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Research article

DE-PASS best evidence statement (BESt) – Modifiable determinants of physical activity and sedentary behaviour in adults aged 20-64 years: A protocol for systematic review and meta-analysis

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ABSTRACT

Purpose: Physical inactivity among adults remains a public health concern, despite the extensive efforts of researchers and policymakers to promote physical activity (PA) and reduce sedentary behaviour (SB). Challenges arise when attempting to translate research on modifiable determinants of PA and SB into effective policies. Recently it has been emphasized the need to

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Evidence-based determinants
Literature review

consider key settings at the individual, social, and environmental level to maximize the likelihood of effectiveness. The present protocol outlines a comprehensive approach that includes systematic reviews (SLRs) and meta-analyses (MAs) to generate a best-evidence statement (BESt) regarding the modifiable determinants of PA and SB within specific settings during adulthood.
Methods and analysis: The search strategy will be performed through MEDLINE (PubMed), PsycINFO (EBSCO), Web of Science, SPORTDiscus and Cochrane Central Register of Controlled Trials (CENTRAL) platforms. Randomized controlled trials (RCTs), controlled trials (CTs) and longitudinal studies analysing the effects of modifiable determinants on PA and/or SB of male and female adults will be considered. At least two measurement time-points of both modifiable determinants and outcomes related to PA and/or SB are mandatory prerequisites. Risk of bias of RCTs, CTs, and longitudinal studies will be performed through a modified RoB 2.0, a modified ROBINS-I, and an adapted version of the National Institutes of Health tool, respectively. Identified setting-dependent modifiable determinants will be discussed narratively using the SWiM tool and, where possible, MA will be performed using both frequentist and Bayesian statistical inference approaches. Both self-reported and device-based PA measurements will be considered.
Systematic review registration: PROSPERO [Reg. Nr. CRD42023412964]

1. Introduction

According to the World Health Organization (WHO) guidelines of the recommended physical activity (PA) levels, adults should dedicate 150–300 min per week to moderate-intensity aerobic physical activity or 75-150 min per week to vigorous-intensity aerobic physical activity or an equivalent combination to obtain healthy benefits [1,2]. Failure to comply with these recommendations defines inactive people who are at high risk of developing non-communicable chronic diseases (e.g., cancer, diabetes, and respiratory and cardiovascular diseases) [3]. Latest global estimates indicate an alarming prevalence of physical inactivity among adults, ranking as the fourth leading cause of death worldwide: in fact, about 27.5% of the world's adult population does not meet the recommended levels of physical activity (PA) [4,5], especially in high-income countries and in women living in the Americas and Eastern Mediterranean Regions [4]. In addition, sedentary behaviour (SB) is as an independent risk factor for non-communicable chronic diseases and mortality, although the links among SB, disease, and mortality are still poorly understood [6]. Whilst PA refers to any bodily movement, produced by skeletal muscles, that results in energy expenditure [7], SB represents the lowest intensity level of the PA spectrum and is commonly defined as an energy expenditure below 1.5 metabolic equivalents of task (METs) in a sitting or reclining posture during waking hours [8]. Despite they belong to the same energy expenditure continuum, PA and SB are often considered different outcomes because the way they are measured is not comparable (e.g., PA intensity/volume/frequency vs screen time). On the other hand, SB and physical inactivity definitions clarify that these are not just interchangeable terms, as sedentary individuals may be physically active, while inactive people may not be sedentary. At this regard, WHO recommends limiting SB throughout the day, substituting it with PA at any intensity (from light to vigorous), including also muscle-strengthening activities, that involve all major muscle groups, at least two days a week [2]. In the present work, the term PA behaviours (PABs) is used as an umbrella term which include the full range of PA levels, from sedentary, to light, moderate and vigorous activities [9].

