Body composition and risk of heart failure: protocol for a systematic review and meta-analysis

Ayodipupo S. Oguntade, Danyao Jin, Nazrul Islam, Reem Malouf, Hannah Taylor, Rishi Caleyachetty, Sarah Lewington, Ben Lacey

ABSTRACT

Introduction Although there is strong evidence of an association between general adiposity and incidence of heart failure, previous systematic reviews and meta-analyses have not reliably assessed the association of heart failure risk with other aspects of body composition (such as body fat distribution or lean mass), or between body composition and risk of heart failure subtypes. We aim to conduct a systematic review and meta-analysis of prospective studies to address these uncertainties, and inform efforts to prevent and treat heart failure.

Methods and analysis The Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols statement was used as a template for this protocol. A systematic search of Medline, Embase and Global Health database inception to present will be conducted to identify prospective studies reporting on the associations between major measures of body composition (body mass index, waist circumference, waist–hip ratio, total body fat, visceral adiposity tissue and lean mass) and risk of heart failure. Article screening and selection will be performed by two reviewers independently, and disagreements will be adjudicated by consensus or by a third reviewer. Data from eligible articles will be extracted, and article quality will be assessed using the Newcastle-Ottawa Scale. Relative risks (and 95% CIs) will be pooled in a fixed effect meta-analysis, if there is no prohibitive heterogeneity of studies as assessed using the Cochrane Q statistic and I² statistic. Subgroup analyses will be by age, sex, ethnicity and heart failure subtypes. Publication bias in the meta-analysis will be assessed using Egger’s test and funnel plots.

Ethics and dissemination This work is secondary analyses on published data and ethical approval is not required. We plan to publish results in an open-access peer-reviewed journal, present it at international and national conferences, and share the findings on social media.

PROSPERO registration number CRD42020224584.

INTRODUCTION

Heart failure (HF) is the pathophysiological endpoint of many cardiac diseases. There are about 65 million new cases of HF globally, and despite improvements in HF care over the last few decades, 5-year mortality continues to exceed 50% in most settings. HF is commonly classified into subtypes according to the proportion of ventricular blood volume remaining after systole (the ‘ejection fraction’), including HF with preserved ejection fraction (HFP EF), HF with reduced ejection fraction (HFrEF), and, more recently, HF with midrange ejection fraction (HFmEF). The clinical management of HF varies by HF subtype.

There is increasing evidence of the importance of adiposity, body fat distribution and lean (or ‘fat-free’) mass (collectively referred to here as ‘body composition’) to risk of cardiovascular disease. Body composition can be assessed directly using whole-body imaging (including dual energy X-ray absorptiometry, CT scans and MRI), or indirectly using bioelectric impedance or anthropometric measures. The relevance of the different measures of body composition to risk of HF is the subject of current investigation. The findings will be valuable in understanding the biological relationship between body composition and HF, and will inform efforts to prevent HF and manage patients with HF.

Body mass index (BMI; calculated by dividing weight in kilograms by the square of height in metres) is the most commonly used anthropometric measure of general adiposity. However, BMI is imprecise, it does not differentiate between body fat and lean mass and does not account for different distributions of body fat. The precise measurement and distinction between body fat distribution and lean mass are important in cardiovascular risk prediction in clinical practice. Therefore, the shortcomings of BMI have important implications for conditions such as HF, in which there can be rapid changes in body fat and lean mass. Although some studies have shown a linear relationship between HR risk and BMI, others have found a ‘J’-shaped association, with those in...
the underweight (BMI<18.5 kg/m²) and overweight or obese ranges (BMI>25 kg/m²) at higher risk than those in the normal range (18.5–25 kg/m²). For example, a recent study in the UK using the electronic health records of 2 million never smokers, found a J-shaped association of BMI with HF mortality with lowest risk in the 20–25 kg/m²; above this level, 10 kg/m² higher BMI was associated with about 50% higher risk of HF mortality.

The relationship between HF risk and measures of central adiposity, such as waist circumference or waist–hip ratio, has been less well studied than for BMI. However, some studies, such as the Health, Ageing and Body Composition study, have found waist circumference to be more strongly associated with HF risk than the BMI. Furthermore, prospective studies using whole-body imaging to directly measure body fat distribution have tended to be small, although there is some evidence of markedly strong associations of visceral adipose tissue with vascular risk factors, such as blood pressure. As such, the separate relevance of general and central adiposity to HF risk remains unclear, and the value of whole-body imaging above simpler anthropometric measures in the prognostic stratification of individuals in clinical practice is undetermined.

