Title: Informing behaviour change intervention design using Bayesian meta-analysis: physical activity in heart failure

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**Protocol:**

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**Availability of data, code and other materials:**

https://github.com/AliyaAM/bayes_meta

It is made available under a CC-BY-NC 4.0 International license.
Abstract

Embracing the Bayesian approach, we aimed to synthesise evidence regarding barriers and enablers to physical activity in HF in a way that can inform behaviour change intervention development. This approach helps in concluding on the uncertainty in the evidence and facilitates the synthesis of qualitative and quantitative evidence. Qualitative and observational studies investigating barriers and enablers to physical activity in adults diagnosed with HF were included in a Bayesian meta-analysis. Evidence from three qualitative and 16 quantitative studies was synthesised. Qualitative evidence was annotated using Theoretical Domains Framework and represented as a prior distribution using an expert elicitation task. The maximum a posteriori probability (MAP) and Credible Intervals (CrI) was calculated as a summary statistic for the probability distribution of physical activity conditioned on each determinant, according to qualitative evidence alone and qualitative and quantitative evidence combined. Evidence concerning the modifiable barriers and enablers is highly uncertain: social support (MAP=0.11, CrI=[0.08;0.13]), negative attitude (MAP=0.22, CrI=[0.17;0.27]), positive attitude (MAP=0.27, CrI=[0.23;0.31]), self-efficacy (MAP=0.31, CrI=[0.29;0.33]), symptom distress (MAP=0.21, CrI=[0.18;0.24]). The contextual barriers – low, moderate and high uncertainty respectively – are age (MAP=0.22, CrI=[0.22;0.23]), low Left Ventricular Ejection Fraction (MAP=0.20, CrI=[0.19;0.22]), and depression (MAP=0.14, CrI=[0.12;0.16]). This work extends the limited research on the modifiable barriers and enablers for physical activity by individuals living with HF.

Keywords: physical activity, heart failure, Bayesian meta-analysis, behaviour change, barriers and enablers, Theoretical Domains Framework.
Word count: 5949 words, 15 pages.

Excluding abstract, figures, tables, references

Three tables.

Six figures.

Supplements:

1. Detailed Inclusion criteria. The scope of the review: pi(e)cos and spider
2. Search strategy.
3. Statistical analysis.
4. The citations for the included studies.
5. The citations for the studies that were excluded but appear to meet the inclusion criteria (with reasons for exclusion).
6. Studies that appear to meet the inclusion but were excluded (with the reasons for exclusion).
7. Physical activity assessment across studies.
8. Individual studies risk of bias.
9. Checklist: criteria for evaluating studies employing Bayesian statistics (1).
10. PRISMA checklist: https://prisma.shinyapps.io/checklist/.
Introduction

Heart Failure (HF) is a complex clinical syndrome of symptoms that suggest reduced efficiency with which the heart pumps blood around the body (2). It is a prevalent condition worldwide (3) and in the UK (2) affecting 2% of the population.

Physical activity is associated with improved quality of life (4–7), reduced hospitalisation (6) and increased longevity (8,9) in individuals living with HF. Therefore, regular physical activity is a key component of recommended treatment (10). While the minimal clinically important difference in physical activity levels in HF is not known (11,12), the recommendation for older adults, in general, is to perform a minimum of 75–150 minutes per week of moderate-intensity aerobic physical activity and engage in functional balance and muscle strength training at a moderate intensity at least three days a week (13).

A structured form of physical activity – exercise – is included in cardiac rehabilitation (CR) and is offered to newly diagnosed HF patients (2). However, uptake of CR programmes is less than 1% among individuals diagnosed with HF (14). Levels of everyday physical activity in HF are also low (15,16), partially due to the many challenges individuals with HF face in initiating and maintaining a physically active lifestyle, as proposed by the European Society of Cardiology (17). Understanding how best to improve physical activity in individuals living with HF is warranted.

There is emerging evidence that behaviour change interventions (18) and interventions based on a behaviour change theory (19) addressing physical activity are potentially promising for promoting physical activity in individuals living with HF. However, only a small number of theories have been applied in the development of existing interventions to improve physical activity in HF (18). These were Motivational Interviewing (20); a combination of Self-Determination Theory, Common-Sense Model, and Control Theory (21); Cognitive Behavioural Therapy (22); Social Cognitive Theory alone (23,24); and in combination with the Transtheoretical Model of Change (25). The extent to which a theory informed interventions was limited (18).

Guidelines for developing behaviour change interventions recognise that the modifiable and contextual barriers and enablers need to be systematically identified and described to inform intervention design (26–31). Knowledge about relevant determinants increases the intervention's chances to be effective and conserves research effort and resources (26,29). Systematically identified evidence concerning modifiable and contextual barriers and enablers can guide theory choice and therefore inform behaviour change intervention design.
However, the factors influencing physical activity participation in individuals living with HF are not well understood. A systematic review of qualitative studies found a lack of research on individual accounts of barriers and enablers to physical activity in individuals living with HF (19). The review reported sparse summaries about physical activity extracted from the studies that elucidated beliefs and personal accounts of living with HF in general, including physical activity only as one of many themes (19). The following enablers: knowledge of risks and benefits associated with physical activity (e.g., reduced mortality and morbidity, and improved quality of life); confidence in one's ability to engage in physical activity; anticipated outcomes of physical activity; and social support, as well as a barrier such as weather, were previously identified in a systematic narrative review (19). However, these barriers and enablers have not been confirmed in quantitative studies. The review highlighted the need to explore further what influences physical activity in HF (19).

A recent paper called for the adoption of Bayesian statistics in Health Psychology research (1,32–34), which might be useful in understanding the contextual and modifiable determinants influencing physical activity in HF. The Bayesian approach views evidence synthesis as a decision-making process (35); new evidence is considered in light of existing evidence, beliefs, and practices. Beliefs are often presented in the form of qualitative research. Qualitative research is readily available from research studies on health and health management; however, its findings are not utilised in healthcare decision-making and policy development (35). Qualitative research provides rich data, but the required formal systematic evaluation impedes the inclusion of qualitative evidence in decision-making and policy development (35). This makes it difficult for qualitative evidence to inform policy-making (35). It is also recommended to account for stakeholders' needs – the needs of those living with HF in this instance – in research concerning intervention development (26). While Bayesian methods provide an opportunity to incorporate qualitative evidence in decisions about health management (36). Therefore, Bayesian methods are useful when evidence from diverse sources needs to be synthesised.

However, to perform Bayesian synthesis, qualitative research should be formally and systematically catalogued before it can be integrated with quantitative findings, which is often not straightforward (35). Theoretical Domains Framework (37) is a tool developed through an international collaborative effort that systematically describes domains and constructs that may influence behaviour under investigation. The identified physical activity barriers and enablers in HF were categorised in accordance with the TDF. In addition, a model developed from a systematic synthesis of behaviour change frameworks – COM-B (38) – was used to inform future behaviour change interventions targeting physical activity in HF. In particular, following the consensus on the link between barriers and enablers and the strategies (39), several strategies (i.e., behaviour change techniques, BCTTv1 (40)) that are likely to amplify the identified relevant enablers or tackle the barriers were proposed.
Objectives

The present review and meta-analysis aim to systematically integrate qualitative and quantitative evidence on the clinical, environmental, and psychosocial barriers and enablers influencing physical activity in those living with HF. The secondary aim, which is a response to the recent call (1,32–34), is to apply the Bayesian approach in synthesising evidence regarding barriers and enablers to physical activity in HF in a way that can inform behaviour change intervention development.

Method

The meta-analysis was implemented adhering to guidance on conducting systematic reviews and meta-analyses of observational studies of aetiology, COSMOS-E (41). The review is reported following PRISMA 2020 guidelines. The review's protocol was registered on PROSPERO: CRD42021232048.

Eligibility criteria

Qualitative and observational studies investigating any clinical, environmental, social, or psychological barriers and enablers to physical activity in adults diagnosed with HF were included in this review (supplement 1).

Information sources

A total of 14 online databases were searched from inception to 05 January 2020 (Embase, Global Health, HMIC Health Management Information Consortium, MEDLINE; PsychINFO; CINAHL; Health policy reference centre; PsychARTICLES; PubMed; The Cochrane Library; Academic search complete, Pedro). The reference lists of the obtained articles included at full-text screening were hand searched for relevant studies meeting the inclusion criteria. In addition, ClinicalTrial.gov was searched for observational studies but yielded no results.

Search strategy

The MeSH terms and keywords describing the Population of interest (i.e. HF and nine synonyms combined using a Boolean operator ‘OR’) and Outcome of interest (i.e. physical activity and 21 synonyms combined using a Boolean operator ‘OR’) were combined using a Boolean operator ‘AND’ (supplement 2). The initial search yielded 11,678 hits (11,678). For practical reasons, the search results were further restricted to peer-reviewed articles in English.

Selection process

Two reviewers (AA and LT) independently screened abstracts and selected articles meeting the criteria for full-text screening in Rayyan. Qualitative studies meeting the eligibility criteria informed the prior elicitation task (i.e. appraisal by a panel of experts). Quantitative studies were included in the frequentist meta-analysis. The results of the elicitation task and the frequentist meta-analysis were combined in the Bayesian meta-analysis.
Data collection process

Two reviewers (AA and LT) independently extracted relevant data items from the reports of the included studies.

