Home-Based Cardiac Rehabilitation Alone and Hybrid With Center-Based Cardiac Rehabilitation in Heart Failure: A Systematic Review and Meta-Analysis

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***Background*—**Center-based cardiac rehabilitation (CBCR) has been shown to improve outcomes in patients with heart failure (HF). Home-based cardiac rehabilitation (HBCR) can be an alternative to increase access for patients who cannot participate in CBCR. Hybrid cardiac rehabilitation (CR) combines short-term CBCR with HBCR, potentially allowing both flexibility and rigor. However, recent data comparing these initiatives have not been synthesized.

***Methods and Results*—**We performed a meta-analysis to compare functional capacity and health-related quality of life (hr-QOL) outcomes in HF for (1) HBCR and usual care, (2) hybrid CR and usual care, and (3) HBCR and CBCR. A systematic search in 5 standard databases for randomized controlled trials was performed through January 31, 2019. Summary estimates were pooled using fixed- or random-effects (when $I^2>50\%$) meta-analyses. Standardized mean differences (95% CI) were used for distinct hr-QOL tools. We identified 31 randomized controlled trials with a total of 1791 HF participants. Among 18 studies that compared HBCR and usual care, participants in HBCR had improvement of peak oxygen uptake (2.39 mL/kg per minute; 95% CI, 0.28–4.49) and hr-QOL (16 studies; standardized mean difference: 0.38; 95% CI, 0.19–0.57). Nine RCTs that compared hybrid CR with usual care showed that hybrid CR had greater improvements in peak oxygen uptake (9.72 mL/kg per minute; 95% CI, 5.12–14.33) but not in hr-QOL (2 studies; standardized mean difference: 0.67; 95% CI, −0.20 to 1.54). Five studies comparing HBCR with CBCR showed similar improvements in functional capacity (0.0 mL/kg per minute; 95% CI, −1.93 to 1.92) and hr-QOL (4 studies; standardized mean difference: 0.11; 95% CI, −0.12 to 0.34).

***Conclusions*—**HBCR and hybrid CR significantly improved functional capacity, but only HBCR improved hr-QOL over usual care. However, both are potential alternatives for patients who are not suitable for CBCR. **(*J Am Heart Assoc*. 2019;8:e012779. DOI: 10.1161/JAHA.119.012779.)**

Key Words: cardiac rehabilitation • exercise • heart failure • meta-analysis

Center-based cardiac rehabilitation (CBCR) is safe and has been shown to improve functional capacity, cardiac function, and health-related quality of life (hr-QoL) in patients with heart failure (HF).[1–4] However, multiple barriers such as lack of transportation or conflicting schedules often result in nonparticipation in CBCR among HF patients.[5–7] In these patients, home-based cardiac rehabilitation (HBCR) can be a reasonable alternative to offer exercise-based cardiac rehabilitation (CR).[8] Although previous systematic reviews and meta-analyses have compared outcomes of HBCR with CBCR and usual care,[9–11] sample sizes were limited and at least 11 additional randomized controlled trials (RCTs) have been published since the last meta-analysis. In addition, several studies have used a hybrid approach (hybrid CR) combining short-term CBCR and HBCR as another alternative to either HBCR or CBCR alone, the effects of which have yet to be analyzed in a systematic fashion. Consequently, we undertook the following systematic review and meta-analysis of RCTs to compare the outcomes of HF patients who underwent (1) HBCR versus usual care, (2) hybrid CR versus usual care, and (3) HBCR versus CBCR.

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Accompanying Tables S1 through S5 and Figures S1 through S5 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.119.012779

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Clinical Perspective

What Is New?

- Both home-based and hybrid (combination of home- and center-based) cardiac rehabilitation significantly improved functional capacity compared with usual care.
- Home-based cardiac rehabilitation also improved health-related quality of life.

What Are the Clinical Implications?

- Both home-based and hybrid cardiac rehabilitation are reasonable alternatives for patients who cannot attend center-based cardiac rehabilitation.

Methods

The data that support the findings of this study are available from the corresponding author on reasonable request. We conducted and report this systematic review and meta-analysis in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[12]

Eligibility Criteria

We included RCTs that evaluated exercise-based HBCR or hybrid CR against CBCR or usual care in adult patients aged ≥18 with a diagnosis of HF with reduced ejection fraction or HF with preserved ejection fraction.

Types of Exercise Interventions

In HBCR studies, patients received an exercise training prescription of at least 3 hours of exercise per week exclusively at home or in a community setting (eg, gymnasium, senior center), without real-time supervision by a CR professional during exercise, for at least 8 weeks but <12 months.

In CBCR studies, patients participated in exercise training sessions with real-time supervision by a CR professional in either a hospital or physician's office–based CR center for at least 3 hours/week for ≥8 weeks up to 12 months.

In hybrid CR, patients participated in exercise training sessions of at least 3 hours/week in combined center- and home-based settings for at least 8 weeks up to 12 months. Exercise training sessions can occur in a sequential fashion, with initial short-term CBCR of ≤4 weeks followed by HBCR for at least another 4 weeks, or in a concomitant fashion in both settings where the center-based exercise sessions did not exceed 50% of total prescribed exercise sessions.

In usual care, no exercise intervention was prescribed.

Information Sources

We performed the search on January 31, 2019, in CENTRAL (Cochrane Library; 1944 to issue 2 of 2019), MEDLINE (Ovid; 1879 to January 2019), EMBASE (Ovid; 1945 to January 2019), PsycINFO (Ovid; 1927 to January 2019), and CINAHL Plus (EBSCO; 1976 to January 2019). Further information was sought by hand-searching the bibliographies of selected papers and through contacts with the authors of the published papers. Only studies that showed results (paper or abstract form) in English language were included.

Search

A system-wide electronic search was performed using the following terms: *heart failure* and *cardiac rehabilitation, rehabilitation, exercise therapy, exertion, fitness training,* or *exercise*. Two authors (H.I.) and (M.B.) independently screened all searched articles and discarded irrelevant titles. Both authors independently reviewed articles that met the criteria. Any discrepancy was resolved after review by a third author (W.W.).

Of the 53 studies eligible for review, 22 studies were excluded after complete review. Studies were excluded if study participants had previously completed CBCR, had a different inclusion criterion other than HF (eg, chronic obstructive pulmonary disease or obstructive sleep apnea), did not report quantifiable outcomes, had duplication of data from previous studies, or had a crossover design (Table S1).

Study Outcomes

We evaluated functional capacity and hr-QoL as primary outcomes, and hospital admissions (all-cause and cardiac) and all-cause mortality as secondary outcomes.

Functional capacity was measured by cardiopulmonary exercise test, exercise stress test, 6-minute walk test or incremental shuttle walk test. When studies assessed functional capacity using both maximal stress (ie, cardiopulmonary exercise test or exercise stress test) and submaximal stress (ie, 6-minute walk test or incremental shuttle walk test), data from maximal stress were extracted. For uniformity of data, all measures of functional capacity were converted to peak oxygen uptake by using the following formulas: Peak oxygen uptake=4.948+[0.023×6-minute walk distance (meters)] or Peak oxygen uptake=4.19+[0.025×incremental shuttle walk distance (meters)].[13,14]

For hr-QOL, studies reported general hr-QOL, HF-specific hr-QOL questionnaires, or both. For those that reported both, we pooled the scores only from HF-specific questionnaires—Minnesota Living with Heart Failure (MLWHF),[15] Kansas City

Cardiomyopathy Questionnaire (KCCQ),[16] Chronic Heart Failure Questionnaire (CHF Questionnaire),[17] and Heart Failure Functional Status Inventory[18]—to be specific, when possible, for HF. For the remaining studies, we pooled the hr-QOL tool that was utilized, general or HF-specific. For uniformity purposes, mean differences of the scores from these distinct questionnaires were standardized by dividing them by their own standard deviation and then reported as standardized mean differences (SMDs). The scores in MLWHF were reverse coded because, unlike other hr-QOL tools, a decrease in MLWHF score indicates better hr-QOL.

Risk for all-cause and cardiac-specific hospitalizations (HF, revascularization, acute myocardial infarction) were extracted as relative risks.

All-cause mortality was low overall, and deaths were counted if they occurred during the study period.

Data Extraction

Some studies did not report a direct comparison of the change from baseline between the arms; instead, they only compared postintervention scores. In those cases, mean change from baseline within each study arm was calculated by subtracting mean functional capacity or hr-QoL score at entrance from the exit value. To err on the conservative side, the higher standard deviation between the entry or the exit results was selected as the standard deviation for the change from baseline within each arm.

Risk Assessment for Bias in Included Studies

We evaluated the risk of bias in studies by using Cochrane Risk of Bias Tool for RCTs.[19] We reviewed studies for evidence of balance in baseline characteristics of groups. The risk of bias was assessed by each reviewer (M.B. and H.I.) independently (Table S2) for all studies.

Statistical Analysis

For continuous variables, means and standard deviations were extracted. SMD with 95% CI was calculated for functional capacity and hr-QOL scores. For categorical variables, relative risk with 95% CI was calculated for hospitalizations and mortality outcomes if applicable. Using a fixed-effects or DerSimonian and Laird random-effects model (when $I^2>50\%$), results from included studies were pooled to give an overall estimate of the treatment effect[20] to test 3 a priori hypotheses in HF: (1) HBCR improves functional capacity, hr-QOL, and all-cause hospitalization over usual care; (2) hybrid CR improves functional capacity, hr-QOL, and all-cause hospitalization over usual care; and (3) HBCR improves functional capacity and hr-QOL over CBCR.

Heterogeneity in included studies was explored quantitatively using Q statistics. Funnel plots and the Egger test were performed to assess publication bias.[21,22] Subgroup analyses, based on duration of exercise training in CR, maximal or submaximal effort at functional capacity evaluation, HF with preserved versus reduced ejection fraction, or type of questionnaire used to assess hr-QoL, were performed to assess potential sources of heterogeneity, as applicable. A 2-sided P value <0.05 was considered significant. Stata SE v15.0 (StataCorp) was used for analysis.

