality-adjusted life year.
Note: costs reported as published in studies and not adjusted for currency or time.

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