Data items

The Strengthening the Reporting of Observational Studies in Epidemiology items, STROBE (42) were utilised to design the data extraction form (supplement 3).

Study risk of bias assessment

Two reviewers (AA and LT) independently assessed the study-level risk of bias present in the included quantitative studies. The following sources of bias were considered: selective reporting, participant selection, missing data (including non-respondents and dropouts), confounding (measured and unmeasured confounds; time-varying confounds in cohort studies), and outcome definition and measurement (i.e. information bias) (41). Due to the lack of a comprehensive risk of bias tool designed specifically for observational studies (43), three instruments were used jointly: the Appraisal tool for Cross-Sectional Studies (AXIS), Working Group Item Bank (WGIB), and Risk Of Bias In Non-randomised Studies - of Interventions (ROBIN-I; (43–45). The ROBIN-I item concerning the randomisation procedure was omitted; an "intervention" was substituted with "exposure".

Summary measures

Standardised mean differences (SMD) were estimated to describe the impact of exposure on the levels of physical activity as follows: (a) cross-sectional assessment of the differences between the group presenting with a characteristic and the group not presenting with a characteristic (e.g. female = 1; male = 0); (b) pre-post-assessment of physical activity in a cohort study before and after an event of interest (e.g. SMD between physical activity outcome before surgery and after surgery); cross-sectional assessment of differences between exercise compliant and non-compliant participants on a range of continuous variables (e.g. SMD in self-efficacy between compliers and non-compliers). The cut-off points used to define exercise compliance were noted for each study. In studies reporting categorical variables, the two upper bound categories and one lower bound category were used as an effect size estimate and integrated into the frequentist meta-analysis. The r-z transformation was applied in the frequentist meta-analysis of coefficients to mitigate heterogeneity in measurements across studies. The Hartung-Knapp (Sidik-Jonkman) adjustment was made for the evaluation to mitigate small sample size bias (46).

For the Bayesian meta-analysis, the maximum a posteriori probability (MAP) estimate and credible Intervals were calculated as a summary statistic for the probability distribution of physical activity conditioned on each determinant, according to qualitative evidence alone (i.e., prior) and qualitative and quantitative evidence combined (i.e., posterior).
Synthesis methods

Bayesian meta-analysis (36) was conducted in R (Figure 1). Bayesian updating was performed to obtain the probability of physical activity in HF conditioned on each barrier or enabler separately (35). Detailed statistical analysis is reported in supplement 3. When the barrier/enabler was described in both qualitative and quantitative studies, then Bayesian updating was performed twice, Procedure 1 (Figure 2). First, evidence for physical activity in the general HF population (i.e., hyperprior) described in Jaarsma et al. (15) was updated with evidence concerning a barrier/enabler from qualitative studies (i.e., prior). The qualitative evidence was synthesised using the Theoretical Domains Framework (37). Then, a prior elicitation task was developed to capture experts’ (N = 6) beliefs about the probability distribution for physical activity conditioned on the constructs identified relevant in qualitative evidence (i.e. informative prior). A prior elicitation task is described in supplement 3. This then was updated with quantitative evidence concerning this barrier/enabler (i.e., likelihood). When solely qualitative evidence was available, only the first step was completed (Procedure 2). Likewise, when a barrier or enabler was assessed solely in quantitative studies, only the second step was performed (Procedure 3).

Applying findings to intervention development

The identified modifiable barriers and enablers were mapped onto TDF (47) and COM-B (38). Accordingly, several corresponding strategies (i.e., behaviour change techniques, BCTTv1 (40)) that are likely to amplify these enablers or tackle the barriers were proposed following the consensus on the link between barriers and enablers and the strategies (39).

Reporting bias assessment

To assess the impact of the qualitative evidence on the findings of this meta-analysis, we performed sensitivity analysis by excluding the qualitative evidence.

Certainty assessment

The uncertainty in the evidence was expressed using Credible Intervals (CrI) and visually, in the form of the distribution dispersion, for each barrier or enabler separately.

Results

Study selection

The search results are summarised in Figure 3. A total of 9026 titles and abstracts and 80 full-text articles were screened. Nineteen studies cited in supplement 4 (N = 2739) were included in the review, Figure 3. Studies that might appear to meet the inclusion criteria but were excluded, as well as the reasons for exclusion, are reported in supplement 5.
Study characteristics

Studies were conducted in the United States of America (n=8), United Kingdom (n=3), Netherlands (n=2), Sweden (n=2), Australia (n=1), Germany (n=1), Taiwan (n=1), and South Korea (n=1). The majority of the included studies were of a cross-sectional design (n=7, Table 1). The average sample size for quantitative and empirical qualitative studies were 150 and 17, respectively. Physical activity operationalisation and assessment methods are reported in supplement 6. The mean age of the participants was 63.44 years old (SD = 8.39, median = 62.15, IQR: [59.5; 68]). The Left Ventricular Ejection Fraction (LVEF, %) was moderately low (mean = 34.52%, SD=9%). Overall, the majority of samples in the included studies were homogeneous.

Risk of bias in studies

The risk of bias across the included studies is reported in Figure 4. The low overall risk of bias was present in 12 (75%) studies, moderate – in three (18.75%) studies (Alosco et al., 2012; Chien et al., 2014; Corvera-Tindel et al., 2004), and serious – in one study (Evangelista et al., 2001). One (6.25%) study was exposed to a serious risk of reporting bias, as only statistically significant results were reported (Evangelista et al., 2001). A total of nine (56.25%) studies did not have a pre-registered protocol, and therefore no information on the bias in the selection of reported results was available. The measurement bias caused by the dichotomisation of the age variable was present in two (12.50%) studies (Evangelista et al., 2001; Evangelista et al., 2003). Participant selection bias was present in one (6.25%) study (Klompstra et al., 2018). Out of four prospective (25%) studies, only one (6.25%) controlled for time-confounding variables by matching participants in exposed and unexposed groups (Moreno-Suarez et al., 2019). Only three (18.75%) studies were exposed to low risk of bias attributed to confounding; two matched participants (i.e., by gender and severity of the disease) when assessing differences in exposed and unexposed groups (Evangelista et al., 2003; Moreno-Soarez et al., 2019), and one measured appropriate confounding variables (Klompstra et al., 2018). The study-level risk of bias assessment is reported in supplement 7.

Results of synthesis

Qualitative evidence

The qualitative evidence synthesis and results are detailed in supplement 3. One theme, 'Losing one's social role in daily life', was annotated as Social, Professional Role and Identity. It captured how the loss of participants' social network and position in society negatively influenced their engagement in physical activity (Pihl et al., 2011). A theme, 'Need of finding practical solutions in daily life' (Pihl et al. 2011), was classified into Behavioural Regulation and summarised the need for effective problem solving that enabled integration of physical activity in daily life with ease (supplement 3). One study (Tierney et al., 2011b) identified the relevance of the following domains: Environmental Context & Resources, Social Influences, Knowledge (supplement 3). Overall, the following barriers and enablers influencing physical activity performance by individuals living with HF were found uniquely in qualitative evidence: Social, Professional Role and Identity, Environmental Context and Resources, Behavioural Regulation, according to three included qualitative studies (Tierney et al., 2011a; Tierney et al., 2011b, Pihl et al., 2011).
The determinants that were reported by both qualitative and quantitative studies were: age, perceived symptoms of HF, functioning, comorbidity, negative attitude, positive attitude, social support, and self-efficacy. In qualitative studies, the influence of ageing processes was described as 'Changing Soma' (Beliefs about Capabilities) (Tierney et al., 2011b). Perceived symptoms of HF were described as 'Fluctuating health' (Beliefs about Consequences) which impacted physical activity participation (Tierney et al., 2011b). Positive attitude toward physical activity in qualitative studies described as 'Mental Outlook' (Belief about Consequence) (Tierney et al., 2011b), and negative attitude toward physical activity in the included qualitative study described as 'Negative emotional responses', (Emotion/Optimism (Tierney et al., 2011a), social support was described as 'Interpersonal Influences' (Social Influences) (Tierney et al., 2011a), and self-efficacy as 'Not believing in one's ability' (Beliefs about Capabilities) (Pihl et al., 2011). These qualitative findings informed the expert elicitation task (supplement 3).

**Frequentist meta-analysis results**

The findings, the number of studies assessing the identified constructs, and the assessment method of both physical activity and the construct are reported in Table 2. In the meta-analysis including univariate associations (r-z coefficient, 95% CI), the following determinants were significantly and negatively correlated with physical activity levels: age, comorbidity, depression, and HF-diagnosis duration (Table 2). Positive attitude toward physical activity, physical functioning, 6-minute walking test, perceived symptoms, and self-efficacy were significantly and positively correlated with physical activity (Table 2). In the meta-analysis of differences (SMD, 95% CI), the following barriers to physical activity were identified: being employed, Left Atrial Volume index (LAV; l/m2), perceiving higher social support in managing HF, and living with a partner (Table 2).

Individuals living with HF who adhered to the recommendations to walk for at least 225 minutes of per week had a significantly larger mean PeakV02, mean HF diagnosis duration (years), and comorbidity score (Charlston Comorbidity Index, CCI), than those who did not (Table 2). Individuals with low levels of physical activity (average daily accelerometry units = 5077 ± 1154) had significantly worse renal function (estimated glomerular filtration rate, eGFR, ml/min), higher doppler estimated filling pressure, and reduced Quality of Life (KCCQ scale, Table 2) than those with high levels (average daily accelerometry units = 15287 ± 4821). Individuals who had a Left Ventricular Assist Device (LVAD) implanted had significantly higher daily energy expenditure than those who did not have an LVAD (404.1±169.1 kcal/d-1 for the LVAD group and 222.5 ± 163.4 kcal/d), Table 2.