In addition to general adiposity and body fat distribution, there is emerging evidence that lean body mass (measured using bioelectric impedance or whole-body imaging) is associated with cardiovascular risk. In particular, individuals with reduced lean mass (or ‘sarcopenia’) have been found to be at increased risk of HF, independent of level of adiposity. However, it remains unclear whether this is due to reverse causality, whereby HF causes loss of lean mass, or the effect of changes in the distribution of body fat, or reduced muscle mass itself.

The subtyping of HF based on left ventricular ejection fraction (LVEF) into those with preserved, midrange, or reduced ejection fraction, requires cardiac echocardiography or cardiac MRI. To date, few studies have achieved sufficient scale to reliably describe the association of body composition and HF ejection fraction subtypes. Obesity has been shown to be a risk factor for HFpEF in some observational studies but data on HFpEF and HFmEF are scarce. Furthermore, previous reviews have tended not to assess the effect of body fat distribution on risk of different HF LVEF subtypes, or on classifications of HF based on likely aetiology, such as ischaemic and non-ischaemic HF. This is especially important since the association between body composition and HF varies by HF aetiological types as shown in recent studies in the Swedish population.

In summary, although there is strong evidence of an association of obesity (as measured by BMI) with incidence and mortality from HF, previous systematic reviews and meta-analyses have not reliably assessed the association of HF risk with body fat distribution and lean mass, or between any of the measure of body composition and risk of HF LVEF subtypes or HF aetiologies. This is in part because such studies require measures of bioelectric impedance, whole-body imaging or measures of cardiac function that it has not been feasible to include in large-scale studies until recently. We aim to conduct a systematic review and meta-analysis of prospective studies to address these uncertainties, and inform efforts to prevent and treat HF.

Objectives

The primary objective of this study is to determine the associations of HF incidence with body composition. The secondary objective is to determine the extent to which these associations vary by age, sex, ethnicity, HF LVEF subtypes and HF aetiologies.

Review questions

1. What is the association between general adiposity (as measured by BMI and total body fat) and HF incidence?
2. What is the association between central adiposity (as measured by waist circumference, waist–hip ratio and visceral adipose tissue) and HF incidence?
3. What is the relationship between lean body mass and HF incidence?
4. To what extent do these associations between body composition and HF incidence vary by age, sex, ethnicity, HF LVEF subtypes and HF aetiologies?

METHODS AND ANALYSIS

This study will be a systematic review and meta-analysis of prospective studies which report the association between body composition measures and HF risk. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Protocols (PRISMA-P) review guidelines to draft our protocol (see PRISMA-P checklist in online supplemental appendix 1). This is a standardised format for reporting systematic review protocol that guarantees accuracy, completeness and transparency of systematic review protocols. This review is registered on PROSPERO (number CRD42020224584), which is an international prospective register of systematic reviews. Registration of the protocol in a prospective register prevents duplicity of studies and strengthens the rigour of the proposed study and compliance with systematic review standards.

Eligibility criteria

Eligibility criteria will be defined using the participants, exposures, outcomes and study type strategy. Studies that meet the following criteria will be included in the review: (1) participants must be 18 years or over; (2) population-based prospective studies reporting the association between body composition (BMI, waist circumference, waist–hip ratio, total body fat, visceral adiposity tissue, and lean mass) and HF incidence; (3) studies must report outcomes as incident HF diagnosis, HF hospitalisation or HF mortality; (4) study types eligible for inclusion will be prospective cohort, nested case-control,
retrospective cohort or randomised controlled trials; (5) studies must have been published in English.

Exclusion criteria
We will exclude: (1) studies other than prospective studies, such as case-control studies (except nested case-control studies), review articles, conference abstracts, editorials, letters to the editor and cross-sectional studies; (2) studies which do not report effect sizes of associations between the selected measures of body composition and HF incidence; (3) studies conducted in participants with established HF; (4) studies with incomplete data (which preclude reliable analysis) which could not be obtained after reasonable request from the corresponding author of such studies; (5) studies with too few HF events for reliable analyses (defined here as 20 events or fewer).

Search strategy
We will conduct a systematic search of Medline, Embase and Global Health databases for articles published from the inception of each of the databases to present using the search strategy developed in conjunction with the information specialist (NR). The MeSH terms were chosen from the thesaurus used for indexing the subject headings. We also checked the search strategy used in previous systematic reviews.8 19 MeSH search terms and textwords associated with ‘body composition’, ‘adiposity’, ‘lean mass’, ‘obesity’, ‘sarcopenia’, ‘heart failure’, ‘cardiac dysfunction’, ‘ventricular dysfunction’, ‘cardiomyopathies’, ‘cohort studies’ and ‘adults’ will be used for the searches. Reference lists of eligible articles will also be screened for inclusion. Full details of the search strategy in Medline are shown in table 1 below. The syntax of this search strategy will be adapted to Embase and Global Health databases. The search will be limited to English, adults and observational studies or randomised controlled trials with no restriction by date.