Current projections suggest that, if the secular trend of PABs continues according to the estimations, a significant proportion of adults will not meet the 2018-2030 global action plan on PA target, which aims to reduce physical inactivity by 15% worldwide [4]. This shortfall highlights an urgent need for effective strategies to counteract inactivity trends and promote active lifestyles. To achieve this objective, it is essential to identify the key factors influencing PA and SB at the individual, social, economic, and environmental levels. Moreover, translating this evidence into policies and public health interventions, that effectively encourage PA and reduce SB, should be a priority for both researchers and policymakers. Over the years, numerous efforts have been made to understand what makes individuals more or less physically active. Various theoretical approaches have attempted to explain these behaviours, each emphasizing different determinants. Some have focused on individual psychological factors, such as motivation, self-efficacy, and decision-making processes, while others, such as ecological models, have highlighted the importance of contextual influences, considering how social, environmental, and policy-related factors shape PA behaviours [10,11]. Meanwhile, Condello et al. (2016) adopted a systematic concept mapping methodology to classify the determinants of PA into two broad categories: (1) the 'Person', including 'Intra-Personal Context and Wellbeing' and 'Family and Socioeconomic Status' clusters, and (2) the 'Society', which encompasses 'Policy and Provision', 'Cultural Context and Media', 'Social Support and Modelling', and 'Supportive Environment' clusters [12]. Therefore, in recent years, the impact of contextual factors has received increasing attention in the study of PABs, with a growing focus on the role of settings in shaping the effects of modifiable determinants [13–16].

According to the WHO Glossary [17], a setting for health is "the place or social context in which people engage in daily activities, in which environmental, organizational and personal factors interact to affect health and well-being" and "[…] where people actively use and shape the environment and thus create or solve problems relating to health. Settings can normally be identified as having physical boundaries, a range of people with defined roles, and an organizational structure". A settings perspective offers an opportunity to promote health and equity focusing on the interplay between individual, environmental and social determinants [18]. Despite the fact that the determinants of health through settings have been extensively investigated and reviewed [16,18], the contextualization of mechanisms leading to the adoption of an active lifestyle in PABs research is still at an early stage. More recent systematic reviews on the role of contextual factors across key settings or domains confirmed the limited and biased scientific evidence and urged scholars to consider a range of factors at the individual, social, and environmental levels to maximize the likelihood of effectiveness [19,20].

Therefore, the current protocol will synthesize high-quality evidence on the role of key modifiable determinants in relation to PABs, considering the setting in which the interplay take place, and producing a Best Evidence Statement (BESt) that can inform future interventions and influence policymakers' decisions aimed at mitigating physical inactivity trends. Here, the term 'modifiable determinants' of PABs refers to the potentially modifiable factors (e.g., social environment, self-efficacy, body mass index, etc.) that drive and explain behavioural adaptations in specific contexts [21,22] and are of interest from a public health and policy perspective [13,23]. Thus, 'modifiable determinants' are distinguished from those factors that are commonly considered unchangeable (e.g., age, sex, and genetic endowment) [24–26]. To ensure a structured approach in identifying modifiable determinants, we will adopt the framework developed by Condello et al. (2016), which categorizes a comprehensive list of physical activity determinants into different clusters. Based on this framework, we will establish an initial list of modifiable determinants, including psychological, social, and environmental factors. This predefined list will be further refined and expanded through the systematic review process to incorporate additional relevant determinants emerging from the literature [12].

Previous systematic literature reviews (SLRs), meta-analyses (MAs) or umbrella reviews claimed that the fragmented and inconclusive evidence on the effectiveness of modifiable determinants of PABs is due to a large range of methodological approaches to PA and SB research and to a questionable quality and internal validity of the studies [23,24,27–32]. Among the various research designs and measurement methods that determine high-quality PABs studies, randomized controlled trials (RCTs) are considered the gold-standard approach, which allows for identifying causality [13,23,33]. As PABs studies randomization can be challenging, well-designed controlled trials (CTs) represent a credible alternative to RCTs in terms of quality of evidence [34]. Furthermore, longitudinal studies can also capture prolonged exposure to potential determinants [23,33]. Therefore, RCT, CT, and longitudinal studies will be considered as the most suitable high-quality studies to develop the BESt.

