

Apps and wearables for monitoring physical activity and sedentary behaviour: A qualitative systematic review protocol on barriers and facilitators

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Abstract

Objective: Monitoring of physical activity and sedentary behaviours by mobile phone applications (apps) and wearable technology (wearables) may improve these health behaviours. This systematic review aims to synthesise the qualitative literature on the barriers and facilitators of using apps and wearables for monitoring physical activity and/or sedentary behaviour in adults.

Methods: This review protocol is registered in PROSPERO (CRD42017070194). Scientific databases including CINAHL Complete, MEDLINE, PsycINFO, SPORTDiscus, Cochrane Library and Scopus will be searched for relevant studies published from 1 January 2012 to the date the searches are conducted. Studies will be included if they incorporated adults who used an app or wearable for monitoring physical activity and/or sedentary behaviour; explored the barriers and/or facilitators of using an app and/or wearable; and were published in English. Following duplicate screening of titles and abstracts, full texts of potentially eligible papers will be screened to identify studies using qualitative approaches to explore barriers and facilitators of using apps and/or wearables for monitoring physical activity and/or sedentary behaviour. Discrepancies will be resolved through consensus or by consulting a third screener. Relevant excerpts (quotes and text) from the included papers will be extracted and analysed thematically. The Critical Appraisal Skills Programme Qualitative Research Checklist will be used to appraise included studies.

Conclusion: The results of this work will be useful for those intending to monitor physical activity and/or sedentary behaviour using these technologies.

Keywords

Qualitative synthesis, exercise, sitting, technology, adults, experiences, activity tracker, pedometer, monitor, mHealth

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Introduction

Low levels of physical activity and sedentary behaviour are major risk factors for the development of chronic health conditions, such as type 2 diabetes, cardiovascular disease and some cancers.¹ Furthermore, low levels of physical activity have been associated with a significant economic burden in terms of healthcare costs and indirect costs to productivity.^{2, 3} The benefits of increasing physical activity include improved health and well-being, thus promoting physical activity is a

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public health priority.^{4–6} However, many people do not meet recommended physical activity levels, or spend a lot of time sedentary.^{7, 8} As a response, a World Health Organization action plan has been launched to promote physical activity and reduce sedentary behaviour in an effort to attenuate the burden of chronic diseases.⁹

In 2016, 78% of global consumers had smartphones and nearly 10% owned wearable technology (wearables).¹⁰ Also, around 81% of United Kingdom (UK) adults owned a smartphone¹¹ and approximately 58% of smartphone users in the United States of America (USA) have downloaded a health-related app.¹² Mobile phone applications (apps) are increasingly integrated with wearables. Wearables are defined as “any body-worn computer that is designed to provide useful services while the user is performing other tasks”¹³ and include activity trackers, pedometers, accelerometers, smart watches or smart clothes. Wearable usage is expected to grow from approximately 325 million connected wearables in 2016 to over 830 million in 2020 worldwide.¹⁴

Apps and wearables have been used in studies to investigate physical activity and sedentary behaviour in a wide range of populations, including overweight and obese adults, people with type 2 diabetes, cancer patients, emergency medicine residents and people with chronic obstructive pulmonary disease.^{15–21} Apps and wearables are used by people for personal use, in interventions and in clinical settings. Such technologies can be used to self-monitor, and thereby improve, levels of physical activity and sedentary behaviour. Self-monitoring activity levels has been associated with increased physical activity.^{22–24} Additionally, activity monitors can promote high retention and compliance during interventions or therapy.²⁵

So far, systematic review evidence on physical activity and sedentary behaviour using apps and wearables is drawn from quantitative studies. These reviews have explored their acceptability, efficacy and effectiveness.^{22–24, 26–28} A qualitative systematic review explored the barriers and facilitators to participating in digital health interventions, which included mobile phone apps and pedometers.²⁹ However, no qualitative systematic review has investigated the barriers and facilitators to using apps and wearables for monitoring physical activity or sedentary behaviour. A synthesis of the qualitative research can help gather a coherent overview of users’ engagement with apps and wearables for physical activity and sedentary behaviour, providing individual perspectives and a contextual understanding.³⁰ Therefore, this systematic review aims to synthesise the qualitative literature on the barriers and facilitators of adults using apps and wearables for monitoring physical activity and/or sedentary behaviour.