Results

Description of Studies

Search results

The PRISMA flow diagram is shown in Figure 1. We identified 11 studies in addition to the 20 studies included in previous systemic reviews and meta-analyses,[10,11] for a total of 31 studies and 1791 participants with HF. All studies but 2 had 2 comparison arms. The study by Gary et al had 4 arms: exercise only, cognitive behavior therapy only, exercise and cognitive behavior therapy, and usual care.[23] Exercise only and exercise with cognitive behavior therapy arms were compared with usual care. The study by Cowie et al had 3 arms: HBCR, CBCR, and usual care. We compared HBCR with (1) CBCR and (2) usual care.[24] All studies reported outcomes in patients with HF with reduced ejection fraction except for Gary et al and Lang et al, who reported outcomes for patients with HF with preserved ejection fraction.[25,26]

Exercise Training

The majority (13/18) of HBCR studies enrolled patients in the high-risk category (based on low left ventricular ejection fraction) of the American Association of Cardiovascular Pulmonary Rehabilitation (AACVPR). Participants (in 14/18 studies) were prescribed mild- to moderate-intensity aerobic exercises (mostly walking) with target heart rates at 40% to 75% of the maximal heart rate achieved during stress test or at a rate of perceived exertion of 11 to 13 on a Borg Scale. One study prescribed high-intensity aerobic (interval) exercise training.[27] Strength training and stretch exercises were prescribed in relatively fewer studies (8/18). Seven of 9 hybrid CR studies enrolled patients with high AACVPR risk, but they were also prescribed only mild- to moderate-intensity exercises. The participants were able to perform the prescribed exercises in nearly all RCTs without any adverse outcomes except for 1 study in which a patient

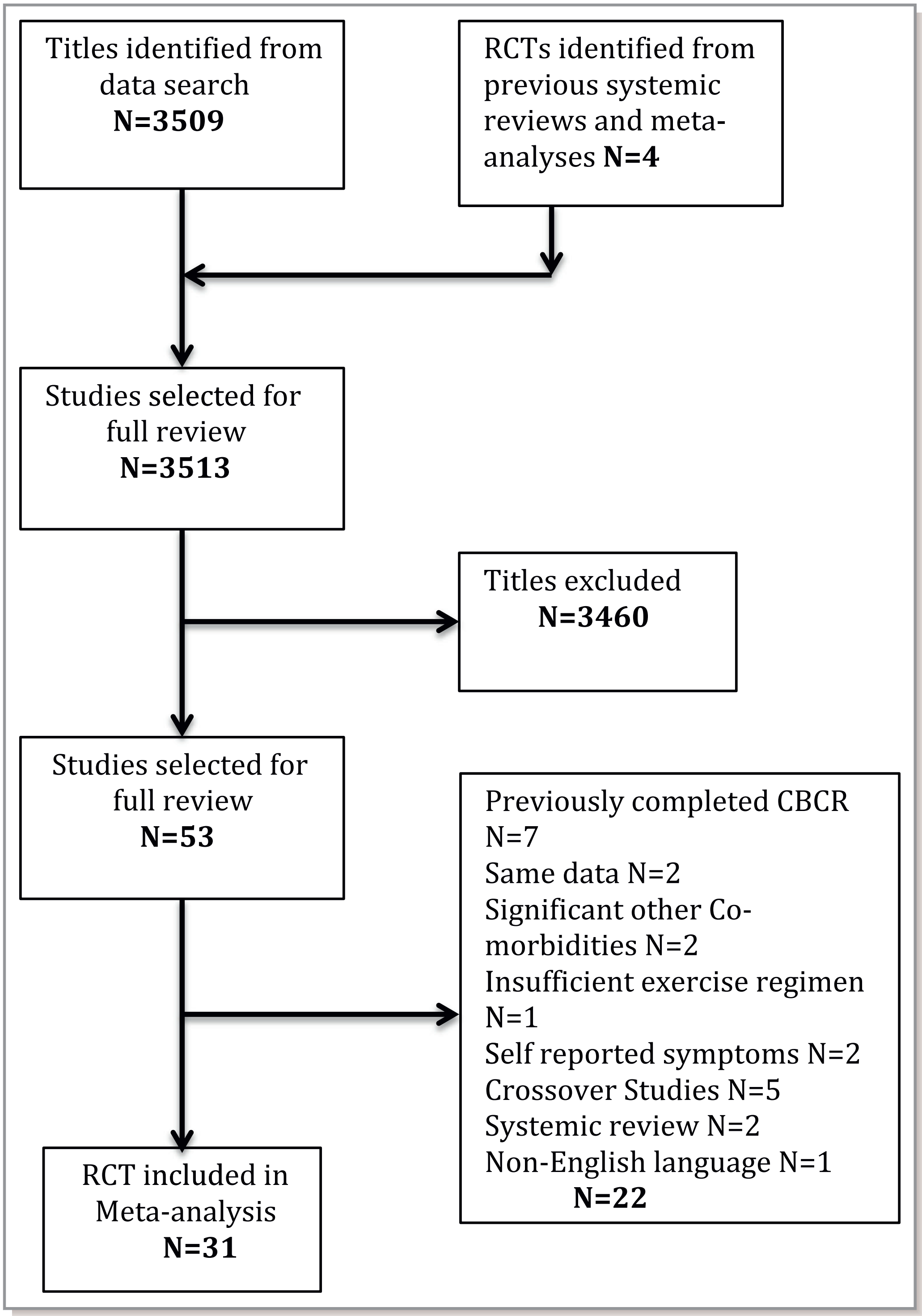

Figure 1. Comparison of functional capacity between home-based cardiac rehabilitation and usual care. CBCR indicates center-based cardiac rehabilitation; RCTs, randomized controlled trials.

was hospitalized for hypoglycemia during exercise.[28] Overall adherence to prescribed exercise sessions was 74% to 110% for HBCR and 60% to 80% for hybrid CR compared with 86% to 97% for CBCR. Program completion rates were 44% to 100% for HBCR and 31% to 100% for hybrid CR versus 72% to 100% for CBCR.

Effect of Intervention

Functional capacity

HBCR versus usual care. Eighteen studies involving 1191 participants compared functional capacity of HBCR and usual care (Table S3). On pooled assessment using a random-effects model, functional capacity significantly increased in HBCR (678 participants) compared with usual care (563 participants; 2.39 mL/kg per minute; 95% CI, 0.28–4.49; I^2=83.1%; Figure 2).[20,23–27,29–40] Subgroup analysis based on HF subtype showed functional capacity significantly improved only in HF with reduced ejection fraction (1109 participants; 3.18 mL/kg per minute; 95% CI, 0.95–5.47) but not in HF with preserved ejection fraction (82 participants; 0.42 mL/kg per minute; 95% CI, −2.52 to 3.58). On metaregression analyses, neither duration (P=0.37) nor method of functional capacity evaluation (P=0.15) significantly explained the heterogeneity of results.

Hybrid CR versus usual care. Nine studies, involving 306 participants, reported functional capacity at end of exercise training (n=155, hybrid CR; n=151, usual care; Table S4). On pooled assessment by a random-effects model, functional capacity significantly improved at the end of the intervention (9.72 mL/kg per minute; 95% CI, 5.12–14.33; I^2=90.1%; Figure 3).[28,41–48] Eight studies, involving 276 participants (n=140, hybrid CR; n=136, usual care), evaluated functional capacity by maximal stress, and 1 study, involving 30 (n=15, hybrid CR; n=15, usual care), assessed functional capacity by submaximal stress. On metaregression analyses, neither method of functional capacity assessment (P=0.15) nor duration of exercise intervention (P=0.13) explained the heterogeneity of the results.

HBCR versus CBCR. Five studies, involving 314 participants (n=166, HBCR; n=148, CBCR), compared functional capacity with HBCR and CBCR after exercise training (Table S5). All studies compared functional capacity by cardiopulmonary exercise test or incremental shuttle walk test at the end of an intervention of ≤3 months. Both groups experienced similar improvements in functional capacity from baseline, using the fixed-effect model (SMD: 0.00; 95% CI, −1.91 to 1.91 mL/kg per minute; I^2=0%; Figure S1).

Quality of life

HBCR versus usual care. Sixteen studies (n=576, HBCR; n=505, usual care) assessed HF-specific hr-QoL outcomes. Eleven studies, involving 771 participants, used the MLWHF

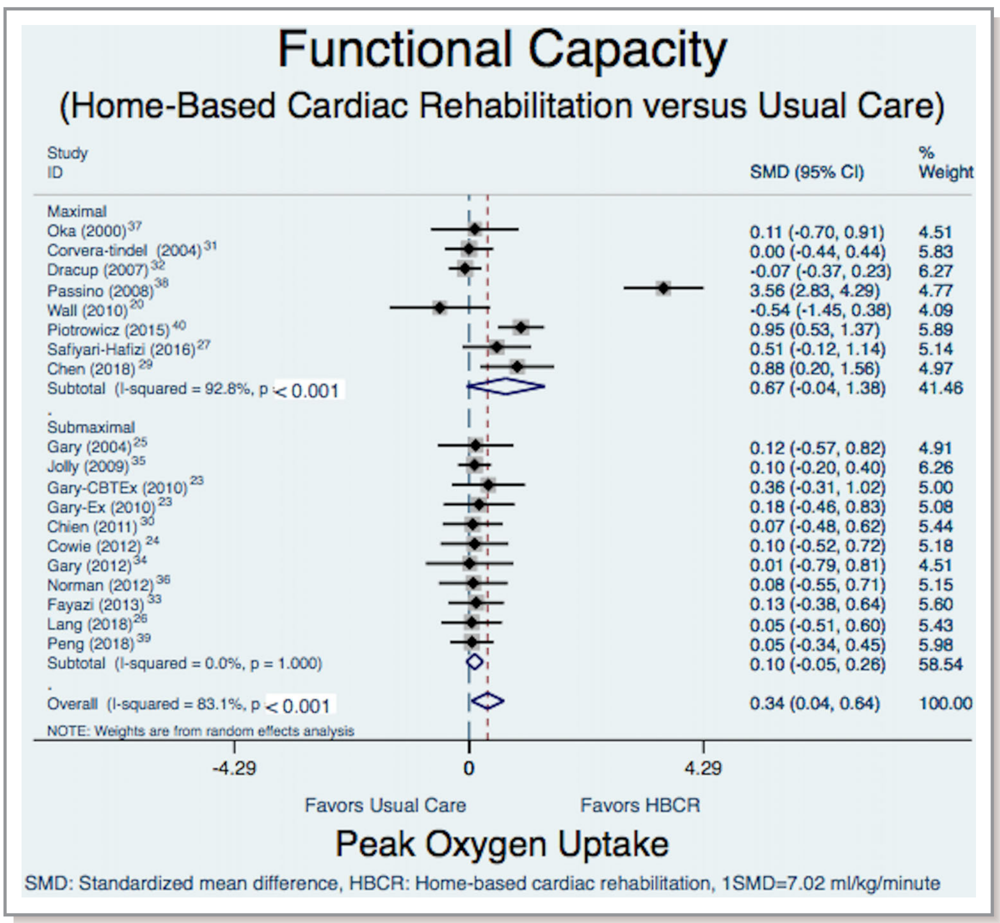

Figure 2. Functional capacity significantly improved in home-based cardiac rehabilitation (HBCR) compared with usual care; 1 standardized mean difference (SMD)=7.02 mL/kg per minute.