In general, PABs can be measured using self-report or device-based methods. Self-report methods rely on the individual ability or willingness to report storing information about multiple quantitative (e.g., duration, intensity, frequency) and qualitative (e.g., type of PA, domain) dimensions. Furthermore, this methodological approach is cognitively demanding and subjected to recall and social desirability biases, interpretation discrepancies, under-/overestimation, and under-/overreporting, which makes it less sensitive to behaviour changes compared to device-based methods [35,36]. On the other hand, self-report methods are relatively inexpensive, can be administered to large populations, and allow for the estimation of qualitative dimensions that would not be assessed by means of device-based methods [35,36]. Conversely, being able to continuously detect activity patterns and durations of PABs events (and even posture when applied to specific body sites) and to capture the number of transitions from one level to another, device-based methods are considered suitable for measuring and continuously monitoring behavioural changes over time. Despite such advantages, they are more expensive than self-report methods, do not account for work against resistance, do not allow to identify domains or types of behaviour, and present a high variability between devices and data processing leading to poor comparability between studies [35,37]. Hence, in considering the strength and weakness of self-report and device-based methods and the low level of agreement between them [38], the present study will apply separate SLRs and MAs.

To gather high-quality evidence on modifiable determinants of PABs from RCTs, CTs, and longitudinal studies, this protocol adopts a rigorous methodology by including only studies with validated measures of PABs (i.e., self-report questionnaires and device-based methods). Furthermore, a setting-based perspective is essential to provide policymakers with meaningful information for designing effective interventions aimed at promoting PA and reducing SB. This approach overcomes key limitations of previous systematic reviews and meta-analyses, specifically: (1) methodological heterogeneity, which has hindered the comparability of findings; (2) the predominance of cross-sectional studies, limiting causal inference; and (3) the lack of a setting-based approach, failing to consider how different environments (e.g., workplace, home, community) shape the influence of modifiable determinants. To address these gaps, this protocol proposes a rigorous and comprehensive approach, characterized by: (1) implementing a robust analytical strategy, incorporating frequentist and Bayesian meta-analyses, as well as the SWiM (Synthesis Without Meta-Analysis) approach where necessary, to synthesize heterogeneous evidence while ensuring methodological rigor; (2) focusing on high-quality study designs, restricting inclusion to RCTs, CTs, and longitudinal studies; and (3) applying a setting-based framework to contextualize the role of modifiable determinants in real-world conditions. By integrating these elements, this systematic review and meta-analysis will provide a (BESt) to inform evidence-based interventions and policy recommendations.

2. Objectives

The proposed protocol aims to identify modifiable determinants of PABs in adults (aged 20-64 years) and to assess the quality, strength, and relevance of the evidence. The main research questions are:

Which modifiable determinants are included in interventions targeting PABs in adults involved in RCTs, CTs, and longitudinal studies?

What is the quality of the included studies and strength of evidence supporting the potential of the identified determinants to affect PABs in adults?

What are the settings in which the determinants are investigated?

3. Methods and analysis

This protocol is part of a wider research project investigating modifiable determinants of PA and SB across the lifespan. The present protocol focuses on adults, whereas other research teams focus on children, adolescents and older adults [22,39–42]. Here we developed a strategy according to the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) guidelines [43] and we registered the protocol on the International Prospective Register of Systematic Reviews (PROSPERO) on 15/04/2023 (registration number: CRD42023412964).

Modifiable determinants investigated in the selected studies will be reported and analysed narratively in SLRs through the SWiM tool [44] suitable for studies that are not sufficiently homogenous. On the other hand, quantitative data related to PABs, in form of self-report and/or device-based data, from RCTs, CTs, as well as from longitudinal studies, will be submitted to meta-analytic methods focusing on specific adult settings (such as workplace, neighbourhood, universities).