**Bayesian meta-analysis results**

The relative probability of physical activity conditioned on the identified barriers and enablers is described in Figure 5 and Figure 6.

Contextual barriers

the Bayesian meta-analysis identified the following contextual barriers – with low, moderate, and high uncertainty, respectively – age (MAP = 0.22, CrI: [0.22;0.23]), low Left Ventricular Ejection Fraction (MAP...
Older age (>70) and low LVEF (<35%) reduced the probability for physical activity in HF, \( MAP_{PA|HF, Age>70} = 0.221 \) and \( MAP_{PA|HF, LVEF<35\%} = 0.202 \), respectively. Depression, measured using HADS-D CES-D and PROMIS-29, reduced the probability for physical activity in HF by twofold (MAP\(_{PA|HF, Depression} = 0.140\) vs MAP\(_{PA|HF} = 0.32\)). High pro-b-type natriuretic peptide, pro-BNP and low LAV reduced the probability for physical activity by twofold, \( MAP_{PA} = 0.142 \) and \( MAP_{PA} = 0.150 \), respectively. Having an implantable device (LVAD, MAP = 0.395), high doppler estimated filling pressure (MAP = 0.403), and high 6-minute walking test result (meters, MAP = 0.347), as well as a diagnosis of HFrEF (vs HFpEF, MAP = 0.399), were identified as enablers of physical activity in HF. However, evidence was highly uncertain (Figure 5).

### Modifiable barriers

Evidence concerning the modifiable barriers and enablers is highly uncertain: social support (MAP = 0.11, CrI: [0.08;0.13]), negative attitude (Emotion/Optimism, MAP = 0.22, CrI: [0.17;0.27]), positive attitude (Belief about Consequence, MAP = 0.27, CrI: [0.23;0.31]), and self-efficacy (MAP=0.31, CrI: [0.29;0.33]), and symptom distress (Emotion, MAP = 021, CrI: [0.18;0.24]).

### Reporting biases

**Sensitivity analysis results**

The results of the sensitivity analysis are summarised in Figure 6. Qualitative and quantitative evidence concerning the probability of physical activity conditioned on social support (Social Influences) contradicted each other (Figure 6). While social support (Social Influences) in managing HF was elicited as an enabler in qualitative evidence (i.e., expert elicitation task), it was found to reduce the probability for physical activity in a quantitative study (Gallagher et al., 2011), where it was measured using the social support index (high levels of perceived social support vs low levels of perceives social support) developed as part of the study (Gallagher et al., 2011). However, the results concerning other barriers and enablers identified in both sources of evidence (qualitative and quantitative) were not substantially different to each other (Figure 6).

### Applying findings to intervention development

Table 3 reports barriers and enablers identified in qualitative evidence that need to be further investigated in quantitative studies (high uncertainty) and barriers and enablers supported in quantitative evidence with low or moderate uncertainty and the behaviour change strategies that may be useful in addressing them.

### Certainty of evidence

There is relatively low uncertainty (reflected in narrow Credible Intervals (CrI) and low dispersion of the probability distribution, Figure 5) in qualitative and quantitative evidence suggesting that older age (>70 years old) is a considerable barrier to physical activity in HF. There is moderate uncertainty in the evidence from quantitative studies suggesting that low LVEF (%) and depression are both barriers. However, the
evidence concerning other barriers and enablers is highly uncertain (reflected in wide Credible Intervals (CrI) and high dispersion of the probability distribution, Figure 5).

Discussion

This review aimed to identify, describe, and compare contextual and modifiable barriers and enablers to physical activity in HF using a Bayesian approach. Both qualitative and quantitative studies were included in this review and meta-analysis. This work extends the limited research on the modifiable barriers and enablers for physical activity participation by individuals living with HF. Evidence concerning the modifiable barriers: negative attitude and symptom distress; and enablers: social support, positive attitude, self-efficacy is highly uncertain. The contextual barriers supported by the evidence are age, low Left Ventricular Ejection Fraction, and depression with low, moderate, and high uncertainty, respectively.

Contextual barriers and enablers

This review identified the following contextual barriers: age, depression, and low LVEF (<30%). Older age is a barrier to physical activity in HF, as suggested by both qualitative and quantitative evidence. This result further reiterated the finding of a meta-analysis (18) that older adults living with HF need more support to attain higher physical activity levels.

Depression lowered the probability of physical activity as identified by the quantitative evidence. Depression is a large burden in the HF population. It is associated with poor adherence to pharmaceutical treatment (48) and is an independent predictor of morbidity (49). The physiological determinants perpetuating depression in HF include inflammation, blood cell abnormalities, CNS changes and changes in health-protective behaviours (50). The association between depression, HF, and lack of physical activity is complex. Like any cardiovascular disease, HF is a consequence of low physical activity in clinically depressed individuals (51). More research investigating the mechanism via which depression impacts physical activity in HF is needed.

The review findings concerning employment are in accord with a qualitative semi-structured interview study with a non-clinical sample of adults transitioning to retirement, which found that retirement is perceived as providing opportunities to become physically active (52). On the other hand, authors also reported that this was not always the case, and an individualised approach may be required (52). Similarly, a national survey of 1550 adults aged 60-69 in England in 2007 reported that work commitments and lack of leisure time were major barriers to physical activity (53). Context, social norms surrounding physical activity in older age may impact how physical activity is enacted in older adults who transitioned to retirement (54,55).

The diagnosis of HFrEF and its duration may engender a higher risk of physical inactivity than the diagnosis of HFPpEF However, the available evidence is uncertain, and more evidence is needed before drawing any definitive conclusions. Non-cardiovascular comorbidities in HF include Diabetes Mellitus (type 2), chronic
obstructive pulmonary disease (COPD), and renal dysfunction (56). These comorbidities increase both morbidity and mortality in HF (56). A frequent cardiovascular condition that accompanies HF is atrial fibrillation, AF (57). Another clinical barrier identified by the present review is longer HF duration which is likely to result in deterioration of functioning. Another review investigating barriers and enablers to physical activity post coronary artery bypass graft surgery found a lack of evidence concerning enablers of the behaviour; however, the authors suggested that symptoms like pain and fatigue impede physical activity even three months after the surgery (58). Overall, it is likely that symptoms experienced immediately after recovery and longer HF diagnosis duration, as well as multimorbidity, contribute to limited physical activity levels.

Age, depression and low LVEF (%) need to be carefully considered in both future cross-sectional studies and randomised-controlled trials evaluating the mechanism of change. Understanding the contextual determinants influencing behaviour is useful in informing the design of quantitative research studies investigating modifiable determinants influencing physical activity (59). Contextual differences (i.e., age, LVEF, and depression) indicate that different approaches to behaviour change interventions for these subgroups that take into account their unique clinical characteristics and align with the European Society of Cardiology (10) and NICE (2) guidelines are required. The review encourages the consideration of these patient characteristics in the intervention design and its tailoring. However, contextual understanding does not provide insights into what can and needs to be changed for these demographic and clinical subgroups to engage in physical activity. This urges research on modifiable barriers and enablers to physical activity in HF in these subgroups.

Modifiable barriers and enablers

Both qualitative and quantitative evidence included in this meta-analysis suggests that perceived symptoms and negative attitude (Emotion) are relevant barriers. However, the evidence on the modifiable barriers and enablers is highly uncertain. In addition, the evidence concerning social support (Social Influences) is inconclusive when comparing qualitative and quantitative evidence. A quantitative study included in this review assessed differences in physical activity in individuals with high vs low perceived social support in managing their HF and identified that those who perceived more support engaged in physical activity significantly less (Gallagher et al., 2011). On the other hand, qualitative evidence uncovered both positive and negative influences of social support on physical activity levels (Pihl et al., 2011). This included caregivers shielding individuals with HF from any physical activity by assisting in or even overtaking their daily responsibilities. The qualitative evidence identified by this review suggests that activities of daily living, such as climbing stairs, walking, and housekeeping, are vital to individuals living with HF in preserving their physical functioning. However, their family and friends may limit their independence in carrying out these activities (Pihl et al., 2011). There are two likely explanations for this divergence in the evidence. Either quantitative studies require a more nuanced understanding of Social Influences on physical activity in HF, or qualitative research overestimates the impact of Social Influences. Both possibilities should be explored in future research. In comparison, another review of qualitative and quantitative studies on barriers and enablers.
relevant to older adults (65-70 years old) and middle-aged adults (50-64 years old) identified that older adults might rely on social influence, social reinforcement and assistance in managing the change in lifestyle to a greater extent than the middle-aged adults (60). Older adults require social support in managing HF and daily life.

Overall, three domains were identified uniquely in qualitative research: Beliefs about Consequences, Environmental Context and Resources and Behavioural Regulation and Social Professional Role and Identity. According to qualitative evidence alone, individuals living with HF are driven by the motivation to achieve the desired outcome, such as improved health (Beliefs about Consequences). According to qualitative research, the local environment that encouraged physical activity (e.g., parks; Environmental Context and Resources) was fundamental for physical activity enactment. Beliefs about pharmaceutical treatment (necessity and concerns and its impact on physical activity; Environmental Context and Resources) and the need to find practical solutions to overcome limitations in physical activity (i.e. problem solving; Behavioural Regulation) played a crucial role in physical activity, according to the qualitative studies included in this review. While the change in perceived social role, described as a loss of social network and position in society brought about as a result of HF, had negative implications for physical activity (Social Professional Role and Identity). However, these were not followed up with a quantitative study to confirm their relevance in a larger sample. This meta-analysis suggests exploring and confirming the role of these barriers and enablers in quantitative research.