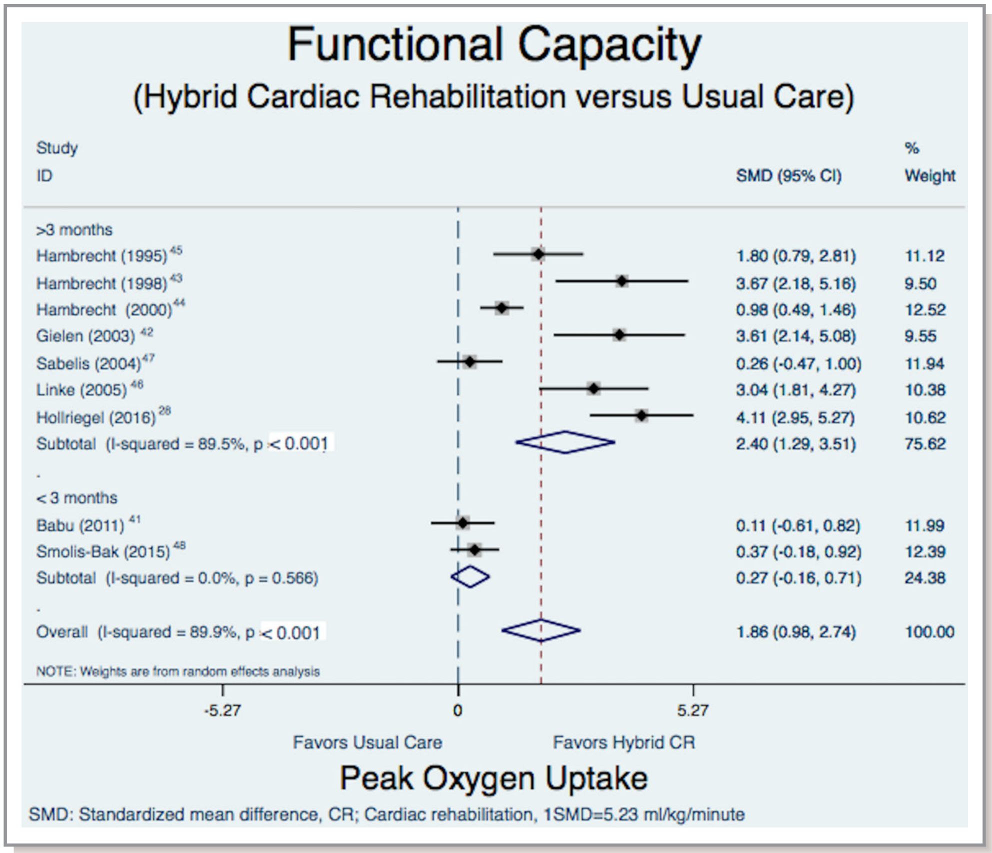

Figure 3. Comparison of functional capacity between hybrid cardiac rehabilitation (CR) and usual care. Functional capacity significantly improved in hybrid CR compared with usual care; 1 standardized mean difference (SMD)=5.23 mL/kg per minute.

questionnaire; 2 studies used the KCCQ; 1 study used the CHF Questionnaire; 1 study used the Heart Failure Functional Symptom Inventory; and 1 study used the Short Form 36 (SF-36) questionnaire (Table S3). On random-effects pooled analyses, hr-QoL significantly increased in HBCR participants compared with usual care (SMD: 0.36; 95% CI, 0.19–0.57; I^2=54.7%; Figure 4).* On metaregression analysis, different questionnaires used for assessment of hr-QOL (P=0.77) did not significantly explain the heterogeneity of results.

Hybrid CR versus usual care. Two studies, involving 102 participants (n=51, hybrid CR; n=51, usual care), reported hr-QoL outcomes and used different questionnaires (SF-36[50] and Nottingham Health Profile,[51] respectively; Table S4). In the pooled estimate of studies, there was no significant difference in hr-QoL among hybrid CR participants compared with usual care by the random-effects model (SMD: 0.67; 95% CI, −0.20 to 1.54; I^2=70.5%; Figure S2).

*References 20, 23, 25–27, 29–36, 39, 40, 49.

HBCR versus CBCR. Only 4 studies (n=155, HBCR; n=137, CBCR) reported comparison of change in hr-QoL between HBCR and CBCR. Three studies used the SF- 36 and 1 study used the MLWHF (Table S5). In a pooled fixed-effect model, there was no significant improvement in hr-QoL between the comparison groups (SMD: 0.11; 95% CI, −0.12 to 0.34; I^2=0%; Figure S3).

All-cause hospitalization

HBCR versus usual care. Four studies compared all-cause hospitalization among 458 participants. Two studies showed 6.6% (4/61) hospitalizations in the HBCR arm versus 10.9% (6/55) in the usual care arm at 3-month follow-up. Two other studies showed 35.7% (61/171) in the HBCR arm versus 33.3% (57/171) in the usual care arm at 1-year follow-up after intervention.

Hybrid CR versus usual care. Five studies compared all-cause hospitalization among 204 participants (n=102, hybrid CR; n=102, usual care). Three studies that reported outcomes after 6 months of exercise training (hybrid CR in 3/58 versus usual care in 3/57) did not show a significant difference in

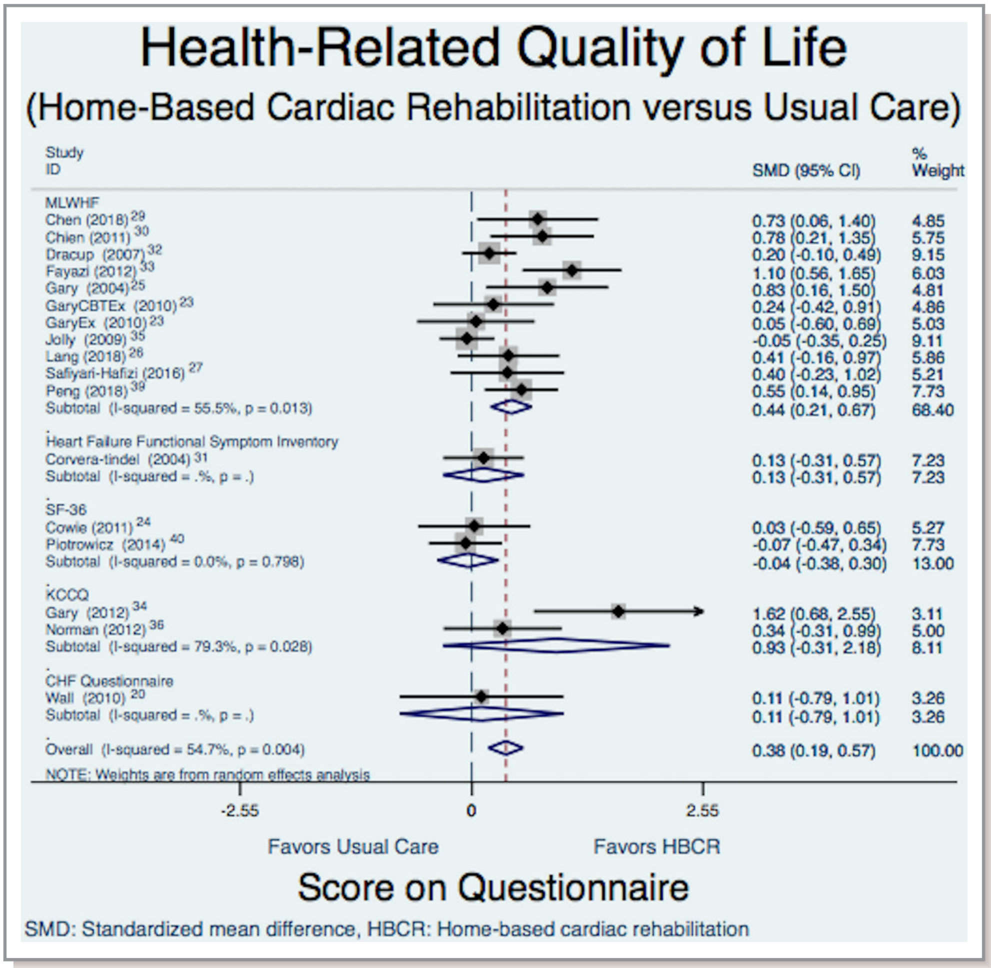

Figure 4. Comparison of health-related quality of life between home-based cardiac rehabilitation (HBCR) and usual care. Health-relate quality of life significantly improved with HBCR compared with usual care. CHF Questionnaire indicates Chronic Heart Failure Questionnaire; KCCQ, Kansas City Cardiomyopathy Questionnaire; MLWHF, Minnesota Living with Heart Failure; SF-36, Short Form 36; SMD, standardized mean difference.

hospitalizations (relative risk: 0.97; 95% CI, 0.25–3.73; I^2=0) between the 2 modalities (Figure S4). Two studies reported outcomes after respective follow-up periods of 12 months (hybrid CR versus usual care: 88.9% [16/18] versus 68.4% [13/19]) and 18 months (hybrid CR versus usual care: 53.8% [14/26] versus 57.7% [15/26]).

HBCR versus CBCR. Only Piotrowicz et al (n=75, HBCR; n=56, CBCR) reported all-cause hospitalizations (8-week outcome), which was none during the 8-week study period.

Cardiac hospitalization

HBCR versus usual care. Three studies, with 285 participants, reported cardiac hospitalizations at 3- and 12-month follow-up periods. Two studies reported a hospitalization rate of 4.9% (3/61) in the HBCR arm versus 7.3% (4/55) in the usual care arm after 3 months of intervention. One study reported a hospitalization rate of 13.1% (11/84) for the HBCR arm versus 12.9% (11/85) for the usual care arm at 1-year follow-up after intervention.

Hybrid CR versus usual care. Four studies reported cardiac hospitalization outcomes among 152 participants. Three studies reported outcomes for hybrid CR at 5.2% (3/58) versus usual care at 5.3% (3/57) at 6-month follow-up and 66.7% (12/18) versus 63.2% (12/19), respectively, at 12-month follow-up.

HBCR versus CBCR. None of the studies reported cardiac hospitalizations.

All-cause mortality

HBCR versus usual care. Four studies, involving 463 participants (n=235, HBCR; n=228, usual care), reported all-cause mortality at the end of the study period. Two studies reported mortality at the end of 3 months, and the other 2

Table. Summary of Findings

Comparison	Functional Capacity	hr-QOL	Clinical Outcomes
HBCR vs UC	HBCR over UC (2.39 mL/kg/min; 95% CI, 0.28–4.49; I^2=83.1%)	HBCR over UC (0.36; 95% CI, 0.19–0.57; I^2=54.7%)	Lack of statistical power to test clinical outcomes
Hybrid CR vs UC	Hybrid CR over UC (9.72 mL/kg/min; 95% CI, 5.12–14.33; I^2=93.0%)	Hybrid CR equivalent to UC (0.67; 95% CI, −0.20 to 1.54; I^2=70.5%)	All-cause hospitalization was similar (RR: 0.97; 95% CI, 0.25–3.73; I^2=0.0%) between hybrid CR and UC at 6 mo; it lacks statistical power to test other clinical outcomes
HBCR vs CBCR	HBCR equivalent to CBCR (0.00 mL/kg/min, 95% CI, −1.91 to 1.91; I^2=0%)	HBCR equivalent to CBCR (0.11; 95% CI, −0.12 to 0.34; I^2=0%)	One study reported no outcomes in either group

CBCR indicates center-based cardiac rehabilitation; CR, cardiac rehabilitation; HBCR, home-based cardiac rehabilitation; hr-QOL; health-related quality of life; RR, relative risk; UC, usual care.

reported mortality at the end of a 1-year study period. The mortality rate was 8.5% (11/129) in the HBCR arm versus 7.3% (9/123) in the usual care arm at 3-month follow-up. Two other studies reported mortality rates of 7.5% (8/106) versus 4.8% (5/105) in the HBCR and usual care arms, respectively, at 1-year follow-up.