4. Population

The target population will be adults aged 20-64 years, thus following WHO guidelines and ensuring consistency with international standards [45]. Studies including partially overlapping age ranges (younger or older) will be included only if the mean age of the groups satisfies the criterion or if data for the adult subgroup within the age range can be extracted. In particular, we will: a) Extract data separately for the adult subgroup whenever possible; b) Contact study authors to request stratified data if it is not directly available; c) Exclude studies where subgroup data cannot be obtained or inferred with reasonable certainty. Moreover, studies with i) adults not able to choose freely their own lifestyle (such as those affected by disabling neurological conditions), ii) hospitalized patients, iii) people included in pre- and post-operative studies on the body (such as back, hip, knee, ankle joints) or iv) receiving terminal or palliative care, will be excluded.

5. Types of studies

RCTs, CTs, and longitudinal studies analysing the effects of modifiable determinants on PABs of adults will be considered. In RCT/CT studies, the presence of control groups or, at least, of comparative groups for the intervention groups is required. Moreover, pre- and post-intervention measurements of both modifiable determinants and outcomes related to PABs are prerequisites. At least two time-points (at least one year apart) are required also in longitudinal studies, but control groups or comparisons are not compulsory. Both RCTs/CTs and longitudinal studies assessing the effects of modifiable determinants on PABs of adults during the transition from adolescence to adulthood, or from adulthood to older age, will be excluded if only one measurement point is left in the age range of interest (20-64 years).

Given the methodological differences between RCTs, CTs, and longitudinal studies, we will analyse them separately to minimize heterogeneity and ensure methodological consistency. This approach allows for a more accurate comparison within study designs, reducing potential biases introduced by methodological variability.

6. Outcomes

The main outcomes of the present protocol study are the quantitative assessment of changes in PABs of adults and the associated modifiable determinants within specific adult settings. As for PABs, four different intensity-based categories will be evaluated: sedentary (below 1.5 METs), light- (between 1.5 and $<$3 METs), moderate- (between 3 and $<$6 METs), and vigorous PA ($\geq$6 METs); in addition, PA levels in various domains will be taken into account, such as: leisure-time, occupation, education, household and/or transportation [8]. Two different types of quantitative measurements of PABs of adult individuals will be considered: validated self-report (e.g., questionnaires, diaries, recalls), and device-based (e.g., accelerometers, pedometers) methods [35]. For consistency across studies, PA and SB will be extracted in terms of duration, typically expressed in minutes per day or per week. Where possible, all

Table 1
Selected search terms.

Domain	Search terms
Determinants[b]	(determinant*) OR (antecedent*) OR (predictor*) OR (mediator*) OR (moderator*) OR (exposure*)
Outcome: Physical activity behaviour[a]	("Physical activ*") OR (exercise) OR (sport*) OR (play) OR (exertion) OR (recreation) OR (training) OR ("motor activit*") OR ("physical performance") OR ("physical movement") OR ("physical effort") OR (exergaming) OR (homebased training)
OR	
Outcome: Sedentary behaviour[a]	(sedentar*) OR ("screen time") OR (gaming) OR ("computer use") OR (sitting) OR (inactiv*) OR ("seated posture") OR ((watch* or view*) AND (TV or television))
AND	
Target population[a]	(adult*) OR (young adult) OR (middle age*) OR (old adult) OR (work*) OR (universit*) OR (college age*) OR (employ*) OR (unemploy*)
AND	
Study design[b]	(RCT) OR ("control* trial*") OR (quasi) OR (longitudinal) OR (intervention*) OR (prospective) OR ("follow up")
AND	
Measurement methods[b]	(acceleromet*) OR ("activity profile") OR (recall) OR (diary) OR (questionnaire*) OR ("activity monitor*") OR ("heart rate monitor*") OR ("direct observation") OR (actigraph*) OR ("activity track*") OR ("self-report*") OR (survey) OR (pedomet*) OR (wearable*) OR (smartwatch*) OR (sportwatch*) OR (sport app*)

[a] Restricted search to title, abstract and keywords.
[b] Search in entire study.

outcome measures will be converted to a common unit of measurement to facilitate comparability in the data synthesis process.