**Study-level limitations**

Currently, there is no gold standard risk of bias assessment for observational studies (43). Therefore, this review included categories of sources of bias traditionally proposed for assessing study-level bias. These include confounding bias, selection bias, measurement bias, missing data bias, and reporting bias (43). These collectively formed the criteria for evaluating the risk of bias across the included studies. Overall, the majority of the studies (75%) were exposed to a low risk of bias. The major source of bias in the included studies is confounding, as the majority of observational studies included in the review (81.25%) did not control for confounding effects when assessing correlates of physical activity.

**Strength and limitations of this review**

The Bayesian approach can enable the comparison of the extent to which a barrier or enabler influences behaviour and helps in concluding on the uncertainty in the evidence. It can be used to inform intervention development with stakeholders’ accounts using qualitative research. The Bayesian approach facilitates the synthesis of qualitative and quantitative evidence. This method also enables situating the evidence regarding barriers or enablers to behaviour in the context of prior evidence. In this study, the probability for physical activity engagement is conditioned on each barrier or enabler is situated in the context of low levels of physical activity in HF.

The present review synthesised evidence from different sources. The prior elicitation task facilitated this. The results of the expert elicitation task were updated with quantitative evidence. Such Bayesian updating of the probability of physical activity in HF conditioned on each construct summarises both qualitative and
quantitative evidence. This approach was first implemented by Dixon-Woods and colleagues (35,61). Dixon-Woods et al. (35,61) advocated for integrating qualitative research in healthcare decision making because it provides valuable insights and places the patient in the heart of care by bringing their perspective into account. However, Roberts et al. (35) highlighted the following shortcoming of using Bayesian meta-analysis. Qualitative research should be formally and systematically catalogued before it can be integrated with quantitative findings, which is often not straightforward. Using the TDF (37) in the present review, we mitigated this limitation.

We have adhered to the criteria for Bayesian research in conducting this review, supplement 8 (1). However, there are three limitations. First, this meta-analysis offered claims about the association, not causality. Second, the prior was elicited using an expert elicitation task with a limited panel of experts. Health psychology researchers appraised qualitative evidence. They then completed a task designed to elicit a prior probability for physical activity conditioned on the constructs identified in the included qualitative studies. While this is an established technique for formalising an informative prior, it is by definition subjective and thus depends strongly on the members of the expert panel (62). In this case, the panel was limited, containing only health psychologists. It would have been beneficial to include other stakeholders such as HF nurses or cardiologists.

Third, while SMD and r-z coefficients were combined appropriately depending on the available data in two different frequentist meta-analyses. For the Bayesian meta-analysis, the available data from each study was converted to a log OR and then pooled in a meta-analysis. This was done so the evidence could be situated in the context of generally low physical activity in HF. An empirical hyperprior was elicited from evidence on physical activity in HF, which was binary – engagement in physical activity (yes/no) among a large sample (15). When performing Bayesian meta-analysis, the choice of a hyperprior is dictated by the objectives and research questions of a study (63–65). In this review, the objective was to compare barriers and enablers in the context of low physical activity in HF. A noninformative prior is much too conservative to be useful for this (66). A noninformative prior would assume that people with HF engage in physical activity as much as any population group, an assumption that is not supported by the available evidence (16). The choice of this empirical hyperprior, while being well-fitted for the objective, resulted in the dichotomisation of the physical activity outcome in the Bayesian meta-analysis (log OR). An alternative would be to obtain continuous data on physical activity in HF from a Biobank and then draw probability distributions for each physical activity level separately (e.g., three probability distributions for performing physical activity at low, moderate, vagarious intensity).

Recommendations for future research and clinical practice

Older adults (>70 years old) living with HF are at risk of low physical activity levels. It is important to explore beliefs about physical activity that are associated with older age. Research informing the development of interventions for this subgroup of the population is needed. The quantitative evidence alone suggests that physical activity probability is reduced in the presence of depression. A better understanding of the mechanism through which depression impacts physical activity in HF and how it can be mitigated is needed. The quantitative evidence on physical activity probability conditioned on other clinical, demographic, and
psychosocial barriers and enablers is uncertain. Research investigating a broad range of clinical, demographic, and psychosocial barriers and enablers to physical activity in HF is warranted.

Social support and self-efficacy to engage in physical activity were identified as considerable enablers according to the qualitative evidence. However, this was not supported by quantitative studies. This indicates that the attributes that define how social support and self-efficacy affect physical activity should be further studied. Finally, less is known about other modifiable determinants of physical activity in HF, which should be addressed in future studies. In addition, identified studies did not explore the mechanism underlying physical activity enactment, including how the barriers and enablers interact, which should be further explored in future research.

Finally, tentative suggestions are made for what a future physical activity intervention needs to include (Table 3). Overall, the review findings indicate that to tackle the barriers and amplify the enablers, a behaviour change intervention containing the following strategies is needed: identity associated with changed behaviour, prompt/cues and adding objects to the environment, behavioural practice/rehearsal, and graded tasks. A previous meta-analysis of randomised controlled trials also suggested that these strategies are associated with the efficacy of interventions (18). In addition, the qualitative evidence included in this review suggests that addressing the change in the social role as a result of acquired HF diagnosis and perceived appropriateness of physical activity in this context need to be addressed. Social Influences, Beliefs about Consequences, Problem Solving, and Emotion via strategies such as social support, information about consequences of the behaviour, problem solving, and reducing negative emotions, may be proven effective in increasing physical activity in HF, according to the present review. However, the latter suggestions need to be considered with caution, considering high uncertainty in the evidence.

Conclusion

The identified contextual barriers and enablers to physical activity in HF need to be carefully considered when designing interventions and randomised-controlled trials evaluating interventions. However, evidence concerning modifiable barriers and enablers that can be addressed in an intervention to improve physical activity in HF is uncertain.

The Bayesian approach in this review enabled comparative predictions about barriers and enablers, helped elicit the extent of uncertainty in the evidence and enabled the combination of qualitative and quantitative evidence in a single synthesis. Thus, the present review supports the usefulness of the Bayesian approach to evidence synthesis concerning barriers and enablers to behaviour and in the development of behaviour change interventions.

Protocol:

The review's protocol was registered on PROSPERO: CRD42021232048

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Availability of data, code, and other materials:

https://github.com/AliyaAM/bayes_meta
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| Author, year       | Country   | Study design                  | Study aims/objective                                                                 | Additional inclusion criteria                                                                 | Sample                  | The summary of the main findings                                                                                                                                                                                                                                                                                                                                                       |
|-------------------|-----------|-------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alosco et al.,    | USA       | A cross-sectional study       | To examine the role of depression in physical activity in HF as assessed using accelerometers. To determine if low physical activity is associated with death and hospitalisation. | Age: 50-85 years old; NYHA class: II and III; without any history of severe neurological disease, injury, sleep apnoea, renal failure and substance abuse | N = 96                  | The number of years of education was significantly associated with a number of steps (b = 0.21, p<0.05) in a simple linear regression. Age, gender, and comorbidities were not identified as significant individual predictors of step count. When adjusted for comorbidity, age was identified as a significant predictor of the daily step count. Comorbidities were not suggested to be associated with the outcome when adjusting for age, gender and education. When adjusting for age, gender, comorbidities and education, the increased depression (BDI-II) was associated with the decreased daily count. |
| 2012              |           |                               |                                                                                      |                                                                                                  |                         |                                                                                                                                                                                                                                                                                                                                                                                      |
| Chien et al.,     | Taiwan    | A prospective observational study | To explore physical activity predictors (as assessed at discharge) one month after discharge. | 75 years old or younger; NYHA class: I-III.                                                                                                     | N = 111                 | 19.12% of daily energy expenditure (DEE) was within low intensity (<three METs), 7.20% within high (3-5 METs), and only 1.42% was intensive (>five METs). BMI, age, self-efficacy for instrumental activities of daily living, and educational level were predictors of total DEE one month after discharge. Self-efficacy for instrumental activities of daily living, gender, and BMI were predictors of high DEE. Age, BMI, and symptom distress were predictors of intensive DEE. |
| 2014              |           |                               |                                                                                      |                                                                                                  |                         |                                                                                                                                                                                                                                                                                                                                                                                      |
| Corvera-Tindel et | USA       | A prospective observational study | To evaluate clinical and psychosocial characteristics                                    |                                                                                                 | N = 39                  | Compliance with the recommendation to walk weekly was associated with higher HF duration, higher comorbidity, lower BMI, and lower hostility                                                                                                                                                                                                                                                   |
| al., 2004         |           |                               |                                                                                      |                                                                                                  |                         |                                                                                                                                                                                                                                                                                                                                                                                      |
| Author, year | Country | Study design | Study aims/objective | Additional inclusion criteria | Sample | The summary of the main findings |
|-------------|---------|--------------|---------------------|-------------------------------|--------|----------------------------------|
| Dontje et al., 2014 | Netherlands | A cross-sectional study | among exercise complaint and non-compliant HF patients. | NYHA class: I and III; with 1-year survival prognosis; without any implantable devices; who have not undergone any surgical interventions; without AF and arrhythmia; without a recent embolism. | Male: not reported | Sig. difference in steps/day between patients within NYHA I-II (median=6113) and patients within NYHA III (median= 3150) (p<0.001); between patients with EF ≤40 (median= 5854) and patients with EF >40 (median=3246) (p<0.05); no significant difference in steps/day between men and women (p=0.389). Steps/day was only significantly correlated to age (Spearman's rho=-0.43) and self-efficacy (Spearman's rho=0.40), but not to other characteristics. NYHA classification, EF, age, and self-efficacy explained 42% of the variance in steps/day (F=8.69; p<0.001) in a linear regression model. |
| Evangelista et al., 2001 | USA | A cross-sectional study | To identify precipitating determinants of self-care noncompliance. | - | <60 y.old: N = 52 (63.4%), Male: N = 51 (62.2%) | Significant correlates of exercise compliance included higher physical (r =0.507) and mental health (r =0.468) and health satisfaction (r = 0.435) lower neuroticism scores (r =—0.317). Age, race, education, and marital status were not significantly associated with physical activity levels. |
| Evangelista et al., 2003 | USA | A case-controlled (matched) cross-sectional study | To describe physical activity differences in older (>70 years old) and Diagnosis duration for over a year | N = 140 | Mean age = 68.59 | The mean compliance score was significantly different between older (>70 y. old) and younger (<70 y. old) adults, 67.14 ± 32.28 and 55.00 ± 29.05, respectively, p= 0.021. |
| Author, year | Country | Study design | Study aims/objective | Additional inclusion criteria | Sample | The summary of the main findings |
|-------------|---------|--------------|----------------------|-------------------------------|--------|--------------------------------|
| Gallagher et al., 2011 | USA | RCT; only the results of the baseline assessment were included in this review | To determine the types and level of social support in HF provided by partners; to evaluate the impact of the partner's social support levels on self-care behaviours compared to an individual without partners on HF. | Not scheduled for or underwent any surgical interventions in the past six months | Male: N = 94 (67%) | The extent of regular exercise ('I exercise regularly': 5-point Likert scale) between groups with low social support (no partner), medium, and high was significantly different, mean = 2.95 (SD=1.28), mean = 2.81 (SD=1.27), mean = 2.41 (SD=1.29), respectively. The authors concluded that not having a partner did not significantly change physical activity levels in individuals with HF. However, the perception of low social support vs high social support did. |
| Klompstra et al., 2018 | Sweden | A cross-sectional study | To evaluate the mediating role of exercise self-efficacy on the relationship between motivation and physical activity. | With life expectancy not shorter than six months | Male: N = 220 (66%) | Exercise motivation significantly predicted physical activity in a bivariate linear regression (b = 0.58, p = .02). After controlling for exercise self-efficacy, the effect of exercise motivation on physical activity was zero (b = 0.76, P = .06). Authors concluded that self-efficacy fully mediated the effect of motivation on physical activity. Age (b = -0.03, P = .22), and NYHA class (b = -0.41, P = .46) did not predict the amount of physical activity. |
| Author, year       | Country    | Study design                        | Study aims/objective                                                                 | Additional inclusion criteria | Sample | The summary of the main findings                                                                                                                                                                                                 |
|-------------------|------------|-------------------------------------|---------------------------------------------------------------------------------------|------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lee et al., 2016  | South Korea| A cross-sectional study             | To describe the relationships between physical functioning, physical activity, exercise self-efficacy, and QOL in individuals with CHF. | -                            | N = 116| Correlations between physical activity and self-efficacy, quality of life, age, income, education, and LVEF were assessed. Physical activity significantly and negatively correlated with age ($r = -0.194$, $p<0.01$) |
| Moreno-Soarez et al., 2019 | Australia  | A case-controlled prospective study (well-matched patients with a Left Ventricular Assist Device (LVAD) versus well-matched patients with CHF, but no LVAD) | To describe daily PA levels in patients with LVAD support compared with well-matched participants with advanced CHF without LVAD support. | Without hypertension | Unexposed: Mean age: 58.3 (SD=8.7), Male: N = 26 (81%) | Exposed: Mean age: 59.1 (SD = 10.8), Male: N = 26 (81%) | In a matched for age (±5 yr.), sex, and New York Heart Association (NYHA) class, cohort study, participants with a fitted LVAD had higher levels of energy expenditure than individuals with HF who were not fitted with the device, 404.1 ± 169.1 kcal/d ay and 222.5 ± 163.4 kcal/day, respectively. |
| Oka et al., 1996  | USA        | A cross-sectional study             | To describe the relationship between Knowledge, attitudes and beliefs, and physical activity levels in HF patients. | Diagnosis duration for at least 23 months; without obstructive valvular disease; congenital heart disease; and tachycardia pacemakers; severe pulmonary hypertension | N = 43 | The association between physical activity and physical fitness (peak VO2); Knowledge, attitudes, and beliefs including self-efficacy for general activity, perceived exertion during daily activity; and marital status) was assessed. Self-efficacy ($p = 0.015$) was the strongest predictor of physical activity. |
| Author, year         | Country   | Study design                                      | Study aims/objective                                                                 | Additional inclusion criteria                                                                 | Sample                  | The summary of the main findings                                                                 |
|----------------------|-----------|--------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------|-----------------------------------------------------------------------------------------------|
| Pihl et al., 2011    | Sweden    | Phenomenological analysis of qualitative interviews | To describe qualitatively how individuals with HF conceived their limitations in daily life activities. | A stratified recruitment strategy to obtain variation in the sample in terms of gender, age, place of residence, education, and NYHA class. | N = 15          | The study supported the relevance of the following domains to physical activity in HF: Knowledge, Social/Professional Role and Identity, Beliefs about Capabilities, Beliefs about Consequences, Goals (low relevance), Memory, attention and decision processes (low relevance), Social Influences, Emotion, and Behavioural Regulation. |
| Pozehl et al., 2018  | USA       | RCT; only the results of the baseline assessment were included in this review | To describe physical activity levels (using accelerometry), operationised as MVPA or EE; to determine the proportion meeting the recommended levels of physical activity; to describe determinants associated with physical activity. | Coronary artery bypass surgery, or biventricular pacemaker less than six weeks prior; participation in 3 times per week aerobic exercise in the past eight weeks; plans to move more than 50 miles from the exercise site within the next year; peak oxygen uptake (pVO2) in females > 21 ml/kg/min and in males > 24 ml/kg/min; and pregnancy planned or current. | N = 204                 | The MVPA (mins/day) was significantly higher in males (than females p < 0.01), Caucasians than non-Caucasian (p < 0.05), those within NYHA class II compared to those within NYHA class III. The higher Charlson comorbidity index and PROMIS anxiety score were significantly associated with a higher level of MVPA. The ejection fraction was not significantly correlated with MVPA. |
| Snipelisky et al., 2017 | USA       | RCT; only the results of the baseline assessment were included in this review | To describe the relationships between daily activity with clinical features and standard HF assessments (NYHA class, 6MWD, HF QOL scores and NT-proBNP) at baseline and the relationship between changes in activity and changes in standard HF assessments with ISMN. | Patients were eligible for study participation if they had NYHA class II-IV were at least 50 years of age. They had preserved (≥50%) EF who attributed inactivity to HF-related symptoms as assessed using a screening questionnaire. | N = 110              | Participants in the group with the lower daily accelerometer units were more likely to have had HF hospitalisation, orthopnea, diabetes and anaemia, be treated with beta-blockers, have higher EF, relative wall thickness and left atrial volume and worse NYHA class, HF specific quality of life (QOL) scores, six-minute walk distance (6MWD) and NT-proBNP (p<0.05 for all). |
| Author, year          | Country | Study design                      | Study aims/objective                                                                 | Additional inclusion criteria                                                                 | Sample       | The summary of the main findings                                                                                                                                 |
|-----------------------|---------|-----------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tierney et al., 2011a | UK      | A narrative review of qualitative studies | To summarise the findings of interview studies on living with HF that concern beliefs about physical activity. | Qualitative studies (n=20) aiming to describe HF beliefs and accounts of living with HF          | N = 306 (average = 15) | Mean age not reported, Male: not reported. The review identified sparse summaries about physical activity from the studies that elucidated beliefs and personal accounts of living with HF in general, including physical activity only as one of many themes. The reported beliefs supported the relevance of the following domains: Knowledge, Social/professional role and identity, Beliefs about capabilities, Beliefs about Consequences, Goals (medium relevance), Environmental context and resources, Social influences, Emotion. |
| Tierney et al., 2011b | UK      | A qualitative semi-structured interview study | To explore why individuals with HF do and do not engage in regular physical activity. | -                                                                                                 | N = 22       | Mean age not reported, Male: not reported. Changing Soma The reported beliefs were coded into the following domains: Knowledge, Social/Professional Role and Identity, Beliefs about Capabilities and Having realistic expectations about the future was coded into Beliefs about Consequences. Also, Mental outlook theme was coded as Optimism/Emotion (medium relevance), Goals (low relevance), Environmental context and |
| Author, year         | Country   | Study design                              | Study aims/objective                                                                                                                                                                                                 | Additional inclusion criteria                                                                 | Sample                                                                                     | The summary of the main findings                                                                                                                                                                                                 |
|---------------------|-----------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| van der Wal et al., | Netherlands| A baseline assessment (cross-sectional)  | To investigate the association between compliance with non-pharmacological recommendations (diet, fluid restriction, weighing, exercise) and outcome in patients with heart failure (HF).                                                                                     | -                                                                                           | N = 830                                                                                       | At baseline assessment, the participants who did not adhere to the exercise recommendation were older, more likely to be female, and have comorbid Atrial fibrillation, diabetes, stroke, and previous HF admission. Depressive symptoms and Knowledge were negatively associated with compliance to exercise recommendation. |
| 2006; 2010          |           | from a prospective study investing clinical outcomes |                                                                                                                                                                                                                   | Mean age = 72 (SD = 11), Male: N = 300.6 (60%)                                                                                                    |                                                                                              |                                                                                                                                                                                                                                    |
| Werhahn et al.,     | Germany   | A prospective observational study        | To evaluate the feasibility and usability of a mobile application designed to enhance self-management.                                                                                                             | Newly diagnosed HF                                                                          | N = 10                                                                                        | Everyday physical activity (the MDSC captured by built-in pedometer functions of smartphone and smartwatch) averaged over 14 days was low following hospital discharge (3612 ± 3311), increased significantly to the first follow-up (6927 ± 4877; P < 0.0001) and to the end of study (7069 ± 5006; P < 0.0001). The MDSC correlated significantly with exercise capacity parameters – the distance in the conventional 6MWT and peak VO2 in CPET. A strong association with patient-reported outcomes in the MLHFQ and KCCQ, especially with the sub-scores representing health-related QoL, HF symptoms, and PA, was observed. |
| 2019                |           | evaluating an intervention; only the results of the baseline assessment were included in this review |                                                                                                                                                                                                                   | Mean age = 46.3 (SD = 7.8), Male: N = 6 (40%)                                                                                                    |                                                                                              |                                                                                                                                                                                                                                    |
| Author, year | Country | Study design | Study aims/objective | Additional inclusion criteria | Sample | The summary of the main findings |
|--------------|---------|--------------|----------------------|-----------------------------|--------|-------------------------------|
| Witham et al., 2006 | UK | RCT; only the results of the baseline assessment were included in this review | Older adults (>70) without ventricular fibrillation, aortic stenosis with peak gradient >30 mm Hg, atrial fibrillation with a ventricular rate of >10 | N = 82 | Mean age = 80.5 (SD = 5), Male: N = 45.1 (55%) | Daily physical activity (accelerometer) was significantly associated with the 6-minute Walking Test (distance in meters). |