Hybrid CR versus usual care. Six studies reported all-cause mortality in 224 participants. Four studies reported mortality at 6 months, 1 reported at 12 months, and 1 reported at 18 months. Mortality rates were 5.9% (4/68) in the hybrid CR arm versus 4.5% (3/67) in the usual care arm during the 6-month study period and 5.5% (1/18) versus 0% (0/19), respectively, at 12 month follow-up; 3 of /14 participants in the hybrid CR arm and 3 of 15 in the usual care arm had died at 18-month follow-up after intervention.

HBCR versus CBCR. None of the studies reported mortality outcomes.

Assessment of publication bias

Risk of publication bias was low for functional capacity comparisons, but potential bias may exist between HBCR and usual care for hr-QoL. Influence analysis did not show any single study that significantly influenced the overall estimate of the effect size (Figure S5). A subgroup analysis based on sample size (n<50 versus n>50 [median: 50]) yielded similar results between the 2 subgroups (P=0.62) and suggested that sample size was unlikely to be a significant component in the interpretation of the results.

Discussion

This updated review and meta-analysis built on previous reports by increasing the sample size (1791 versus 1290 participants) and by investigating the effects of a hybrid CR model. The results showed that both HBCR and hybrid CR significantly improved functional capacity, but only HBCR improved hr-QoL over usual care. compared with CBCR, patients in HBCR achieve similar functional capacity and hr-QoL outcomes (summary in Table).

Compared with previous reports, we generated pooled estimates of improvement from baseline—an important requirement in the evaluation of CR programs, as stated by the American Heart Association and American College of Cardiology Foundation (AHA/ACCF)—as opposed to pooling only exit outcomes.[52] This study overcame previous limitations by converting distinct assessment methods into unified units of comparison before pooling. Functional capacity, for example, was converted into peak oxygen uptake, and the distinct hr-QOL questionnaires were standardized by their own standard deviations using SMDs. Given the methods we utilized, our current results are unique and the effects sizes are applicable to most assessment tools currently used in CR.

Different HBCR models have been implemented safely in the past across different single-payer systems. The included trials required either periodic face-to-face visits or telephone calls to assess progress. The Stanford Coronary Rehabilitation Program and Kaiser Permanente (a private insurer) developed Multifit, an HBCR program complemented by face-to-face follow-up visits with a nurse. The program improved clinical outcomes and reduced healthcare resource utilization by patients with HF.[53] The Veterans Health Administration initiated a telephone-based HBCR as an alternative to CBCR, with high patient satisfaction.[54] Schopfer et al reported a higher participation rate for HBCR than CBCR among veterans.[55] The clinical outcomes data presented in our current meta-analysis showed that both HBCR alone and hybrid CR were at least as safe as CBCR and had the potential to improve clinical outcomes over usual care during short-term follow-up. The small sample size and distinct follow-up periods of the studies preclude a uniform assessment of the clinical outcomes. Some data showed that mobile or web-based platforms for intervention can also be deployed successfully.[56,57] Technological advancements such as smartphone or web-based applications should be considered in the design of new studies to enhance the efficacy and safety of current HBCR practices.

Hybrid CR is a novel model that can provide increased monitoring opportunities during the initial exercise training phase for patients who cannot successfully or safely exercise without direct monitoring by a healthcare professional. The obstacles to exercise may not always be physical and may include psychosocial concerns.[58] In hybrid CR, initial sessions at the CBCR setting can address psychosocial health in susceptible individuals, increase participation in group education sessions, and tailor the exercise regimen based on direct observation. Although the effect size of functional improvement appeared to be higher in hybrid CR versus HBCR, this has not been evaluated against HBCR or CBCR in head-to-head comparisons for a definitive conclusion. Future RCTs should address this knowledge gap.

Although our results showed that HBCR improved functional capacity and hr-QOL in a fashion similar to CBCR, HBCR also has limitations. The studied HBCR models did not provide opportunities for peer support and role modeling that may come from exercising in the type of group setting that is typical of CBCR.[59] Despite the AHA/ACCF recommendation that the HBCR model can be an alternative to CBCR, the Centers for Medicare and Medicaid Services and the majority of private insurers have yet to implement a reimbursement model for HBCR.[60] In one study, the cost of delivery of HBCR (£196.53 [1£ ~ $1.25]) was similar to CBCR (£221.58) for a duration of 8 weeks (average cost of approximately £100 per 4 weeks). A recent study reported similar costs for the duration of 3 months of HBCR (£362.21).[26,49] Nonetheless, the cost of CBCR in the United States is higher than costs these reports, making HBCR models potentially financially attractive. Our results suggest that policy makers and insurers should consider a viable model of reimbursement for HBCR and/or use of a hybrid CR model, summarized in the current meta-analysis, because the known benefits of CBCR for HF patients appeared translatable into these alternative models for patients who are not eligible for traditional CBCR.

Our analysis has limitations. Similar to other meta-analyses, our results relied on the quality and detail of reporting, which were somewhat heterogeneous and may have contributed to the degree of heterogeneity observed in our pooled analyses. Nonetheless, subgroup and bias analyses suggest that single studies were unlikely to have altered our overall results. Next, the majority of the included studies were of patients with stable HF with reduced ejection fraction; therefore, extrapolation of the findings to patients with HF with preserved ejection should be done with caution. We performed subgroup analyses to distinguish these effects before generating the pooled estimates. Finally, most studies did not report or incompletely reported clinical outcomes or had no adverse events because of short and variable follow-up periods. Future RCTs should be designed to assess long-term clinical outcomes of HBCR and hybrid CR in predefined follow-up periods.

Conclusion

In this meta-analysis of RCTs, HBCR and hybrid CR significantly improved functional capacity compared with usual care and are potentially good alternatives for patients who are not suitable for CBCR.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Reasons for Exclusion of Studies.

First Author	Year	Reason for Study Exclusion
De Mello[1]	2006	Previously completed CBCR for 3 months
McKelvie[2]	2002	Previously completed CBCR for 3 months
Witham[3]	2005	Previously completed CBCR for 3 months
Kiilavuori[4]	1999	Previously completed CBCR for 3 months
Kiilavuori[5]	1996	Previously completed CBCR for 3 months
Antonicelli[6]	2016	Previously completed CBCR for 3 months
Beckers[7]	2010	Previously completed CBCR for 6 months
Du[8]	2018	Insufficient exercise regimen (did not meet study criteria)
Evangelista[9]	2006	Study participants were part of Dracup` s study[10]
Gary[11]	2006	Results previously published by author in another journal
Bernocchi[12]	2018	All study participants had additional diagnosis of COPD
Servantes[13]	2012	All study participants had additional diagnosis of sleep apnea
Oka[14]	2005	Study reported self-efficacy of daily activities without objective assessment of functional capacity
Adamopoulos[15]	1993	Cross-Over study with control patients participating in exercise-based CR later
Coats[16]	1990	Cross-Over study with control patients participating in exercise-based CR later
Webb-Peploe[17]	2000	Cross-Over study with control patients participating in exercise-based CR later
Davey[18]	1992	Cross-Over study with control patients participating in exercise-based CR later
Zwisler[19]	2016	Systemic review published previously
Hwang[20]	2009	Systemic review published previously
Gary[21]	2011	Self-reported symptoms without any objective assessment of functional capacity
Senden[22]	2005	Cross-Over study with control patients participating in exercise-based CR later
Shen[23]	2011	Study published in Chinese language

CBCR: Center-based cardiac rehabilitation, COPD: Chronic obstructive pulmonary disease, CR: Cardiac rehabilitation.

Table S2. Bias Analysis of Included Studies.

Study	Randomized Sequence	Allocation Concealment	Selective Reporting	Blinding of Outcome Assessment	Incomplete Outcome Data	Groups Balanced at baseline	Groups Received Same Co-Intervention
Home-Based Cardiac Rehabilitation versus Usual Care							
Chen	unclear risk	unclear risk	unclear risk	low risk	high risk	low risk	no
Chien	unclear risk	unclear risk	low risk	unclear risk	low risk	high risk	no
Corvera-Tindel	unclear risk	unclear risk	low risk	high risk	low risk	low risk	no
Dracup	unclear risk	unclear risk	low risk	low risk	low risk	high risk	no
Fayazi	high risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Gary 2004	low risk	unclear risk	low risk	high risk	low risk	low risk	no
Gary 2010	unclear risk	unclear risk	low risk	low risk	high risk	unclear risk	no
Gary 2012	unclear risk	unclear risk	low risk	unclear risk	low risk	high risk	no
Safiyari-Hafizi	unclear risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Jolly	low risk	unclear risk	low risk	low risk	low risk	low risk	no
Lang	unclear risk	unclear risk	low risk	low risk	low risk	high risk	no

Norman	unclear risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Oka	unclear risk	unclear risk	low risk	unclear risk	unclear risk	unclear risk	no
Passino	unclear risk	unclear risk	low risk	unclear risk	low risk	high risk	no
Peng	low risk	low risk	low risk	low risk	low risk	low risk	no
Wall	unclear risk	unclear risk	low risk	unclear risk	low risk	high risk	no
Piotrowicz 2015	low risk	unclear risk	low risk	high risk	low risk	high risk	no
Hybrid Cardiac Rehabilitation versus Usual Care							
Babu	unclear risk	low risk	low risk	unclear risk	high risk	low risk	no
Gielen	unclear risk	unclear risk	low risk	low risk	low risk	high risk	no
Hambrecht 1995	unclear risk	unclear risk	low risk	unclear risk	high risk	low risk	no
Hambrecht 1998	unclear risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Hambrecht 2000	low risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Hollriegel	low risk	unclear risk	low risk	low risk	high risk	low risk	no
Linke	unclear risk	unclear risk	low risk	unclear risk	low risk	low risk	no
Sabelis	unclear risk	unclear risk	low risk	unclear risk	low risk	unclear risk	no
Samolis-Bak	unclear risk	unclear risk	low risk	unclear risk	low risk	high risk	no
Home-Based versus Center-Based Cardiac Rehabilitation							
Cowie	low risk	low risk	low risk	unclear risk	high risk	high risk	low risk

Daskapan	unclear risk	unclear risk	low risk	unclear risk	low risk	low risk	low risk
Hwang	high risk	low risk	low risk	low risk	low risk	low risk	low risk
Karapolat	unclear risk	low risk	low risk	unclear risk	unclear risk	low risk	low risk
Piotrowicz 2010	unclear risk	unclear risk	low risk	unclear risk	high risk	low risk	high risk

Table S3. Studies Comparing Home-Based Cardiac Rehabilitation versus Usual Care.

