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Association Between Daily Step Count and All-Cause and Cardiovascular Mortality: A Systematic Review and Meta-Analysis Protocol

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We use this protocol and it's working

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Keywords: daily step count, higher daily step count, association between daily step count, step count assessment, methods for step count assessment, overall physical activity, physical activity, step count, incremental increase in step count, proxy for overall physical activity, cardiovascular mortality, protocol regular physical activity, determinant of health, risk of various chronic disease, various chronic disease, cumulative analysis, health, proliferation of wearable technology, step

Abstract

Regular physical activity is a well-established determinant of health, reducing the risk of various chronic diseases and premature death. With the proliferation of wearable technology, daily step count has emerged as an easily measurable and widely used proxy for overall physical activity. A growing body of literature suggests that higher daily step counts are associated with lower risks of all-cause and cardiovascular mortality. However, available studies vary in terms of populations studied, methods for step count assessment, thresholds for “active” versus “inactive” individuals, and adjustment for confounders. A rigorous systematic review and meta-analysis are therefore warranted to synthesize the current evidence, quantify the associations, and explore potential dose–response relationships.

This advanced analysis updates and extends previous work by:

- Incorporating 5 new studies (adding 23,111 patients) for a total of 22 studies.
- Examining the association between daily step count and both all-cause and cardiovascular mortality.
- Applying state-of-the-art methods including forest plots, funnel plots, dose-response analysis using restricted cubic splines, meta-regression, subgroup analyses, sensitivity analyses, and cumulative meta-analysis.

The primary objectives are to:

- Quantify the pooled hazard ratios (HRs) per incremental increase in step counts.
- Investigate potential nonlinear dose-response relationships.
- Explore how study-level characteristics (e.g., follow-up duration, baseline population risk) might moderate the observed associations.
- Assess the robustness of the findings via sensitivity and cumulative analyses.

Background and Rationale

1 Regular physical activity is a well-established determinant of health, reducing the risk of various chronic diseases and premature death. With the proliferation of wearable technology, daily step count has emerged as an easily measurable and widely used proxy for overall physical activity. A growing body of literature suggests that higher daily step counts are associated with lower risks of all-cause and cardiovascular mortality. However, available studies vary in terms of populations studied, methods for step count assessment, thresholds for “active” versus “inactive” individuals, and adjustment for confounders. A rigorous systematic review and meta-analysis are therefore warranted to synthesize the current evidence, quantify the associations, and explore potential dose–response relationships.

Objectives

2 **Primary Objectives**

- To systematically review the evidence on the association between daily step count and all-cause mortality in adult populations.
- To evaluate the association between daily step count and cardiovascular mortality in adult populations.

3 **Secondary Objectives**

- To assess the presence and nature of a dose–response relationship between the number of daily steps and mortality outcomes.
- To explore the influence of study characteristics (e.g., age, sex, geographic location, and method of step count measurement) on the reported associations.

Methods

4 **Eligibility criteria**

- Study Designs: Prospective and retrospective cohort studies that report an association between objectively measured daily step count and mortality outcomes. Randomized controlled trials (if available and reporting relevant outcomes) may be considered in sensitivity analyses.

- Participants: Adults (≥18 years) from any setting. Studies including specific populations (e.g., patients with chronic diseases) will be included if the association between daily step count and mortality is reported separately or can be extracted.

- Exposure: Daily step count measured objectively using wearable devices (e.g., pedometers, accelerometers, or smart devices). Studies relying solely on self-

reported physical activity will be excluded.

- Primary outcomes: All-cause mortality; Cardiovascular mortality. Studies must report effect estimates (e.g., hazard ratios, relative risks, odds ratios) with corresponding 95% confidence intervals, or provide sufficient data to calculate these.

- Language and publication date: No restrictions on language or publication date will be imposed. Non–English articles will be translated where feasible.

5 **Information Sources and Search Strategy**

A systematic literature search will be conducted in the following electronic databases with Free-Text_only Search Strategies (No Mesh/Emtree Terms):

- PubMed/MEDLINE
- Embase
- Web of Science
- Cochrane Library

PubMed/MEDLINE (Free-Text Strategy):
1. ("daily step count" OR "daily steps" OR "step count" OR "walking"):ti,ab.
2. ("mortality" OR "all-cause mortality" OR "cardiovascular mortality" OR "cardiac mortality"):ti,ab.
3. ("cohort" OR "prospective" OR "observational"):ti,ab.
4. 1 AND 2 AND 3
5. Limit 4 to English language and humans.

Embase (Free-Text Strategy):
1. ("daily step count" OR "daily steps" OR "step count" OR "walking"):ti,ab,kw
2. ("mortality" OR "all-cause mortality" OR "cardiovascular mortality" OR "cardiac mortality"):ti,ab,kw
3. ("cohort" OR "prospective" OR "observational"):ti,ab,kw
4. 1 AND 2 AND 3
5. Limit 4 to English language and human studies.