Total number of studies: 19

- cross-sectional study = 7 (matched = 3); baseline assessment (RCT) = 4; prospective observational study = 4 (matched = 1); qualitative study = 2; narrative review = 1.

N = 2739
Table 2. Summary of the quantitative evidence, probability of physical activity conditioned on each identified construct according to quantitative evidence alone and qualitative and quantitative evidence combined.

| Construct | Construct and physical activity assessment | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------|-------------------------------------------|--------------|----------------------------------|------------|--------------------------------------|--------------------------------------------------------|
|           |                                           |              | Estimate (SMD or r-z) | 95%CI | Log OR | 95%CI | MAP* | 95%CrI | MAP* | 95%CrI |
| Age       | Years Compliant vs non-compliant with exercise prescription (67–69) | 4 | SMD | 0.49 | [-1.01; 1.99] | -0.41 | [-1.44; 0.62] | 0.221 | [0.217; 0.225] | 0.243 | [0.239; 0.247] |
|           | Daily accelerometry units – lowest tertile vs highest tertile (70) |              |                                |        |        |        |        |        |        |        |
|           | Years Average daily accelerometer units (71) | 7 | r-z | -0.28* | [-0.38; -0.18] | -0.94 | [-1.65; -0.24] | 0.291 | [0.245; 0.339] | 0.232 | [0.194; 0.273] |
|           | Energy expenditure average daily kcal (69,72,73) |              |                                |        |        |        |        |        |        |        |
|           | Steps per day total (74,75), IPAQ scale (76) |              |                                |        |        |        |        |        |        |        |
| Comorbidity | Charlson Comorbidity Index Compliant vs non-compliant with exercise prescription (77) | 1 | SMD | -0.76* | [-1.22; -0.30] | -0.94 | [-1.65; -0.24] | 0.291 | [0.245; 0.339] | 0.232 | [0.194; 0.273] |
|           | Charlson Comorbidity Index Energy expenditure, average daily kcal (73) | 1 | r-z | -0.18* | [-0.31; -0.04] | -0.94 | [-1.65; -0.24] | 0.291 | [0.245; 0.339] | 0.232 | [0.194; 0.273] |
| Social support | High(>9) vs low(<=9) perceived social support scale score The European Heart Failure Self-care Behaviour Scale score (78) | 1 | SMD | -0.42* | [-0.15; -0.68] | 0.76 | [0.26; 1.26] | 0.105 | [0.080; 0.134] | 0.366 | [0.327; 0.406] |
|           | -- Negative Attitude Scale (78) Energy expenditure (average daily kcal) | 1 | r-z | -0.14 | [-0.27; 0.00] | -0.51 | [-1.01; -0.01] | 0.219 | [0.174; 0.266] | 0.222 | [0.178; 0.268] |
| Negative attitude | -- Negative Attitude Scale (78) Energy expenditure (average daily kcal) |              |                                |        |        |        |        |        |        |        |
| Positive attitude | -- Positive Attitude Scale (78) Energy expenditure, average daily kcal (73) | 1 | r-z | 0.27* | [0.02; 0.49] | 1.02 | [0.06; 1.98] | 0.266 | [0.225; 0.309] | 0.330 | [0.287; 0.374] |
|           | Meter/minute | 2 | SMD | 1.00* | [0.49; 1.50] | 1.77 | [1.33; 2.21] | 0.347 | [0.321; 0.374] | 0.352 | [0.326; 0.378] |
| Construct | Construct and physical activity assessment | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------|-------------------------------------------|--------------|---------------------------------|------------|-------------------------------------|--------------------------------------------------|
| Six-minute Walking Test (6MWT) | Compliant vs non-compliant with exercise prescription(77) Daily accelerometry units – lowest tertile vs highest tertile(70) Meter/minute Average daily accelerometer units(71) Energy expenditure (average daily kcal)(73) Steps per day total(79) | 3 | \( r-z \) 0.42* \([ 0.35; 0.49]\) | | | |
| Physical functioning (self-report) | Scale score (MOS SF-36)* Compliant vs non-compliant with exercise prescription(68) Scale score (KCCQ)* Daily accelerometry units – lowest tertile vs highest tertile(70) Scale score (KCCQ)* Energy expenditure and steps per day (73,79) | 2 | SMD 0.67* \([ 0.40; 0.94]\) | Log OR 0.90 \([ 0.54 ; 1.26 \]) | 0.340 \([ 0.303 ; 0.379 \]) | 0.322 \([ 0.287 ; 0.359 \]) |
| Symptoms | -- | -- | -- | -- | -- | -- | |
| KCCQ6, total symptom score Energy expenditure(73) | 1 | \( r-z \) 0.13* \([ 0.03; 0.23]\) | 0.48 \([ 0.11 ; 0.84 \]) | 0.260 \([ 0.236 ; 0.284 \]) | 0.316 \([ 0.292 ; 0.341 \]) | |
| Left Ventricular Ejection Fraction (LVEF), % | Percentage, % Compliant vs non-compliant with exercise prescription(77) Percentage, % Energy expenditure(69,72,73) Steps per day(75,79) | 1 | SMD -0.08 \([-0.17; 0.02]\) | 0.16 \([ -0.48 ; 0.80 \]) | 0.202 \([ 0.185 ; 0.220 \]) | 0.273 \([ 0.254 ; 0.292 \]) | |
| -- | -- | -- | -- | -- | -- | -- | |
| Self-efficacy | An unspecified self-efficacy scale score A single-item exercise scale(76) Self-efficacy scale Energy. Expenditure(72) Self-efficacy scale*score Daily energy expenditure(69) Self-efficacy scale Steps per day, total(75) | 6 | \( r-z \) 0.22* \([ 0.07; 0.36]\) | 0.84 \([ 0.26 ; 1.41 \]) | 0.313 \([ 0.294 ; 0.332 \]) | 0.317 \([ 0.299 ; 0.336 \]) | |
| Construct | Construct and physical activity assessment | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------|------------------------------------------|--------------|----------------------------------|------------|-----------------------------------|-----------------------------------------------|
|           |                                          |              | Estimate (SMD or r-z) 95%CI | Log OR 95%CI | MAP 95%Cr | MAP 95%Cr |
| Self-efficacy scale<sup>12</sup> | Daily physical activity<sup>11/(80)</sup> |              |                              |            |         |         |
| KCCQ self-efficacy score | Energy expenditure, kcal<sup>(73)</sup> |              |                              |            |         |         |
| Presence of clinical depression | Daily activity units – lowest tertile vs highest tertile<sup>(70)</sup> |              |                              |            |         |         |
| Hospital Anxiety and Depression scale (HADS) subscale score | Compliant vs non-compliant with exercise prescription<sup>(77)</sup> | 3             | SMD 0.00 [-0.44 ; 0.44 ] | -0.54 [-1.13 ; 0.05 ] | 0.140 [0.121 ; 0.159 ] | -- -- |
| Centre for Epidemiology Surveys-Depression scale (CES-D) | Compliant vs non-compliant with exercise prescription<sup>(81)</sup> |              |                              |            |         |         |
| HADS score | Total steps/day<sup>(74)</sup> |              |                              |            |         |         |
| HADS score | Accelerometry counts<sup>(71)</sup> | 3             | r-z -0.20* [-0.37 ; -0.02 ] | -0.71 [-1.21 ; -0.21 ] | 0.403 [0.331 ; 0.477 ] | -- -- |
| PROMIS-29 score | Energy expenditure, kcal<sup>(73)</sup> |              |                              |            |         |         |
| Digoxin prescription | Compliant vs non-compliant with exercise prescription<sup>(77)</sup> | 1             | SMD -0.28* [-0.47 ; -0.07 ] | -1.06 [-1.85 ; -0.27 ] | 0.216 [0.150 ; 0.288 ] | -- -- |
| Doppler estimated filling pressure | Daily accelerometry units – lowest tertile vs highest tertile<sup>(70)</sup> | 1             | SMD -0.39* [-0.66 ; -0.12 ] | -0.71 [-1.21 ; -0.21 ] | 0.403 [0.331 ; 0.477 ] | -- -- |
| MAACL emotional dysphoria score | Compliant vs non-compliant with exercise prescription<sup>(77)</sup> | 1             | SMD 0.21 [-0.24 ; 0.65 ] | 0.38 [-0.41 ; 1.17 ] | 0.241 [0.150 ; 0.343 ] | -- -- |