Author (Year)	Sample Size HBCR	UC	Age (Years) Mean ± SD HBCR	UC	Male % HBCR	UC	Follow-Up Protocol for HBCR during training	Inclusion Criteria	Duration (Exercise Frequency) Exercises Aerobic Exercise Prescription	Completion Rate (%) Prescribed Sessions Attended (%) Safety HBCR	Baseline Functional Capacity (Mean ± SD) Peak Oxygen Uptake (ml/kg/minute) HBCR vs. UC	Quality of Life Assessment
Chen (2018)[24]	18	19	60 ± 16	61 ±11	77.8	89.5	Biweekly telephone calls	1. HF with EF < 50%	3 months (3 times weekly) Walking, Jogging, Stationary cycling 60-80% HR of initial HR during CPET at Borg scale 12-13	65.6% -- No events	CPET 18.2 ± 4.1 vs. 18.7 ± 4.2	MLWHF
Chien (2011)[25]	24	27	58 ± 16	57 ± 16	83.3	66.7	Weekly 1-2 phone calls	1. NYHA I-III 2. Diagnosis of HF for >6 months 3. Medically stable for > 3 months	8 weeks (3 times weekly) Walking and muscle strengthening exercises Patients received brochure on safe regimen for exercise (not available from review)	91.7% -- No events	6MWT 14.7 ± 8.3 vs. 14.9 ± 6.8	MLWHF
Corvera-Tindel (2004)[26]	42	37	63.8 ± 10.1	61.3 ± 11.1	100	97.3	Home visits weekly for initial 6 weeks, then biweekly for study duration	1. NYHA class II/III 2. EF ≤ 40% 3. Diagnosis of HF for > 3 months	12 weeks (5 times weekly) Walking with pedometer Initially at 40% of maximum HR for 10 minutes, then increase	76% 74-88% No events	CPET 14.3 ± 3.7 vs. 14.2 ± 3.4	HFFSI

									to 65% for up to 60 minutes			
Cowie (2011)[27]	20	20	65.5 Range (35-82)	61.4 Range (39-79)	90.0	85.0	Biweekly telephone calls	1. Diagnosis of HF 2. Clinically stable for one month 3. Optimal medical therapy 4. Followed by heart failure nurse service	3 months (2 times weekly) Circuit training for aerobic exercise 40-60% of heart rate reserve based on initial exercise capacity (Ten 90-second exercise stations per circuit, performed twice)	75% 77% --	ISWT 10.9 ± 7.7 vs. 10.0 ± 7.5	SF-36
Dracup (2007)[10]	87	86	53.3 ± 12.7	54.6 ± 12.5	73.3	70.1	Home visit weekly for first 2 weeks, then every month	1. NYHA II-IV 2. EF <40% 3. Age 18-80 years 4. Sinus rhythm 5. English Speaking	3 months (4 times weekly) Walking initially at 40% of maximum HR for 10 minutes, then increase to 65% for up to 45 minutes Resistance training at 80% of 1 repetition maximum for 2 sets of 10 repetitions	44% -- No events	CPET 14.3 ± 3.7 vs. 13.3 ± 3.4	MLWHF
Gary (2004)[28]	16	16	67 ± 11	69 ± 11	0	0	Weekly home visits	1. Age > 50 years 2. Females 3. Diagnosis of diastolic HF 4. Medically optimized for 3 months	12 weeks (3 times weekly) Walking Initially at 40% of target heart rate for 20 minutes, eventually 60% for 30 minutes	93.7% -- No events	6MWT 10.8 ± 7.5 vs. 10.7 ± 7.5	MLWHF
Gary-CBTex	18	17	65.8 ± 13.5	65.8 ± 13.5	41.9	41.9	Weekly home visits	1. EF > 15% 2. Diagnosis of HF	12 weeks (3 times weekly)	88.89% 85%	6MWT 13.3 ± 7.3 vs.	MLWHF

(2010)[29] *								3. On GMDT 4. Hamilton Rating Scale for Depression >11 5. Positive results for Mini International Neuropsychiatric Interview in last 6 months	Walking Walking 20% above baseline intensity, keeping rate of perceived exertion below 15 on 20-point Borg scale	No events	12.9 ± 8.8	
Gary-Ex (2010)[29] *	20	17	65.8 ± 13.5	65.8 ± 13.5	41.9	41.9	Weekly home visits	1. EF > 15% 2. Diagnosis of HF 3. On GMDT 4. Hamilton Rating Scale for Depression > 11 5. Positive results for MiNI in last 6 months	12 weeks (3 times weekly) Walking Walking 20% above baseline intensity, keeping rate of perceived exertion below 15 on Borg scale	100% 82% No events	6MWT 12.5 ± 8.1 vs. 12.9 ± 8.8	MLWHF
Safiyari-Hafizi (2016)[30]	20	20	57.8 ± 8.1	58.9 ± 6.9	75	70	Weekly contact by telephonic calls, internet or fax	1. Age 45-75 years 2. EF < 40% 3. Peak oxygen uptake < 69% predicted of age 4. NYHA I-III (stable) 5. Stable dose of medication	12 weeks (3-5 times weekly) Home-based walking at high intensity exercise at 80-85% of Vo2 peak followed by active recovery at 40-50% of Vo2 peak depending upon initial functional capacity Strength exercises	-- 77 ± 20% No events	CPET 10.1 ± 3.1 vs. 10.1 ± 2.8	MLWHF
Jolly (2009)[31]	84	85	65.9 ± 12.5	70.0 ± 12.5	76.2	72.9	Home visits at 4, 10 and 20 weeks	1. EF < 40% 2. NYHA II-IV 3. Stable for 4 weeks	6 months (5 times weekly) Walking	54% 100% --	ISWT 9.9 ± 7.2 vs. 9.3 ± 7.6	MLWHF

								4. On optimal medical therapy 5. Not high-risk for HBCR	Intensity of walk was set at 70% of peak oxygen uptake during ISWT with goal of 5 times every week for 20-30 minutes with Borg breathlessness scale of 3 or rate of perceived exertion 12-13 on Borg scale Resistance training with 10 repetitions of 8 exercises			
Lang (2018)[32]	25	25	71.8 ± 9.9	76.0 ± 6.6	36	56	1. Face-to-face visit initial 2. Telephone calls x 2 during study period	1. Age > 21 2. EF > 45%	6 months Daily exercise Progressive exercise training delivered as walking or chair-based exercises through DVD	90% -- No events	ISWT 8.8 ± 8.5 vs. 8.1 ± 7.1	MLWHF
Norman (2012)[33]	20	20	63.0 ± 3.4	56.0 ± 2.7	60	55	Weekly visit with healthcare professional	1. Age > 21 2. Resting EF < 40% 3. On Optimal medical therapy for 30 days 4. Alert and oriented x3 5. No language barrier (speak and read English)	24 weeks (3 times weekly) Aerobic exercises at 40 to 70% of heart rate reserve or rate of perceived exertion at 11-14 on Borg scale Resistance training 8-10 exercises for one set of 10 to 15 repetitions, twice weekly	90.9% 73% --	6MWT 14.3 ± 6.3 vs. 13.1 ± 6.8	KCCQ
Oka (2000)[34]	12	12	60 Range (30-76)	60 Range (30-76)	---	---	Weekly telephonic call Additional face-to-face meeting during regular clinic visit	1. Age > 30 years 2. Diagnosis of HF > 3 months 3. EF < 40%	3 months (3 times weekly) Walking at 70% of heart rate reserve for 40-60 minutes	-- 110% of prescribed aerobic, 87% of	CPET 18.4 ± 4.0 vs. 19.0 ± 3.7	---

								4. On optimal medical therapy for 2 months 5. Medically stable at enrollment	Resistance training for up to 40-60 minutes twice weekly	upper body and 75% of lower body resistance sessions at 3 months No events		
Passino (2008)[35]	71	19	61 ± 2	63 ± 2	87.3	73.7	Monthly visit to training center	1. EF < 45% 2. Exercise capacity < 25 ml/kg/minute	9 months (3 times weekly) Cycling on bike Cycling at 65% of peak Vo2 for a minimum of 30 minutes	97.3% -- --	CPET 14.8 ± 0.6 vs. 14.7 ± 1.1	---
Piotrowicz (2015)[36]	77	34	54.4 ± 10.9	62.1 ± 12.5	85.3	93.9	Daily telephonic call	1. Diagnosis of HF for at least 3 months 2. EF < 40% 3. NYHA class II/III 4. Clinically stable for at least 4 weeks 5. On optimal medical therapy 6. Can participate in exercise	8 weeks (5 times weekly) Nordic Walk Initially walking for 10-20 minutes at 40-70% heart rate reserve, then 45-60 minutes later	100% 94.7% (>80% of prescribed sessions) No events	CPET/6MWT 16.1 ± 4.0 vs. 17.4 ± 3	SF-36
Fayazi (2013)[37]	30	30	60.9 ± 9.0	61.8 ± 9.0	90	90	Daily telephonic calls	1. Age 40-75 years 2. HF diagnosis > 6 months 3. EF < 40% 4. NYHA class II/III 5. Stable on cardiac medications for at least 6	8 weeks (3 times weekly) Home walking Walking for 20 minutes under instruction on self-monitoring of symptoms, level of exertion	-- -- --	6MWT 13.5 ± 6 vs. 14.4 ± 6.7	MLWHF

								months	and exercise-related problems in 1- page brochure (not available for review)			
Wall (2010)[38]	9	10	69.0 ± 4.4	70.0 ± 4.0	66.7	50	Not clearly delineated, but patients received home visits and telephonic calls	1. HF with NYHA I-III 2. Systolic HF with EF <60% 3. Completion of 3 minutes on modified Bruce Protocol on exercise test 4. Physical approval 5.	12 months (3 times weekly) Treadmill walking Minimum of 15 minutes on treadmill based on individual symptom severity	88.% -- No events	METs 12.0 ± 0.6 vs. 10.2 ± 0.8	CHFQ
Gary (2012)[39]	12	12	59 ± 11	61 ± 10	58.3	41.7	Weekly home visits for initial 8 weeks, then weekly telephone calls and additional home visit at 10 weeks	1. EF > 15% 2. Diagnosis of HF for > 6 months 3. Clearance by attending cardiologist to enroll	12 weeks (3 times weekly) Walking and Resistance training Initially walking at 50% of heart rate reserve, eventually 70% of heart rate reserve for 30 to 60 minutes	100% 83% for walking sessions, 99% for resistance training sessions No events	6MWT 13.3 ± 6.8 vs. 12.0 ± 7.7	KCCQ
Peng (2018)[40]	49	49	66.3 ± 10.5	66.3 ± 10.5	57.1	61.2	Weekly telephonic contact via Wechat or QQ software	1. Age > 18 years 2. Diagnosis of HF for at least 3 months 3. NYHA I-III 4. Clinically stable on optimal medical therapy for at least 4 weeks 5. Ability to use Wechat or QQ software via a smart phone	24 weeks (3 sessions for 5-8 weeks, then 5 times weekly) Walking, Jogging Aerobic exercises at 40-70% of heart rate reserve for 10-14 minutes initially, 20-24 minutes later Resistance exercises	85.7% -- No events	6-MWT 14.3 ± 5.2 vs. 14.3 ± 5.2	MLWHF

								6. Ability to understand and speak Chinese				

HBCR: Home-based cardiac rehabilitation, UC: Usual care, SD: Standard deviation, HF: Heart failure, EF: Ejection fraction, NYHA: New York Heart Association, GDMT: Guideline directed medical therapy, CPET: Cardiopulmonary exercise test, 6WMT: 6-miute walk test, ISWT: Incremental shuttle walk test, METs: Metabolic equivalents, MLWHF: Minnesota Living with Heart Failure, HFFSI: Heart failure functional symptom inventory, SF-36: Short form 36, KCCQ: Kansas City Cardiomyopathy Questionnaire, CHFQ: Congestive heart failure questionnaire.