Methods

Our systematic review protocol has previously been registered with the PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD42017070194). For the preparation of the present protocol, we ensured all items mentioned in the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) Protocols 2015 checklist have been addressed (see Appendix 1).^{31, 32}

Criteria for considering studies for this review

Inclusion and exclusion criteria are outlined below according to the Sample, Phenomenon of Interest, Design, Evaluation, and Research type tool.³³

Inclusion. Studies will be included if they meet the following criteria:

Sample.

- Study participants are adults (18 years or above).

Phenomenon of interest.

- Participants who have used an app or wearable for monitoring physical activity and/or sedentary behaviour. Apps will be programs stored on a smartphone to access data on the user’s physical activity, for example, MyFitnessPal, RunKeeper, or Pokémon Go. Wearable devices may include activity trackers, pedometers, accelerometers, smart watches or smart clothes. Wearables may also integrate or communicate with mobile phones and mobile phone apps.

Design.

- Research methods are qualitative (e.g. through grounded theory, ethnography, phenomenology, action participatory research, interviews, focus groups, questionnaires with open questions). Mixed methods studies will be considered for inclusion if they report qualitative data. Studies that include physical activity or sedentary behaviour as a sub-analysis or secondary analysis will be considered for inclusion.

Evaluation.

- Barriers and/or facilitators of using an app or wearable for monitoring physical activity or sedentary behaviour were explored qualitatively.

Research type.

- The population and the app and/or wearable used were described.
- Published in English.

Timeframe.

- Published from 1 January 2012 to the date the searches are conducted. Consequently, the most up-to-date research will be identified to account for the rapid technological advancements and to obtain barriers and facilitators of current technology use.

Exclusion. Studies will be excluded if:

Phenomenon of interest.

- Physical activity and/or sedentary behaviour has not been monitored or measured by an app or wearable.
- Physical activity and/or sedentary behaviour has been measured through self-report (e.g. self-report data has been input into the app).

Sample.

- Participants did not personally interact with the app or wearable (e.g. caregivers, family members or therapists).
- Participants are children and/or adolescents (under 18 years old) as children have very different motivations for using technology and apps are made to appeal very differently to them.³⁴

Design.

- They report on systematic reviews, narrative reviews, meta-analyses, meta-syntheses, study protocols, or are editorials or commentaries.

Search strategy

The search strategy was developed by the authors in consultation with a subject librarian. Databases to be searched include CINAHL Complete, MEDLINE, PsycINFO, SPORTDiscus, Cochrane Library and Scopus. The search strategy was first piloted in MEDLINE and has been refined and appropriately modified to each database. The search comprises of terms surrounding the following components: a) physical activity (for inclusion), b) technology (for

inclusion), c) participant experiences (for inclusion), d) qualitative methodology (for inclusion) and e) children (for exclusion). Search terms will be combined with the appropriate Boolean operators ('OR', 'AND' and 'NOT') and/or medical subject headings (MeSH) or thesaurus terms (see Appendix 2 for the full search strategy). Terms will be searched in titles, abstracts and subjects, except child-related terms, which will only be searched in titles. The child-related terms will be used to exclude studies investigating only children and/or adolescents. Reference lists of included studies and studies that cite the included studies will be searched to identify additional papers. Relevant literature already known to authors will also be screened for inclusion.