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| Construct | Construct and physical activity assessment                                                                 | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------|---------------------------------------------------------------------------------------------------------------|--------------|---------------------------------|------------|--------------------------------------|-----------------------------------------------|
|           | Estimate (SMD or r-z)                                                                                         | 95%CI        | Log OR                          | 95%CI      | MAPα                                 | 95%CrI                                      | MAPα | 95%CrI |
| Education | Education above junior                                                                                        | 4            | SMD 0.06 [-0.15 ; 0.27]         | 0.17       | 0.288                                | [ 0.266 ; 0.310 ]                           | --   | --     |
|           | Energy expenditure (69)                                                                                       |              |                                 |            |                                      |                                               |      |        |
|           | College or over                                                                                               |              |                                 |            |                                      |                                               |      |        |
|           | Energy expenditure MET/min/week (72)                                                                          |              |                                 |            |                                      |                                               |      |        |
|           | College or over                                                                                               |              |                                 |            |                                      |                                               |      |        |
|           | Compliance rate (68)                                                                                          |              |                                 |            |                                      |                                               |      |        |
|           | Post-secondary degree                                                                                        |              |                                 |            |                                      |                                               |      |        |
|           | Energy expenditure, kcal (73)                                                                                 |              |                                 |            |                                      |                                               |      |        |
| Education | Years Accelerometer, steps per day (74)                                                                        | 1            | r-z -0.06 [-0.24 ; 0.12]        |            |                                      |                                               |      |        |
| Employment| Employment Yes vs no                                                                                        | 2            | SMD -0.43 [-0.82 ; -0.05]       | -0.21      | 0.215                                | [ 0.179 ; 0.253 ]                           | --   | --     |
|           | Energy expenditure (72,73)                                                                                    |              |                                 |            |                                      |                                               |      |        |
| Ethnicity | Ethnicity Caucasian vs non-Caucasian                                                                          | 2            | SMD 0.22 [-0.10 ; 0.54]         | 0.34       | 0.280                                | [ 0.248 ; 0.312 ]                           | --   | --     |
|           | Daily accelerometer units – lowest tertile vs highest tertile (70)                                             |              |                                 |            |                                      |                                               |      |        |
|           | Energy expenditure (73)                                                                                       |              |                                 |            |                                      |                                               |      |        |
| Ethnicity | Years Accelerometer, steps per day (74)                                                                        | 1            | r-z --                         |            |                                      |                                               |      |        |
| HF duration| HF duration Compliant vs non-compliant with exercise prescription (77)                                          | 1            | SMD -0.66 [-1.11 ; -0.20]       | -0.95      | 0.283                                | [ 0.227 ; 0.341 ]                           | --   | --     |
|           | Energy expenditure total (72)                                                                                 |              |                                 |            |                                      |                                               |      |        |
| HFpEF (Yes)| HFpEF vs HFpEF                                                                                                | 1            | SMD 0.00 [-0.19 ; 0.19]         | -0.22      | 0.399                                | [ 0.345 ; 0.454 ]                           | --   | --     |
|           | Energy expenditure, kcal (73)                                                                                 |              |                                 |            |                                      |                                               |      |        |
|           | Years Accelerometer, steps per day (74)                                                                        | 1            | r-z -0.20 [-0.37 ; -0.02]      |            |                                      |                                               |      |        |
|           | Duration, hours/day (79)                                                                                      |              |                                 |            |                                      |                                               |      |        |
| pro-BNP   | pro-BNP                                                                                                                                                     |              |                                 |            |                                      |                                               |      |        |
|           | ng/mL                                                                                                                                                        |              |                                 |            |                                      |                                               |      |        |
|           | Duration, hours/day (79)                                                                                      | 1            | r-z 0.37 [-0.34 ; 0.81]         | -1.16      | 0.142                                | [ 0.094 ; 0.197 ]                           | --   | --     |
|           | MACACL hostility score                                                                                        |              |                                 |            |                                      |                                               |      |        |
| Hostility | Compliant vs non-compliant with exercise prescription (77)                                                    | 1            | SMD 0.43 [-0.02 ; 0.88]         | 0.79       | 0.241                                | [ 0.150 ; 0.343 ]                           | --   | --     |
| Hostility | Years Accelerometer, steps per day (74)                                                                        | 1            | r-z --                         |            |                                      |                                               |      |        |

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| Construct                          | Construct and physical activity assessment | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------------------------------|-------------------------------------------|--------------|----------------------------------|------------|--------------------------------------|----------------------------------------------------------|
|                                   |                                           |              | Estimate (SMD or r-z) | 95%CI | Log OR | 95%CI | MAP | 95%CI | MAP | 95%CI |
| Income                           |                                           |              | SMD | -- | 0.18 | [ -0.44 ; 0.80 ] | 0.252 | [ 0.192 ; 0.317 ] | -- | -- |
|                                   | Above poverty                             | 1            | r-z | 0.05 | [ -0.13 ; 0.23 ] | 1.12 | [ -1.62 ; -0.62 ] | 0.150 | [ 0.101 ; 0.206 ] | -- | -- |
| Left Atrial Volume index (LAV)   | Daily accelerometry units – lowest tertile vs highest tertile (70) | 1            | SMD | -0.61* | [ -0.88 ; -0.34 ] | -0.20 | [ -0.70 ; 0.30 ] | 0.313 | [ 0.246 ; 0.384 ] | -- | -- |
| Left Ventricular Remodelling (LVR) | Relative myocardial wall thickness         | 1            | SMD | -0.11 | [ -0.37 ; 0.16 ] | -0.20 | [ -0.70 ; 0.30 ] | 0.313 | [ 0.246 ; 0.384 ] | -- | -- |
|                                   | Daily accelerometry units – lowest tertile vs highest tertile (70) | --            | r-z | -- | -- | -- | -- | -- | -- | -- |
| Partner                          | Living with a spouse, Yes vs No           | 2            | SMD | -0.50* | [ -0.92 ; -0.08 ] | -0.46 | [ -1.36 ; 0.44 ] | 0.297 | [ 0.273 ; 0.322 ] | -- | -- |
| Marital status                   | Daily energy expenditure (69)             |              | r-z | -- | -- | -- | -- | -- | -- | -- |
| Compliance rate (68)             |                                           |              | -- | -- | -- | -- | -- | -- | -- | -- |
| PeakVO2                          | mL/kg/min                                 | 1            | SMD | 0.79* | [ 0.33 ; 1.25 ] | 1.54 | [ 0.71 ; 2.37 ] | 0.283 | [ 0.193 ; 0.380 ] | -- | -- |
| Compliant vs non-compliant with exercise prescription (77) |                 |              | r-z | 0.57 | [ -0.09 ; 0.88 ] | -- | -- | -- | -- | -- |
| mL/kg/min                        | Steps/day, total (79)                     |              | -- | -- | -- | -- | -- | -- | -- | -- |
| Perceived exertion               | --                                        |              | SMD | -- | -- | -- | -- | -- | -- | -- |
|                                   | IPAQ scale (80)                           |              | r-z | -0.26 | [ -0.52 ; 0.04 ] | -- | -- | -- | -- | -- |
| Quality of Life (QoL)            | KCCQ scale total score                    | 1            | SMD | 0.47* | [ 0.33 ; 0.60 ] | 0.51 | [ 0.11 ; 0.92 ] | 0.243 | [ 0.221 ; 0.266 ] | -- | -- |
|                                   | Daily accelerometry units – lowest tertile vs highest tertile (70) |              | r-z | 0.01 | [ -0.17 ; 0.18 ] | -- | -- | -- | -- | -- |
|                                   | KCCQ scale total score                    | 2            | r-z | -- | -- | -- | -- | -- | -- | -- |
| Construct | Construct and physical activity assessment | Num. studies | Frequentist meta-analysis results | Likelihood | Posterior: quantitative evidence only | Posterior: quantitative evidence and qualitative evidence |
|-----------|-------------------------------------------|-------------|----------------------------------|------------|-------------------------------------|---------------------------------------------------------|
| Renal function | Estimated glomerular filtration rate (eGFR) ml/min Accelerometer units lowest tertile vs highest tertile (70) | 1 | SMD 0.59* [0.32; 0.86] | 1.07 [0.57; 1.57] | 0.216 [0.157; 0.279] | -- |
| Smoking | Smoking (yes vs no) Energy expenditure (72) | 1 | r-z 0.18 [-0.01; 0.35] | 0.66 [-0.05; 1.37] | 0.307 [0.242; 0.375] | -- |
| Symptom distress | MSAS-SF 12Energy expenditure, total daily (69) | 1 | r-z -0.13* [-0.22; -0.03] | -0.46 [-0.82; -0.10] | 0.211 [0.181; 0.243] | -- |