* Study did not report baseline characteristics for intervention and control group separately

Study did not report baseline age for intervention and control group separately

Table S4. Studies Comparing Hybrid Cardiac Rehabilitation versus Usual Care.

Author (Year)	Size		Age (Years) (Mean ± SD)		Sex (Male) (%)		Follow-Up Protocol for Hybrid CR during training Estimated Prescribed Sessions at CBCR (%)	Inclusion Criteria	Duration (Exercise Frequency) Exercises Aerobic Exercise Prescription	Completion Rates (%) Prescribed Sessions Attended (%) Safety of Hybrid CR	Baseline Functional Capacity (Mean ± SD) Peak Oxygen Uptake (ml/kg/minute) Hybrid CR vs. UC	Quality of Life Assessment
	Hybrid	UC	Hybrid	UC	Hybrid	UC						
Babu (2011)[41]	15	15	56.7 ± 10.5	58.7 ± 10.8	86.7	66.7	Weekly telephonic call --	1. Not clearly reported, but NYHA II-IV	8 weeks (twice daily) Walking and Resistance training Initially, 5-10 minutes for rate of perceived exertion 3-4/10 At home, they walked 30-40 minutes twice for rate of perceived exertion 4-6/10 Resistance training with 5 reps of 2 sets initially to 8 sets later Breathing exercises	93.3% -- No events	6MWT 14.8 ± 7.8 vs. 12.1 ± 7.7	SF-36
Gielen	10	10	55 ± 2	53 ± 3	100	100	Twice weekly	1. NYHA II/III	6 months	100%	CPET	---

(2003)[42]							visits to training center 19.78%	2. EF < 40% 3. Clinically stable for 3 months 4. Optimal medical management for at least 3 months	(40-60 mins.[a], 20 mins.[b] daily) Bicycle ergometry Biking at HR at 70% of Vo2 peak for 20 minutes at least with weekly walking and calisthenics for 60 minutes	-- --	20.3 ± 1.0 vs. 17.9 ± 1.6	
Hambrecht (1995)[43]	12	10	50 ± 12	52 ± 8	100	100	Twice weekly visits to training center 37.91%	1. EF <30% by echo or 40% by radionuclide scintigraphy 2. Physical Work capacity of > 25 Watts without myocardial ischemia 3. Clinically stable for 3 months 4. Willingness to participate in study for at least 6 months 5. Residence within 25 kilometer radius of training center	6 months (40-60 mins.[a], 40 mins.[b] Daily) Bicycle ergometry Biking at 70% of Vo2 peak for 40 minutes at least with weekly walking and calisthenics for 60 minutes	75% -- No events during exercise	CPET 17.5 ± 5.1 vs. 17.9 ± 5.6	---
Hambrecht (1998)[44]	10	10	54 ± 4	56 ± 3	100	100	Twice weekly visits to training	1. Documented diagnosis of HF	6 months (60 mins.[a], 40 mins.[b]	90% 69.7 ± 9.0%	CPET 18.3 ± 1.2 vs.	---

							center 27.67%	2. EF < 40% 3. Physical Work capacity of > 25 Watts without myocardial ischemia 4. Clinically stable for 3 months	(5xday) Bicycle ergometry Biking at 70% of Vo2 peak for 40 minutes at least with weekly walking	No events	17.6 ± 1.4	
Hambrecht (2000)[45]	36	37	54 ± 9	55 ± 8	100	100	Weekly visit to training center 20.87%	1. Documented diagnosis of HF 2. EF < 40% 3. Physical Work capacity of > 25 Watts without myocardial ischemia 4. Clinically stable for 3 months	6 months (40-60 mins.[a], 40 mins.[b]/day) Bicycle ergometry Biking at 70% of Vo2 peak for 20 minutes at least with weekly walking	86.1% 60% No events	CPET 18.2 ± 3.9 vs. 17.7 ± 4.5	---
Hollriegel (2016)[46]	18	19	60 ± 3	60 ± 2	100	100	Weekly visit to training center 21.91%	1. Documented diagnosis of HF with NYHA class IIIb 2. EF < 30% and LVEDD >60 mm on echo 3. On Optimal medical therapy 4. Clinically stable for 2 months and peak oxygen uptake <	12 months (60 mins.[a], 40 mins.[b]/day) Bicycle ergometry Biking at 60% of Vo2 peak for 20 to 30 minutes at least with weekly walking and calisthenics for 60 minutes	70% 70% 1 hospitalization due to hypoglycemia during exercise	CPET 15.3 ± 0.8 vs. 15.4 ± 0.9	---

								20ml/kg/minute				
Linke (2005)[47]	12	11	55 ± 2	52 ± 3	100	100	Weekly visit to training center 20.88%	1. Documented diagnosis of HF 2. EF < 40% 3. Physical Work capacity of > 25 Watts without myocardial ischemia 4. Clinically stable for 3 months	6 months (40-60 minutes/ day) Bicycle ergometry Biking at 70% of Vo2 peak for 20 minutes at least with weekly walking and calisthenics for 60 minutes	91.7% -- No events	CPET 19.0 ± 0.8 vs. 17.5 ± 1.5	---
Sabelis (2004)[48]	16	13	59.6 ± 8.3	59.6 ± 8.3	100	100	Twice weekly visits to training center 50%	Not reported	6 months (2 times weekly) Cycle ergometry Work phases of 30s alternating with 60s recovery phase for 10 cycles at 50% of maximum short-term exercise capacity on a steep-ramp test. Stretching and resistance training exercises	100% >80% No events	CPET 21.4 ± 4.9 vs. 19.9 ± 4.9	---
Smolis-Bak (2015)[49]	26	26	60.0 ± 8.1	65.1 ± 8.2	96.1	84.6	Daily telephonic call	1. NYHA class III 2. EF < 35%	3 months (5 times weekly)	30.8% --	CPET 13.0 ± 2.3 vs.	Nottingham Health

							27.27%	3. Planned implantation of CRT-D device 4. Controlled HTN, DM and medical problems 5. Can participate in exercise treadmill test 6. Absence of complex arrhythmias	Dynamic and isometric exercises of small and large muscle groups Breathing exercises Range of motion exercises	No events	10.7 ± 3.2	Profile

UC: Usual care, SD: Standard deviation, CR: Cardiac rehabilitation, HF: Heart failure, EF: Ejection fraction, NYHA: New York Heart Association, LVEDD: Left ventricular end-diastolic dimensions, CRT-D: Cardiac resynchronization therapy-defibrillator, HTN: Hypertension, DM: Diabetes mellitus, CRT-D: Cardiac Resynchronization therapy-defibrillator, CPET: Cardiopulmonary exercise test, 6WMT: 6-miute walk test, MLWHF: Minnesota Living with Heart Failure, HFFSI: Heart failure functional symptom inventory, SF-36: Short form 36, KCCQ: Kansas City Cardiomyopathy Questionnaire, CHFQ: Congestive heart failure questionnaire, GDMT: Guideline directed medical therapy.

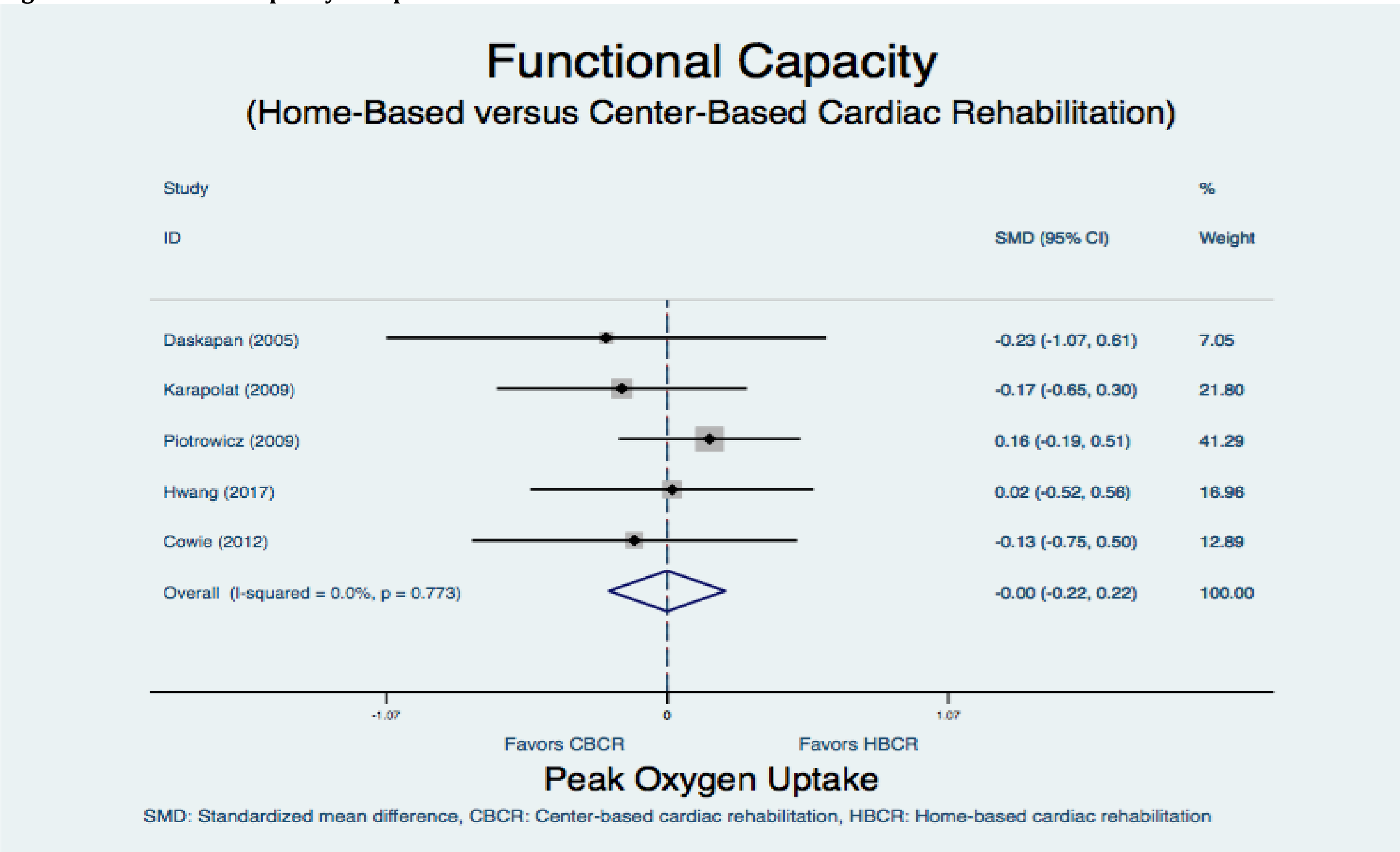
Table S5. Studies Comparing Home-Based and Center-Based Cardiac Rehabilitation.