7. Comparators

Within each identified settings, PABs self-report and device-based data will be analysed by comparing experimental groups from selected CT and RCT studies with matching control groups or other active intervention groups. In CTs and RCTs, control groups refer to those participants who did not receive the intervention or were exposed to a standard condition, while active comparators involve groups receiving a different intervention. In longitudinal studies, the comparison will involve data obtained in two or more time-points of the study (e.g., baseline, first wave, and so on). Self-report and device-based measures will be analysed separately. A comparative synthesis, based on common modifiable determinants, will be eventually performed under the identified settings.

8. Search strategy

Following professional librarians' indications from the universities involved in the project, the search strategy will be performed by means of several scientific databases, such as MEDLINE (PubMed), PsycINFO (EBSCO), Web of Science, SPORTDiscus and Cochrane Central Register of Controlled Trials (CENTRAL) databases, using the selected search terms listed in Table 1 (see also Supplementary file 1 for the putative search strings for each database). In particular, a combination of keywords related to the outcomes of the protocol study is considered, such as determinants and their synonyms, PA or SB and their synonyms, target population (adults and their synonyms), study designs (e.g., CTs, RCTs, longitudinal studies and their synonyms) and measurement methods for PA and/or SB (e.g., both self-reported and device-based).

To ensure feasibility and methodological consistency, only studies published in English will be included. Although the research team comprises members from different countries, it would not be possible to cover all languages comprehensively. Selecting only a subset of non-English languages based on available linguistic expertise could introduce a bias favouring certain languages over others. CTs, RCTs, longitudinal studies will be included if published after 2010, following the first global WHO publication on PA guidelines [46]. These guidelines provided standardized definitions and methodological recommendations that have shaped subsequent research on physical activity and sedentary behaviour. Furthermore, the conceptualization of sedentary behaviour as distinct from physical inactivity, recognizing that sedentary time has independent health effects regardless of physical activity levels, has been widely adopted mainly from this period onward [47]. Restricting the inclusion to studies published after 2010 ensures consistency in definitions and methodological approaches, aligning the findings with contemporary scientific and public health perspectives. Other types of publications, such as grey literature (e.g., abstracts, conference papers and proceedings, expert opinion, posters, research reports, theses, working papers), ongoing studies, protocol papers, observational studies (e.g., analytical and descriptive studies, case-reports, cross-sectional), reviews (e.g., systematic, rapid, scoping, state of art, critical, mapping, meta-analysis) and secondary data analyses will be excluded, as these typology of literature often lacks peer review and standardized reporting, which may affect the reliability and comparability of findings.

9. Study records

Following the search strategy performed by members of the review team, the outputs will be merged and, after removal of grey literature records and duplicates, uploaded on the Covidence online platform [48]. Covidence is a tool able to assist researchers in the several steps (e.g., title and abstract screening, full-text screening, study selection, data extraction and risk of bias assessment) of a systematic literature review, through a blinded procedure, based on the PRISMA flow diagram [49]. Regular meetings among team members will be held throughout the whole process to discuss the procedures for each step, assure agreement and make sure that every member is proficient in the task at hand. To achieve mutual understanding amongst members, specific tutorials will be provided, as well as documents related to inclusion/exclusion criteria, definitions, decision tree files, risk of bias assessment, data extraction template. Both the core group and the review team are members in the COST Action "Determinants of Physical ActivitieS in Settings" (DE-PASS) (https://depass.eu/structure/).