Note. Construct definitions are from the om APA dictionary, NICE (HF), TDF. MAP – Maximum a posteriori probability estimate. The expert-elicited prior distribution is summarised as MAP (Credible Interval), the Beta distribution's shape parameters (ß, œ). The difference in MAP between physical activity in HF (general) and when it is updated with the probability of physical activity conditioned on each construct as informed by the prior elicitation task. Probability of physical activity in HF in general: Pr(PA|HF) = 0.32. The likelihood summarises quantitative evidence as SMD in physical activity (95% CI) between the exposure and control groups; or SMD (95% CI) in physical activity for two categories (e.g. age>70 vs age <70 years old), or SMD (95% CI) in the construct between those meeting the exercise recommendation (compliant) and those not (non-compliant); or/and r-z coefficient (95% CI) for the association between PA and the construct. 1a. MAP summarising the posterior distribution elicited by updating the probability of physical activity in the general HF population (Pr(PA|HF) = 0.32) with quantitative evidence only. 1b. MAP summarising the posterior distribution elicited by updating the probability of physical activity in HF population (Pr(PA|HF) = 0.32) with quantitative and qualitative evidence. 2. The European Heart Failure Self-care Behaviour scale (83). 3. Negative attitude towards physical activity (subscale) (84). 4. Positive attitude towards physical activity (subscale) (84). 5. MOS SF-36 (85). 6. KCCQ – The Kansas City Cardiomyopathy Questionnaire (86). 7. Self-efficacy scale (87). 8. Physical activity in patients scale (88). 9. The Self-efficacy for Physical Activity Scale (89). 10. Self-efficacy scale (87)/Jenkins et al., 1994) 11. Duke Physical activity Index (90). 12. MSAS-SF – The Memorial Symptom Assessment Scale Short Form (91).
| Construct | TDF domain | Mechanisms of Action (MoAs) | Type of evidence | Uncertainty in the evidence | Proposed behaviour change techniques (BCTTv1) | COM-B |
|-----------|------------|----------------------------|------------------|-----------------------------|-----------------------------------------------|-------|
| **CONTEXTUAL BARRIERS** | | | | | | |
| Older age (>70 years old) | - | - | qual and QUANT | low | - | Psychological Capability, Physical Capability |
| low LVEF (<30%) | - | - | QUANT | moderate | - | Physical Capability |
| Depression | - | - | QUANT | high | - | Automatic Motivation |
| **MODIFIABLE BARRIERS AND ENABLERS** | | | | | | |
| Beliefs about ageing | Beliefs about Capabilities | Beliefs about Capabilities | qual | high | Behavioural practice and Rehearsal, Graded tasks, Social comparison, Focus on past success, Verbal persuasion about capability | |
| Social role/self-identity | Social, Professional Role and Identity | Self-image | qual | high | Identity associated with changed behavior, Reframing, Cognitive dissonance | Reflective Motivation |
| Local environment | Environmental Context and Resources | Environmental Context and Resources | qual | high | Adding objects to the environment, Prompts/cues, Avoidance/changing exposure to cues for the behaviour | Physical Opportunity |
| Social support | Social Influences | Social Influences | qual and QUANT (contradictory) | high | Social support (unspecified), Social support (emotional), (Social support practical) | Social Opportunity |
| Outcome expectancies | Beliefs about Consequences | Beliefs about Consequences | qual | high | Information about consequences, Salience of consequences, Feedback on behaviour, Feedback on the outcome of behaviour, Pros and cons, Emotional consequences, Covert sensitisation, Anticipated regret, Comparative imagining of future outcomes, Vicarious reinforcement | Reflective Motivation |
| Self-efficacy | Beliefs about Capabilities | Beliefs about Capabilities | qual and QUANT (contradictory) | high | Behavioural practice and Rehearsal, Graded tasks, Social comparison, Focus on past success, Verbal persuasion about capability | Reflective motivation |
| Problem solving | Behavioural Regulation | Behavioural Regulation | qual | high | Action planning, Self-monitoring behaviour, Problem solving, Goal setting outcome, Feedback on behaviour, Habit formation | Psychological Capability |
| Negative attitude | Emotion/Optimism | Emotion | qual and QUANT | high | Reduce negative emotions, Information about health consequences, Information about emotional consequences | Automatic Motivation |
|-------------------|------------------|---------|----------------|------|--------------------------------------------------------------------------------------------------------|---------------------|
| Positive attitude | **Beliefs about Consequences** | Attitude towards the behaviour | QUAL and qual | high | Information about consequences, Salience of consequences, Feedback on behaviour, Feedback on the outcome of behaviour, Pros and cons, Emotional consequences, Covert sensitisation, Anticipated regret, Comparative imagining of future outcomes, Vicarious reinforcement | Reflective Motivation |

**Note:** 1. Constructs that the reviewers (AA, BV, AC, TF) identified in both qualitative and quantitative studies and only in quantitative studies (quant) are listed in Table 2. Constructs that were identified in qualitative studies only are listed in supplement 3. 2. The uncertainty in the evidence is judged from the Credible Intervals (CrI) and dispersion in the probability distribution (Figure 5) for quant evidence. The evidence from qualitative studies that was not confirmed in quantitative studies is considered high uncertainty in this review. **QUANT** indicates that the majority of the evidence (n=16) was quantitative, and **qual** indicates that only three studies were qualitative.
Evidence evaluation for each barrier or enabler using Bayesian analysis is described in Figure 2. Depending on the availability of the evidence we followed either procedure 1, 2, or 3, and synthesised QUAL + quant; or quant evidence only, following methods described by Roberts et al. (35). Detailed statistical analysis is reported in supplement 3.

Three reviewers (AA, AC, BV) independently, line-by-line, annotated the qualitative studies’ result section using the Theoretical Domains Framework, TDF (37). The coding agreement was high (AA vs AC: 87%; AA vs BV: 76%; BV vs AC: 86%). The descriptions of the important influences on physical activity in HF provided by the authors of the included qualitative studies were annotated using TDF. These descriptions were compared to the definitions of various psychosocial constructs from the TDF, APA dictionary (92), and NICE HF guidelines (93).

A prior elicitation task (62,94,95) was developed to capture experts’ beliefs about the probability distribution for physical activity conditioned on the constructs identified relevant in qualitative evidence (i.e. informative prior). The task asked the experts to share their belief about the probability of physical activity in 30 scenarios. The scenarios illustrated hypothetical HF patients. The 30 hypothetical HF patients were described to either display a construct or not in three sets of combinations of the constructs identified in qualitative studies. Six reviewers (AA; LT; BV; NA; AC; AT) completed the expert elicitation task.

The association between physical activity and determinants assessed in quantitative studies were summarised in a meta-analysis including univariate associations using a random-effect model with maximum likelihood estimation (REML). The bivariate correlation (Pearson's $r$ coefficient, unadjusted) between physical activity and an associated variable and the standardised mean differences ($SMD$) between groups in the dichotomised assessment were summarised in a pooled estimate, separately. The meta-analyses were implemented in R using the metafor library (96). The sampling distribution variance was standardised using an $r$-$z$ transformation. This was done to mitigate heterogeneity in the measurement of the outcome. $SMD$ between exposure and control was estimated for the same reason.

Evidence evaluation for each barrier or enabler using Bayesian analysis is described in Figure 2. Depending on the availability of the evidence we followed either procedure 1, 2, or 3, and synthesised QUAL + quant; or quant evidence only, following methods described by Roberts et al. (35). Detailed statistical analysis is reported in supplement 3.

Note 1. QUNT indicates that the majority of the evidence ($n=16$) was quantitative, and qual indicates that only three studies were qualitative.
Figure 2. Evidence evaluation for each barrier or enabler: Bayesian meta-analysis combining qual and QUANT; or QUANT evidence only. Depending on the availability of the evidence, either procedure 1, 2, or 3 was followed.
Figure 3. Meta-analysis of barriers and enablers of physical activity in HF: PRISMA diagram
Figure 4. Study-level risk of bias: based on WIB, ROBIN-I, and AXIS items combined into six categories proposed by Page et al., 2018 with an addition of the confounding bias described in ROBIN-I.
Figure 5. Bayesian updating: the posterior probability distribution for physical activity conditioned on identified determinants as suggested by the quantitative evidence (quant).

Pr(PA | HF) = 0.32
Figure 6. Bayesian updating: the posterior probability distribution for physical activity conditioned on identified determinants according to qualitative combined with quantitative evidence (QUAL + quant) and according to quantitative evidence alone (quant).