Data collection and analysis

Selection of studies. Titles, abstracts and full texts will be screened for eligibility by two independent screeners. If an inclusion decision cannot be made based on the title and abstract, the full text will be obtained. If necessary, corresponding authors of studies will be contacted for full texts if they are not available in the UK or Singapore. Where eligibility remains unclear at title and abstract or full-text stage, screeners will discuss it until a consensus is reached. If consensus is not reached, a third independent screener will act as an adjudicator. Reasons for exclusion will be recorded at each stage and the inclusion and exclusion process will be documented with a flow diagram as suggested by the PRISMA guidelines.³⁵

Data extraction and management. Relevant excerpts (e.g. participant quotes, author interpretations) from the abstract, results, discussion and conclusion will be extracted from included studies. Study characteristics and relevant information will also be extracted such as:

- General study information, for example, authors, journal, year of publication, country, type of publication (e.g. research article, conference contributions), type of study (e.g. intervention studies, observational studies, qualitative studies).
- Qualitative data collection methods, for example, qualitative methods (e.g. interviews, focus groups, survey, co-design), number of interviews or focus groups, type of interview (e.g. structured, semi-structures, unstructured, open questions), data analysis methods (e.g. framework, thematic, grounded theory).
- Participant characteristics, for example, number of participants, age, gender, clinical diagnosis, eligibility criteria, time since diagnosis, symptom severity, ambulatory status (walking ability).
- Technology details, for example, type of device used (app or wearable), name or brand of app or wearable

device used, description of functions of the technology including any behaviour-change techniques³⁶ of the technology reported (e.g. self-monitoring, goal setting, feedback, social support), context of use (e.g. intervention/programme details), duration of app or device use within the study and/or lifetime use.

- Technological readiness of participants or participants' experiences of using technology.

A data extraction form will be created and piloted, and refinements will be made iteratively. Data will be extracted by LJW. Data extraction will be cross-checked for completeness and correctness on at least 50% of the data by another reviewer. Disagreements will be resolved through discussion until consensus is reached.

Review data will be stored online using Coventry University's recommended secure server, backed up and communicated via secure university email accounts. Data will be managed by LJW during screening, data extraction and analysis using relevant software packages (e.g. EndNote,³⁷ Microsoft Excel and NVivo).³⁸ Following the completion and publication of the review, data will be deposited in a repository.

Critical appraisal. The Critical Appraisal Skills Programme Qualitative Research Checklist will be used to appraise included studies.³⁹ Studies will be included regardless of their quality. However, a sensitivity analysis will be conducted to investigate if inclusion of lower-quality studies affects the level of synthesis.

Analysis and synthesis. Thematic synthesis⁴⁰ will be used to analyse the data. Data will be coded line by line using NVivo qualitative data analysis software³⁸ to identify themes. Data will also be coded as verbatim quotes from participants or author interpretations of the data. Analysis will be led by LJW and supported by the co-authors. A coding scheme will be created and piloted by LJW before provisional themes are discussed with co-authors. Final themes will be iteratively developed and defined with further analysis relating the findings back to the research question and literature.

Subgroup analysis. Subgroup analysis will explore differences between groups, provided the data presented in the literature allow the examination of such, for example, age, gender, health conditions, setting (e.g. free-living, rehabilitation, country), duration of use, and type of technology, context of use.

Reporting: The qualitative systematic review will follow the Enhancing Transparency in Reporting the Synthesis of Qualitative Research guidelines,⁴¹ with additional guidance from the Cochrane Handbook for Reviews of Interventions.⁴²

Conclusion

An understanding of the barriers and facilitators of using apps and wearables for monitoring physical activity and sedentary behaviour in adults will shed light on users' engagement with such technologies. Understanding user engagement is a prerequisite for effective behaviour-change interventions, which can often include objective monitoring using devices.⁴³ The findings of this review will hence provide guidance for planning and designing research that aims to address physical activity and sedentary behaviour with mobile phone apps and wearable technology. In addition, gaps in the literature will be identified for future research on users' experiences of technology for physical activity and sedentary behaviour.