10. Screening process

The screening processes (e.g., title and abstract screening, full-text screening) will take advantage from the Covidence feature that allows two blinded team members to review the same record. A pre-piloted decision tree (Supplementary file 2), based on the inclusion/exclusion criteria, will assist each reviewer to complete the specific task. In particular, adult population (age range 20 – 64 years), PA and/or SB as an outcome with at least two measurement time points, study design as longitudinal, RCT or CT, modifiable determinants with at least two measurement time points, and English language will be the inclusion criteria. The exclusion criteria will encompass: age range $\leq$20 and $\geq$ 64 years, lack of at least two measurement time points for both PABs outcomes and determinants, not modifiable determinants, study designs different from longitudinal, RCT, and CT, medical conditions which may hinder full decision-making autonomy with respect to PABs, grey literature and not revised studies, and languages different from English. In case of discordant evaluations, a third member will resolve the conflict. Each member will review a minimal number of records, randomly selected by the Covidence algorithm. For each record at each stage, a note will be added by the reviewers to justify the evaluation. Tags (e.g., CT, RCT, longitudinal, PA, SB) will be added to the records to help team members proceeding correctly toward the final stage. After full text screening is completed, the occurrence of putative duplicated studies (e.g., same data published more than once) or of partially overlapping reports coming from the same study will be checked: in the former case duplicates will be removed, while in the latter case the inclusion will consider the reports with the highest number of measurements timepoints or the longest follow-up. Finally, to provide a comprehensive search of the relevant articles, the snowball technique will be applied [50].

11. Data extraction

A data extraction form (see Supplementary file 3) will be tested through a pilot phase before the data extraction stage to ensure consistency among researchers. Data extraction will be conducted in duplicate, with each study independently assessed by a pair of reviewers. Any discrepancies will be resolved through discussion within the pair, and if necessary, a third reviewer will be consulted. In case of missing or incomplete data, the reviewers will contact the corresponding author, waiting for the requested information for a reasonable period (about two weeks). If no response is provided, the study will be removed.

The following item will be included in data extraction.

- Source description: author, year of publication, and country of publication.
- Study description: study design, sample characteristics (e.g., sample age, percentage of male and female participants, sample size, and demography), study duration, and type (e.g., non-hospitalized patients, disability/non-disability).
- Intervention description: intervention design, intervention content, control group activity/ies, implementation setting.
- Outcomes and modifiable determinants description: PA and/or SB method of assessment (i.e., self-report vs. device-based), instrument (e.g., name of the questionnaire, device manufacturer and model) and setting specifications (e.g., number of item, recall period, and reported validity and reliability for self-report measurement, sampling rate, body site, wear time detection and requirements, metrics or activity counts algorithm, epoch length, cut points, days of recording, number of valid weekday and weekend days for device-based), modifiable determinant measurement instrument reported validity and reliability.
- Results data: PABs outcome data (mean, measures of variance) and modifiable determinant data (mean, measures of variance).

12. Potential confounders

In this protocol, a confounder is defined as a variable that is associated with both the modifiable determinant and the outcome (PABs), potentially altering the true relationship between them. Confounders can introduce bias by creating spurious associations or masking true effects, leading to inaccurate conclusions. Potential confounders will be identified a priori based on existing literature and expert consensus. These may include, but are not limited to age, sex, socioeconomic status, pre-existing health conditions, other lifestyle behaviours (e.g., diet, smoking status, alcohol consumption). The selection of confounders will be refined based on the variables reported in the included studies. During data extraction, information on potential confounders will be systematically collected when reported in the included studies. Specifically, extracted data will include whether studies controlled for confounders statistically, the methods used for adjustment, and the specific confounders considered. If a study does not report adjustments for confounders, this will be noted. To account for potential confounders in the meta-analysis, different statistical approaches will be applied based on data availability. If sufficient studies report adjusted effect estimates, these will be prioritized in the primary analysis. In cases where both adjusted and unadjusted estimates are available, sensitivity analyses will be performed to assess their impact. Additionally, where data allow, we will conduct subgroup analyses to compare effect estimates in studies that adjusted for confounders versus those that did not, and meta-regression to explore the influence of specific confounders (e.g., age, sex, socioeconomic status) on the effect estimates, provided there are enough studies to ensure statistical power. If confounder adjustment is not possible due to insufficient data, this limitation will be acknowledged in the interpretation of the results.