Author (Year)	Size		Age (Years) Mean ± SD		Sex (Male) (%)		Follow-up Protocol for HBCR during training	Inclusion Criteria	Duration (Exercise Frequency) Exercises Exercise Prescription in HBCR group	Completion Rates (%) Prescribed Sessions Attended (%) Safety of HBCR	Baseline Functional Capacity (Mean ± SD) Peak Oxygen Uptake (ml/kg/minute) HBCR vs. CBCR	Quality of Life Assessment
	HBCR	CBCR	HBCR	CBCR	HBCR	CBCR						
Daskapan (2005)[50]	11	11	49 ± 11	52 ± 8	72.7	72.7	1. Weekly phone calls 2. Biweekly face-to-face	1. NYHA class II/III 2. EF ≤ 40% 3. HF for ≥ 3 months	3 months (3 times weekly) Walking Walking at 60% of peak heart rate during stress for 30 minutes or rate of perceived exertion 12-14 on Borg scale	73.33% 81% vs 97% --	CPET 21.9 ± 5.8 vs. 19.8 ± 7.6	----
Karapolat (2009)[51]	36	32	44.1 ± 11.5	45.2 ± 13.6	62.2	65.6	1. Weekly phone calls 2. Weekly face-to-face	1. NYHA class II/III 2. EF ≤40% 3. Clinical stable for ≥ 3 months 4. HF from ischemic and dilated cardiomyopathy 5. Absence of psychiatric illness 6. Optimal medical therapy 7. No language barrier (Turkish)	8 weeks (3 times weekly) Treadmill walking Walking at 60-70% of Vo2 peak, 60-70% of heart rate reserve and 13-15 Borg scale Stretching exercises Breathing exercises	97.3% 87.5% vs 90% No events	CPET 17.5 ± 6.1 vs. 17.9 ± 4.4	SF-36 (8 component)
Piotrowicz (2010)[52]	75	56	54.6 ± 10.9	60.5 ± 8.8	85.3	94.6	1. Daily phone contact 2. Daily ECG	1. HF diagnosis for ≥ 3 months 2. EF ≤ 40%	8 weeks (Once daily)	100% --	CPET/6MWT 17.8 ± 4.1 vs.	SF-36

							transmission to center	3. NYHA class II/III 4. Clinically stable on optimal medical therapy for at least 4 weeks 5. Able to participate in exercise training	Walking Walking at heart rate reserve of 40-70% (20 bpm lower than ventricular tachycardia detection threshold) or rate of perceived exertion <12 on Borg scale	No events	17.9 ± 4.4	
Hwang (2017)[53]	24	29	68 ± 14	67 ± 11	79.2	72.4	1. Two video conference sessions weekly	1. Diagnosis of chronic HF by either echocardiography or clinical symptoms/signs 2. Adult ≥ 18 years	12 weeks (5 times weekly) Aerobic exercises 40 minutes on 9-13 rate of perceived exertion on Borg scale via audiovisual telerehabilitation system Strength exercises	100% 71% (>80% sessions) No events	CPET/6MWT 12.9 ± 7.3 vs. 13.7 ± 7.4	MLWHF
Cowie (2011)[27]	20	20	65.5 Range (35-82)	71.2 Range (59-85)	90.0	80.0	1. Biweekly phone calls	1. Diagnosis of HF 2. Clinically stable for one month 3. Optimal medical therapy 4. Followed by heart failure nurse service	3 months (2 times weekly) Circuit training for aerobic exercise 40-60% of heart rate reserve based on initial exercise capacity (Ten 90-second exercise stations per circuit, performed twice)	75% 77% vs. 86% --	ISWT 10.9 ± 7.7 vs. 12.1 ± 8.0	SF-36 (2 component)

HBCR: Home-based cardiac rehabilitation, CBCR: Center-based cardiac rehabilitation, SD: Standard deviation, ECG: Electrocardiogram, NYHA: New York heart association, EF: Ejection fraction, HF: Heart failure, VO2max: Peak oxygen uptake, CPET: Cardiopulmonary exercise test, 6WMT: 6-miute walk test, ISWT: Incremental shuttle walk test, SF-36: Short form 36, MLWHF: Minnesota Living with Heart Failure.

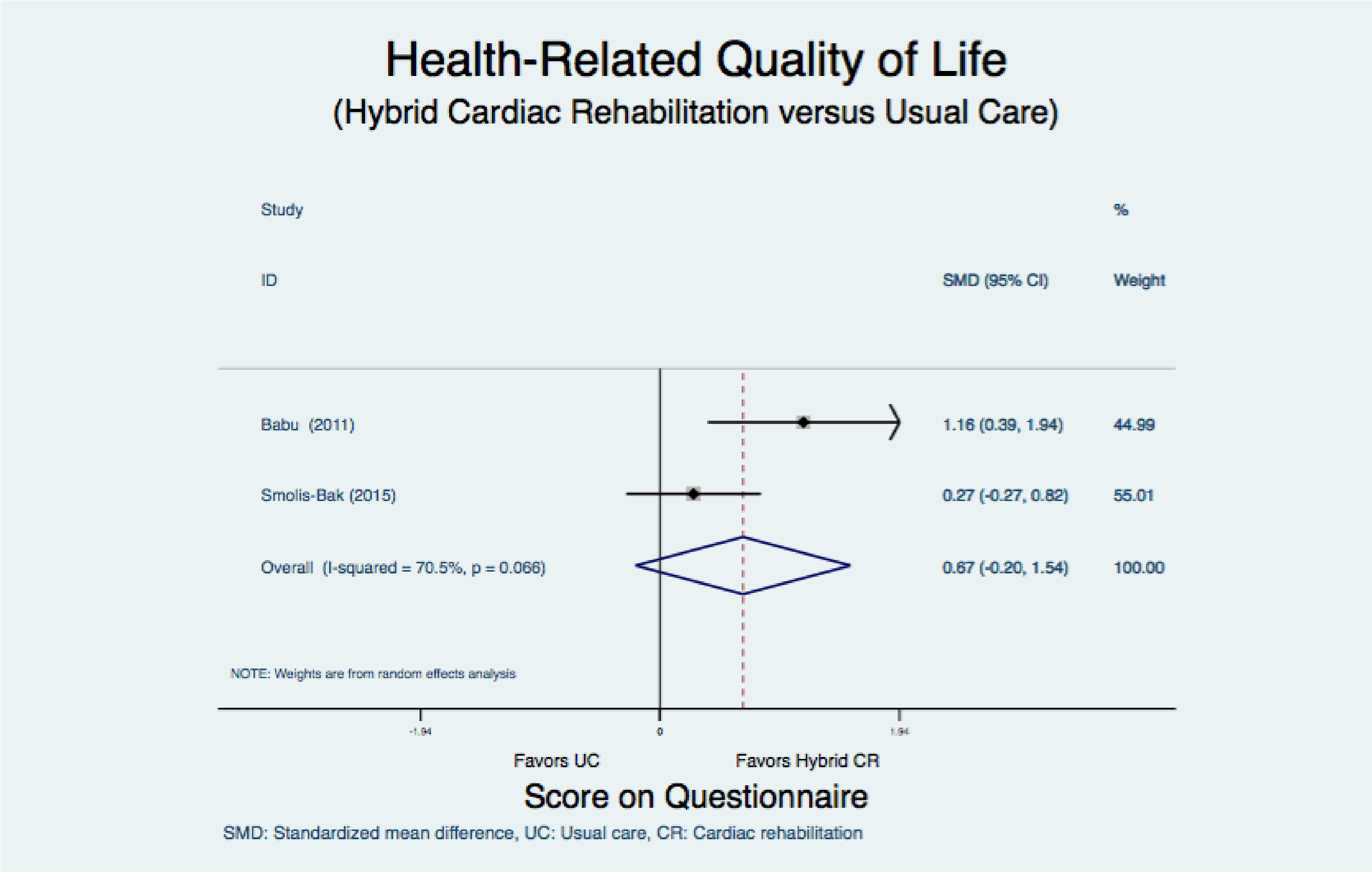
Figure S1. Functional Capacity Comparison between Home-Based and Center-Based Cardiac Rehabilitation.



No significant difference was found in functional capacity between home-based (HBCR) versus center-based (CBCR) Cardiac rehabilitation.