Data extraction and management
Data will be collected from eligible articles using pre-designed data extraction form. We will develop and pilot-test the data collection form before the start of the study and extract the following variables from each of the eligible articles: name of first author, year of publication, country of study, year of baseline survey, mean follow-up time, selection criteria for study participants, baseline characteristics (including number of participants, mean age and per cent women), measures of body composition at baseline, date of resurvey (if performed), number of new cases of HF (fatal and non-fatal), LVEF among patients with HF, HF subtype(s), HF aetiologies, details of statistical analyses performed (including exclusions, type of statistical model, confounders, crude and adjusted relative risk (RR) estimates and 95% CIs).

Assessment of study quality and risk of bias
Quality of included studies will be assessed using the Newcastle-Ottawa Scale (NOS) which has been validated for use in systematic reviews.41 This will be done by two review authors (ASO and DJ), blinded to each other’s selection. Disagreement between the review authors will be resolved by a panel review made up of other study reviewers (NI, BL and RM). The NOS uses three quality assessment parameters (study group selection, group comparability and outcome assessment).42 These quality metrics are divided into an eight-item list using a point score system. A score of 9 points denotes studies of highest quality while less than 5 points denotes high risk of bias.41 42

Data synthesis and analysis
Descriptive characteristics of included studies will be reported, together with tables of the RRs extracted from each study. For the systematic review, findings from each study will be discussed in qualitative analyses. For meta-analyses, the RR estimates and 95% CIs for the association between different body composition measures and HF events will be extracted from each study and pooled using a fixed effects model. We will abstract the risk estimates from the most fully adjusted model except where such models adjusted for potential intermediate risk factors in a further step. In such cases, we will use models which did not include such intermediate factors. Where studies only reported RR in subgroups, we will use fixed-effect meta-analysis to generate an overall study-level RR so that each study will be represented only once in the main analysis. Where possible, subgroup analyses will be performed for each body composition measure and HF outcome, by age, sex, ethnicity, HF LVEF subtypes and HF aetiologies (eg, ischaemic heart disease, cardiomyopathy, congenital heart disease, valvular heart disease, hypertension or diabetes). Risk estimates and their 95% CI will be rescaled to 1-SD increase where appropriate to facilitate comparison across studies. Sensitivity analysis will be performed by restricting analyses to studies with a low risk of bias. In sensitivity analyses,
we will test for the effect of (1) including studies which reported on HF aetiologies (eg, ischaemic heart disease, cardiomyopathy, congenital heart disease, valvular heart disease, hypertension or diabetes) and HF LVEF subtypes (HFpEF, HFrEF and HFmEF); (2) excluding studies which used national databases as opposed to prospective cohort analysis; (3) excluding individual studies to investigate extreme results. Meta-analyses of reported associations will be presented using forest plots. Heterogeneity between studies will be determined using Q statistic and I² statistic. We will consider I²>50% as a significant level of heterogeneity. Publication bias will be assessed using funnel plots and Egger’s test. The quality and risk of bias of included studies will also be presented in tables and discussed in the final publication. Data analysis will be conducted using SAS software, V.9 (SAS Institute).

**CONCLUSION**

This systematic review will provide answers on the biological relationship between different body composition indices and incident HF risk. This will be invaluable for risk prediction of different HF types in clinical practice. It will also shed light on the independent and additive role

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**Table 1  Search strategy in Medline**

<table>
<thead>
<tr>
<th>Search</th>
<th>Keywords</th>
<th>Thesaurus (MeSH)</th>
<th>Textwords</th>
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<tbody>
<tr>
<td>#1</td>
<td>Exposure</td>
<td>Body Composition/</td>
<td>(body or abdom* or intraabdom* or central or truncal or trunk or appendicular or subcutaneous or sub-cutaneous or visceral or limb or arm or leg or peripheral or android or gynoid) adj fat* mp body composition* body weight and measure* adipos* obes* metabolic syndrome* overweight* BMI* adipocyt* fat distribution* fat mass* anthropomet<em>_quotalet</em> index body weight* body height* waist circumference* waist-height ratio* hip circumference* waist-hip ratio* body constitution* Somatotypes* body size* body mass* sarcop?enia* thinness* muscle mass* muscle bulk* lean mass* fat-free mass* skeletal bulk*</td>
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<tr>
<td>#2</td>
<td>Outcomes</td>
<td>exp Heart Failure/</td>
<td>heart failure* cardiac failure* diastolic HF* systolic HF* pulmonary o?dema</td>
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<td>#3</td>
<td>Study type</td>
<td>exp Cohort Studies/</td>
<td>cohort* longitudinal* prospective* follow-up* observational * incidence study*</td>
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<td>#4</td>
<td>#1 AND #2 AND #3</td>
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of whole-body imaging to conventional anthropometric indices in the risk stratification of patients in primary care. This is especially important given the increased prevalence of overweight and obesity globally in the adult workforce. This will contribute to the evidence base for weight management and weight reduction strategies in reducing HF risk.