13. Risk of bias

For RCTs and CTs, the Risk of Bias 2.0 tool (RoB 2.0) [51] and a modified versions of Cochrane's Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) [52] will be applied, respectively. For longitudinal studies, an adapted version of the National Institutes of Health quality assessment tool, based on the instrument used by Kontostoli et al. [53], will be used. Using Covidence forms based on templates aligned with the aforementioned tools, the same two reviewers will perform data extraction and risk of bias to ensure familiarity. In case of conflicts, the reviewers will perform a consensus procedure.

14. Data synthesis

A data file containing information on the included RCT, CT, and longitudinal studies, such as study design, sample characteristics (e.g., age, sex, sample size), modifiable determinants and measurement type, intervention, outcomes and measurement type, timepoints, and settings will be created and summarized in a table. Results on the risk of bias assessment will be provided in a separate table. A narrative synthesis of the findings will identify and rate modifiable determinants in the identified settings in which they were investigated, considering the quality of evidence. Studies will be grouped based on study design (RCTs, CTs, and longitudinal studies) and measurement type (self-report or device-based). Patterns of association between determinants and PABs will be described, highlighting consistencies and discrepancies across studies. If conflicting results would emerge, potential sources of heterogeneity, such as methodological differences, population characteristics, or intervention types, will be explored [54].

Most data are expected to be continuous in nature; thus, meta-analytic methods will be applied if the conditions are satisfied. Meta-analysis will be performed through the JASP statistics software (JASP Team. JASP - Version 0.17.2.1, 2023) using both frequentist and Bayesian statistical inference approaches to investigate the effect of the interventions on PABs and determinants for RCTs/CTs and the strength of the association between identified modifiable determinants and PABs for longitudinal studies. JASP was selected as it allows for both frequentist and Bayesian analyses, providing a robust implementation of Bayesian meta-analysis for probability estimation and publication bias adjustments. If more than one experimental group or modifiable determinant is found in the included studies, they will all be included in the MAs.

Direct effect will be investigated using frequentist pairwise comparisons. The standardized mean difference (SMD) and the 95% CIs will be calculated. Random effect model will be used due to the expected heterogeneity among included studies and the nature, settings or types of interventions. For intervention studies, the between-group difference will be calculated using the post-intervention data while the within-group difference between pre-, post-intervention, and follow-up data will be calculated when the latter are available. For longitudinal studies, the within-group difference will be calculated. According to Cohen, small ($0.20 \leq$ SMD <0.50), medium ($0.50 \leq$ SMD <0.80) and large (SMD ≥ 0.80) effect size values will be considered [55]. We will evaluate heterogeneity among observed effects using τ, the estimated standard deviation of underlying true effects across studies which measures the absolute magnitude of true heterogeneity [56,57]. Statistical significance will be set at $\alpha = 0.05$t for frequentist analyses. To evaluate potential publication bias, we will employ visual inspection methods, depending on the number of studies included in the meta-analysis: If the number of studies is sufficient, we will use funnel plots to visually assess asymmetry. In addition to the frequentist meta-analysis, Bayesian meta-analysis will be performed by random effects models with a Bayesian methodological approach and by Robust Bayesian Meta-analysis (RoBMA) in JASP to calculate the probability for publication bias and to conduct state-of-the-art publication bias-adjusted MA [58,59]. As for RoBMA, it allows (1) the quantification of the evidence on a continuous scale, including for the null, (2) the avoidance of the accumulation bias, and (3) the reduction of estimation problems by using prior distributions. Finally, the mediation effects of determinants on PABs using frequentist meta-analytical structural equation modelling (meta-SEM) will be investigated if information about the covariance structure can be extracted [59]. If information about the covariance structure of the mediation is not present in the included study, the authors will be contacted. If the required data is unavailable, meta-SEM will not be conducted.

15. Conclusion and implications

By means of a rigorous and transparent methodology, this protocol outlines a way to identify and synthesize high-quality evidence on modifiable determinants of physical activity and sedentary behaviour in adults, within specific real-world settings. By applying both frequentist and Bayesian meta-analytical approaches and incorporating a setting-based perspective, this systematic review and meta-analysis will generate a Best Evidence Statement (BESt) that can guide the development of effective, context-sensitive interventions. The findings are expected to support researchers, practitioners, and policymakers in designing evidence-informed strategies aimed at reducing physical inactivity and sedentary behaviour across adult populations.