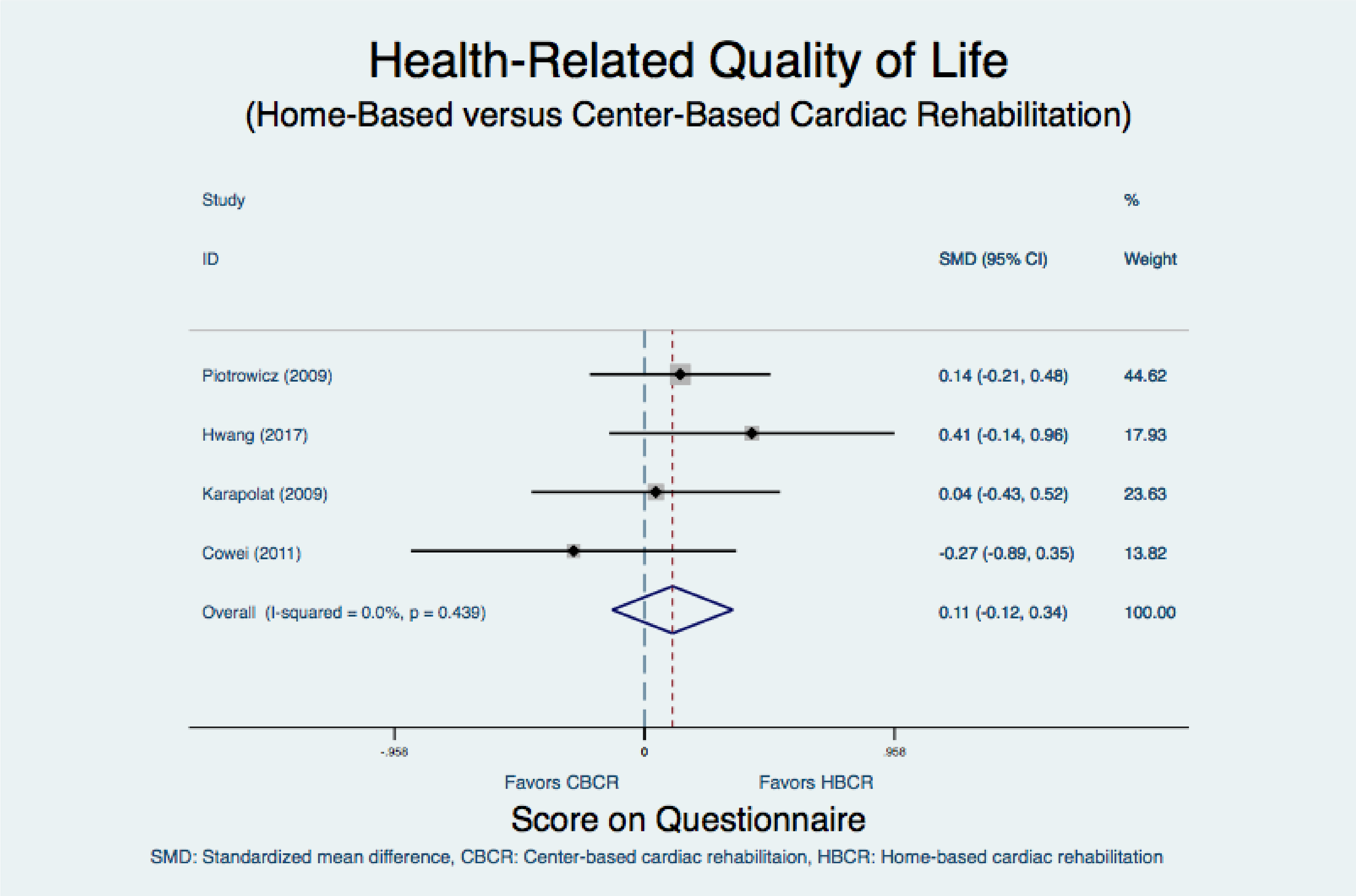
1 SMD = 8.68 ml/kg/minute in oxygen uptake

Figure S2. Health-Related Quality of Life Comparison between Hybrid Cardiac Rehabilitation and Usual Care.



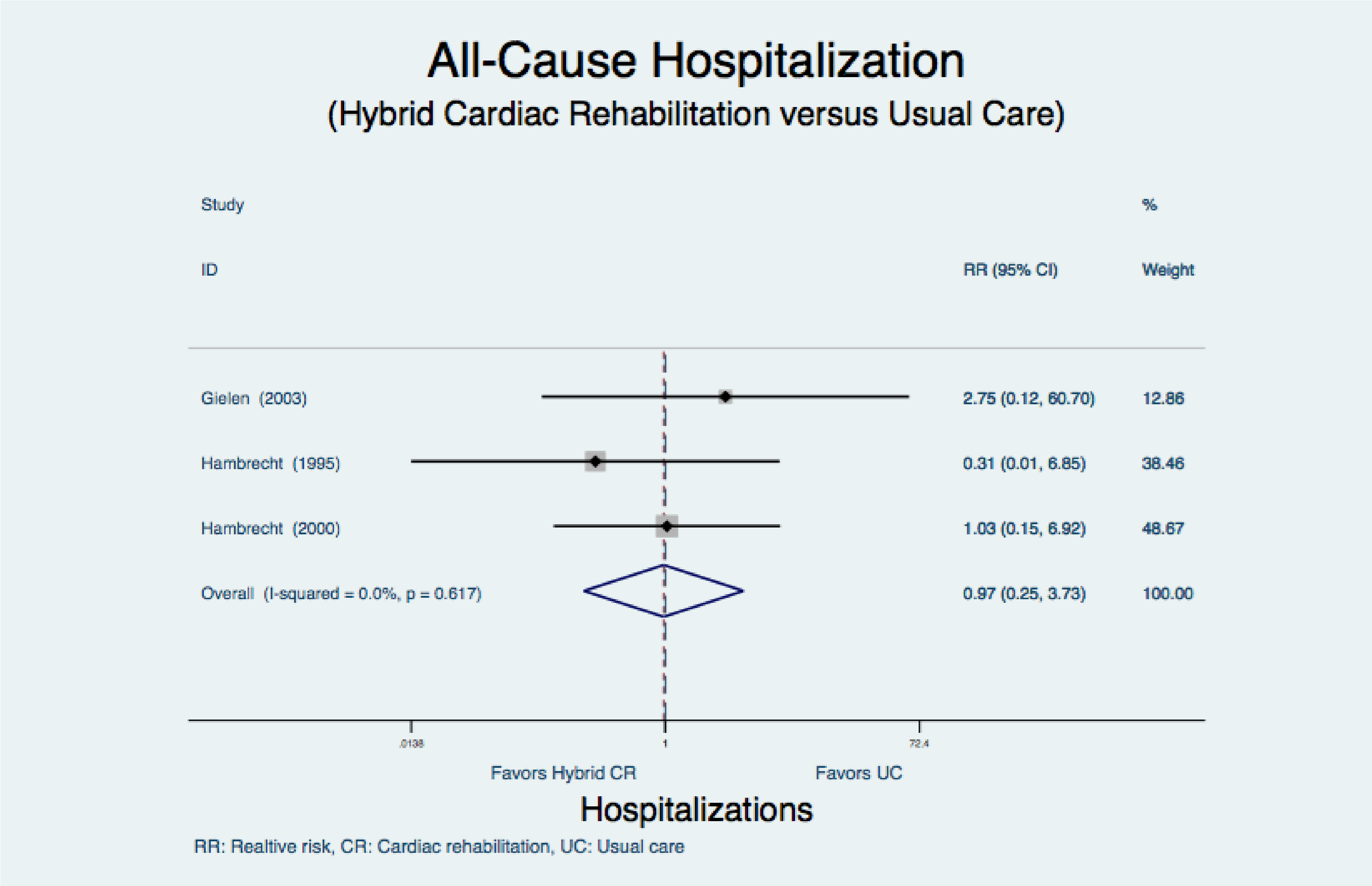
Hybrid Cardiac rehabilitation (CR) did not significantly improve health-related quality of life versus usual care.

Figure S3. Health-Related Quality of Life Comparison between Home-Based and Center-Based Cardiac Rehabilitation.



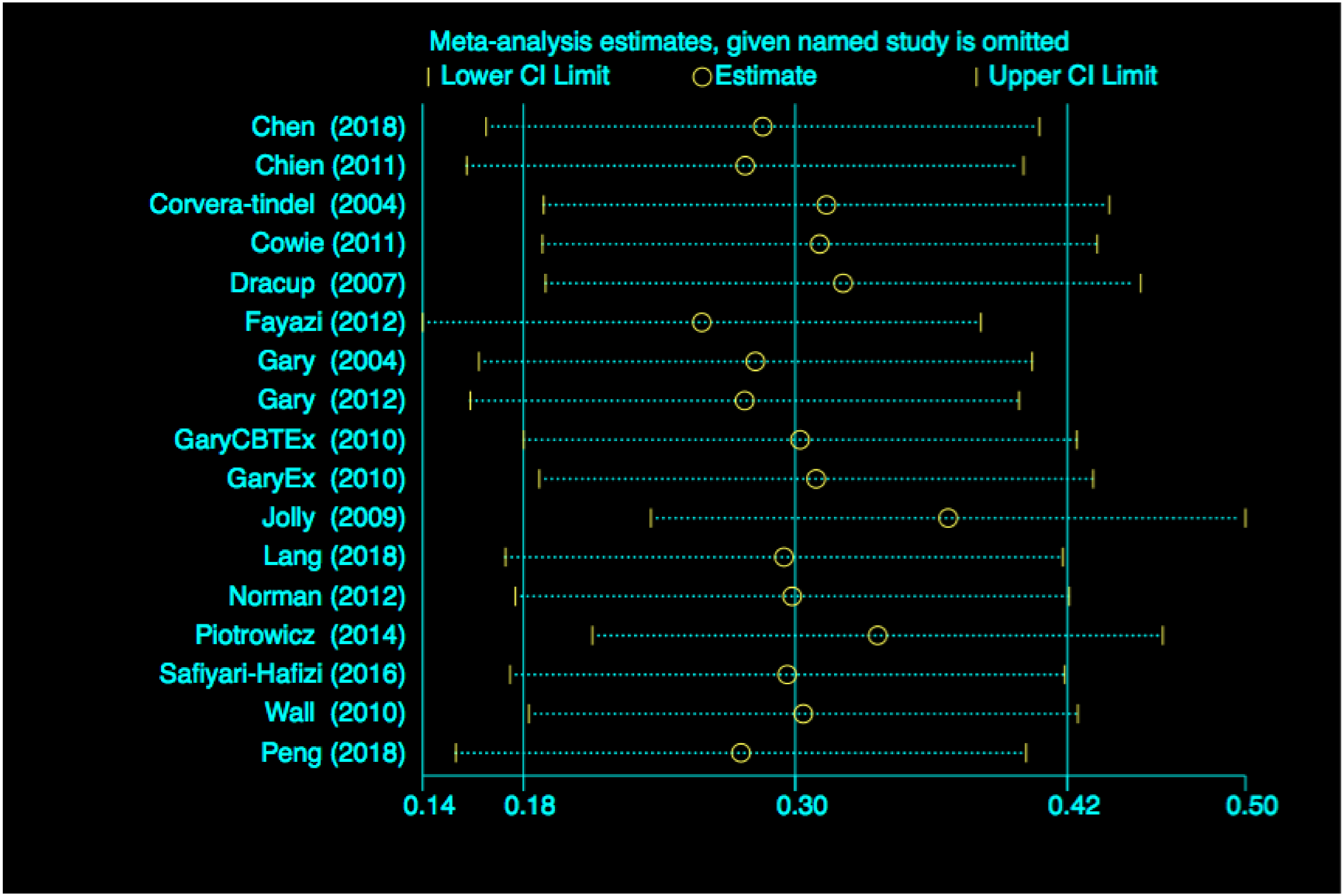
No significant difference was found in health-related quality of life between home-based (HBCR) versus center-based (CBCR) Cardiac rehabilitation.

Figure S4. All-Cause Hospitalization Comparison between Hybrid Cardiac Rehabilitation and Usual Care.



There was no difference in all-cause hospitalization between Hybrid cardiac rehabilitation (CR) and usual care.

Figure S5. Influence Analysis of Health-Related Quality of Life Between Home-Based Cardiac Rehabilitation and usual Care.



This figure showed that no single study influenced results in favor of home-based cardiac rehabilitation.

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