Cochrane Library (Free-Text Strategy):
("daily step count" OR "daily steps" OR "step count" OR "walking")
AND ("mortality" OR "all-cause mortality" OR "cardiovascular mortality" OR "cardiac mortality")
AND ("cohort" OR "prospective" OR "observational")

Apply additional filters for English language and human studies as available.

Additionally, the reference lists of all included studies and relevant reviews will be screened for further eligible studies. Grey literature, conference abstracts, and trial registries (e.g., ClinicalTrials.gov) will also be searched.

6 **Data extraction**

Data will be independently extracted by two reviewers using a standardized data extraction form. Data to be extracted include:

- Study Characteristics: Author, publication year, country, study design, sample size, and follow-up duration.
- Participant Characteristics: Age, sex distribution, and baseline health status.
- Exposure Assessment: Device type, method of step count measurement, average steps per day, and categories of step count (if applicable).
- Outcome Data: Number of events (all-cause and cardiovascular deaths), effect estimates (hazard ratios, relative risks, or odds ratios) with 95% confidence intervals, and covariates adjusted for in the analysis.
- Additional Information: Funding sources and declared conflicts of interest.

Data will be recorded in pre-designed extraction sheets (e.g., CSV files) to facilitate subsequent statistical analysis.

Any discrepancies in data extraction will be resolved by consensus or adjudication by a third reviewer.

A standardized data extraction form will be developed and pilot-tested to capture relevant study information.

All coding decisions and any modifications to the extraction form will be documented.

7 **Risk of bias assessment**

The quality of each included study will be assessed using the Newcastle–Ottawa Scale (NOS) for cohort studies. Two independent reviewers will perform the risk of bias assessment; discrepancies will be resolved by discussion or by involving a third reviewer.

8 **Data synthesis and analysis**

- Quantitative Synthesis: Provided that sufficient data are available, a meta-analysis will be performed using a random-effects model to pool effect estimates comparing different levels of daily step count.

- Effect Measures: Effect estimates (hazard ratios, relative risks, or odds ratios) with 95% confidence intervals will be pooled.

- Heterogeneity Assessment:Statistical heterogeneity will be evaluated using the I^2 statistic and Cochran's Q test. An I^2 value >50% will be considered indicative of substantial heterogeneity.

- Dose–Response Analysis:Where data permit, a dose–response meta-analysis will be conducted using methods such as restricted cubic splines to examine potential non-linear associations between step count and mortality outcomes.

- Subgroup and Sensitivity Analyses:Planned subgroup analyses include stratification by age, sex, geographic region, and type of measurement device. Sensitivity analyses will be performed by excluding studies with a high risk of bias or those that contribute substantially to heterogeneity.

- Publication Bias:Funnel plots will be generated to assess publication bias, and Egger's test will be applied if at least 10 studies are included.

Additional outcomes

9 **Pre-specified Additional Outcomes**

In addition to the primary outcomes (all-cause and cardiovascular mortality), the review will also evaluate the following additional outcomes if reported:

Nonfatal Cardiovascular Events:
- Outcome Description: Incidence of nonfatal cardiovascular events (e.g., nonfatal myocardial infarction, nonfatal stroke).
- Measure of Effect: Effect estimates (hazard ratios, relative risks, or odds ratios) with 95% confidence intervals will be pooled.

Hospitalizations for Cardiovascular Causes:
- Outcome Description: Rates of hospitalizations due to cardiovascular events.
- Measure of Effect: Risk ratios (RR) or odds ratios (OR) with 95% confidence intervals.

Quality of Life Measures:
- Outcome Description: Changes in quality of life as measured by validated instruments.
- Measure of Effect: Mean differences (MD) or standardized mean differences (SMD) with 95% confidence intervals.

If no additional outcomes are identified during the review process, this section will be updated to "None" or "Not applicable."

Dissemination

10 The findings of this systematic review and meta-analysis will be submitted for publication in a peer-reviewed journal and presented at relevant scientific conferences. A summary of the findings may also be shared with public health stakeholders to inform physical activity recommendations.

Timeline

11 Protocol Registration: 28/2/25

Literature Search: 7/3/25

Screening and Data Extraction: Estimated 1 month following the search

Data Analysis: Estimated 1 month post data extraction

Manuscript Preparation and Submission: Estimated within 4 months of protocol registration

Any changes to this timeline or the protocol itself will be documented and updated in the registration record.

Amendments

12 Any amendments to this protocol will be clearly described, with the rationale provided, and updated in the registration record.

Conflicts of interest and Funding

13 **Conflicts of Interest**
All authors declare no conflicts of interest relevant to this systematic review and meta-analysis.

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