16. Strength and limitations

- The study will describe modifiable determinants in adult settings, their interplay, and assess the effectiveness of interventions on both determinants and PABs, helping to contextualize their interaction.
- The summary of body of evidence from high-quality research will take into account differences in study designs, methodological quality, and measurement methods of physical activity behaviours in adults.
- In addition to frequentist meta-analysis, Bayesian meta-analysis will be performed to provide more robust results especially when there are limited studies that can be pooled for meta-analysis. Additionally, Bayesian meta-analysis can provide an interpretation of likelihood an intervention effect, instead of the all-or-nothing interpretation from the frequentist approach.
- Separating RCTs, CTs, and longitudinal studies ensures methodological consistency and enhances the reliability of findings by reducing biases associated with study design variability.
- While the present study focuses on specific modifiable determinants reported in study designs, it is important to note that other relevant determinants not included in our analysis might be overlooked. Exploring these unaddressed determinants in future reviews could provide additional insights into potentially effective interventions, highlighting a limitation of the current study.
- In instances of unclear data affecting the quantification of modifiable determinants, a narrative approach will be employed. This approach, while useful for qualitative understanding, may pose limitations in achieving precise quantitative assessments within the current study.
- While this approach improves internal validity, it may reduce the overall statistical power by limiting the number of studies included in each analysis, potentially affecting the generalizability of the results.

CRediT authorship contribution statement

Pascal Izzicupo: Writing – original draft, Methodology, Conceptualization, Supervision. **Simone Ciaccioni:** Writing – original draft, Methodology, Conceptualization. **Sofia Serafini:** Writing – original draft, Methodology, Conceptualization. **Flavia Guidotti:** Methodology, Conceptualization, Writing – review & editing. **Andrea Michele Ciorciari:** Methodology, Conceptualization, Writing – review & editing. **Chiara Corvino:** Methodology, Conceptualization, Writing – review & editing. **Chiara D'Angelo:** Methodology, Conceptualization, Writing – review & editing. **Angela Di Baldassarre:** Methodology, Conceptualization, Writing – review & editing.

Andrea Di Credico: Methodology, Conceptualization, Writing – review & editing. **Andrea Fusco:** Methodology, Conceptualization, Writing – review & editing. **Caterina Gozzoli:** Methodology, Conceptualization, Writing – review & editing. **Linda Ernstsen:** Methodology, Conceptualization, Writing – review & editing. **Fiona Chun Man Ling:** Writing – review & editing, Methodology, Conceptualization. **Paul Jarle Mork:** Methodology, Conceptualization, Writing – review & editing. **František Bartoš:** Conceptualization, Methodology, Writing – review & editing. **Mohammed Khudair:** Conceptualization, Methodology, Writing – review & editing. **Maximilian Maier:** Conceptualization, Methodology, Writing – review & editing. **Anna Marcuzzi:** Conceptualization, Methodology, Writing – review & editing. **Kwok Ng:** Conceptualization, Methodology, Writing – review & editing. **Gavin Tempest:** Conceptualization, Methodology, Writing – review & editing. **Ciaran MacDonncha:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Laura Capranica:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Cristina Cortis:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Stefania Orrù:** Writing – original draft, Supervision, Methodology, Conceptualization.

Ethics and dissemination

The present protocol requires no ethical approval as this is a protocol for a systematic review and meta-analysis based on previously published data. Results will be disseminated through peer-reviewed publications and academic conferences. The BESt will be also shared with policy makers within and outside the Determinants of Physical Activities in Settings (DE-PASS) consortium.

Data availability statement

No new data were created or analysed in this study. Data sharing is not applicable to this article.

Statements and declarations:

The authors have no conflicts of interest relevant to this article.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2026.e45226.

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