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Contributors ASO, DJ, BL, RC and SL conceptualised the study. ASO, NI, SL, BL, RC and HT designed the statistical analysis plan. BL, RC, SL, NI, RM and HT provided training in systematic review, data synthesis and supervised the protocol. ASO wrote the initial draft. All authors contributed to the final draft and approved the final manuscript.

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Competing interests SL reports grants from the Medical Research Council (MRC) and research funding from the US Centres for Disease Control and Prevention Foundation (with support from Amgen) during the conduct of the study.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing is not applicable as no datasets generated and/or analysed for this study.

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REFERENCES

30 Tsujimoto T, Kajjo H. Abdominal obesity is associated with an increased risk of all-cause mortality in patients with HFpEF. J Am Coll Cardiol 2017;70:2237–8.


39 Covidence systematic review software [Internet]. Melbourne, Australia: Veritas Health Innovation. Available: www.covidence.org


### PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

<table>
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<th>Section and topic</th>
<th>Item No</th>
<th>Checklist item</th>
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<tr>
<td>Title:</td>
<td>1a</td>
<td>Identify the report as a protocol of a systematic review</td>
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<td></td>
<td>1b</td>
<td>If the protocol is for an update of a previous systematic review, identify as such</td>
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<tr>
<td>Registration</td>
<td>2</td>
<td>If registered, provide the name of the registry (such as PROSPERO) and registration number</td>
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<td>Authors:</td>
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<td></td>
<td>3a</td>
<td>Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author</td>
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<td>3b</td>
<td>Describe contributions of protocol authors and identify the guarantor of the review</td>
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<tr>
<td>Amendments</td>
<td>4</td>
<td>If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments</td>
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<td>Support:</td>
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<td>5a</td>
<td>Indicate sources of financial or other support for the review</td>
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<td>Provide name for the review funder and/or sponsor</td>
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<td>5c</td>
<td>Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol</td>
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<tr>
<td><strong>INTRODUCTION</strong></td>
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<tr>
<td>Rationale</td>
<td>6</td>
<td>Describe the rationale for the review in the context of what is already known</td>
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<tr>
<td>Objectives</td>
<td>7</td>
<td>Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)</td>
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<tr>
<td><strong>METHODS</strong></td>
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<tr>
<td>Eligibility criteria</td>
<td>8</td>
<td>Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review</td>
</tr>
<tr>
<td>Information sources</td>
<td>9</td>
<td>Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage</td>
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<tr>
<td>Search strategy</td>
<td>10</td>
<td>Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated</td>
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<td>Study records:</td>
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<td>11a</td>
<td>Describe the mechanism(s) that will be used to manage records and data throughout the review</td>
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**Open Heart**

Oguntade AS, *et al.* *Open Heart* 2021; 8:e001632. doi: 10.1136/openhrt-2021-001632
<table>
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<tr>
<th>Selection process</th>
<th>11b</th>
<th>State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)</th>
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<tbody>
<tr>
<td>Data collection process</td>
<td>11c</td>
<td>Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators</td>
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<tr>
<td>Data items</td>
<td>12</td>
<td>List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications</td>
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<tr>
<td>Outcomes and prioritization</td>
<td>13</td>
<td>List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale</td>
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<td>Risk of bias in individual studies</td>
<td>14</td>
<td>Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis</td>
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<tr>
<td>Data synthesis</td>
<td>15a</td>
<td>Describe criteria under which study data will be quantitatively synthesised</td>
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<td>15b</td>
<td>If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall’s τ)</td>
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<td>15c</td>
<td>Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)</td>
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<td>15d</td>
<td>If quantitative synthesis is not appropriate, describe the type of summary planned</td>
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<td>Meta-bias(es)</td>
<td>16</td>
<td>Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)</td>
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<tr>
<td>Confidence in cumulative evidence</td>
<td>17</td>
<td>Describe how the strength of the body of evidence will be assessed (such as GRADE)</td>
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</table>

* It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.