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Contributorship: LJW, PAW and GW conceived the idea for the systematic review. LJW conducted the searches, obtained ethical approval, registered the systematic review with PROSPERO, piloted the search strategy, developed the inclusion and exclusion criteria, and drafted the protocol manuscript. PAW, GW, LS and AMM provided input on the formulation of the research question and methods, reviewed drafts thereof and critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript.

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Guarantor: PAW

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Appendices

Appendix 1: Preferred reporting items for systematic review and meta-analysis protocols 2015 checklist: recommended items to include in a systematic review protocol

| Section and topic | Item no. | Checklist item | Reported on page no. |
|--|----------|---|----------------------|
| Administrative information | | | |
| Title: Apps and wearables for monitoring physical activity and sedentary behaviour: A qualitative systematic review protocol on barriers and facilitators. | | | |
| Identification | 1a | Identify the report as a protocol of a systematic review | 1 |
| Update | 1b | If the protocol is for an update of a previous systematic review, identify as such | N/A |
| Registration | 2 | If registered, provide the name of the registry (such as PROSPERO) and registration number | 2 |
| Authors: | | | |
| Contact | 3a | Provide name, institutional affiliation, email address of all protocol authors; provide physical mailing address of corresponding author | 1 |
| Contributions | 3b | Describe contributions of protocol authors and identify the guarantor of the review | 4 |
| Amendments | 4 | 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 | N/A |
| Support: | | | |
| Sources | 5a | Indicate sources of financial or other support for the review | 4 |
| Sponsor | 5b | Provide name for the review funder and/or sponsor | N/A |
| Role of sponsor or funder | 5c | Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol | N/A |

(continued)

Continued.

| Section and topic | Item no. | Checklist item | Reported on page no. |
|------------------------------------|----------|--|----------------------|
| Introduction | | | |
| Rationale | 6 | Describe the rationale for the review in the context of what is already known | 1–2 |
| Objectives | 7 | Provide an explicit statement of the question(s) the review will address with reference to PICO | 2 |
| Methods | | | |
| Eligibility criteria | 8 | Specify the study characteristics (such as PICO, study design, setting, timeframe) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review | 2–3 |
| Information sources | 9 | 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 | 3 |
| Search strategy | 10 | Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated | 6 |
| Study records: | | | |
| Data management | 11a | Describe the mechanism(s) that will be used to manage records and data throughout the review | 4 |
| Selection process | 11b | 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) | 3 |
| Data collection process | 11c | 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 | 3–4 |
| Data items | 12 | List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications | 3–4 |
| Outcomes and prioritization | 13 | List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale | 3–4 |
| Risk of bias in individual studies | 14 | 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 | 4 |
| Data synthesis | 15a | Describe criteria under which study data will be quantitatively synthesised | N/A |
| | 15b | 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) | N/A |
| | 15c | Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression) | 4 |

(continued)

Continued.

| Section and topic | Item no. | Checklist item | Reported on page no. |
|-----------------------------------|----------|---|----------------------|
| | 15d | If quantitative synthesis is not appropriate, describe the type of summary planned | 4 |
| Meta-bias(es) | 16 | Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies) | N/A |
| Confidence in cumulative evidence | 17 | Describe how the strength of the body of evidence will be assessed (such as GRADE) | N/A |

PICO, participants, interventions, comparators and outcomes

Appendix 2: Search strategies

MEDLINE search strategy in EBSCOhost

| | |
|----|--|
| #1 | (physical* AND activ*) OR sit OR sits OR sat OR sitting OR MH 'physical fitness+' OR fitness OR MH 'Walking+' OR walk* OR (stair* AND climb*) OR MH 'Stair Climbing' OR 'physical mobility' OR sport* OR MH 'Sports+' OR MH 'Sports for Persons with Disabilities' OR cycling OR cycle* OR bicycle* OR MH 'Jogging' OR jog* OR MH 'Running+' OR run* OR MH 'Motor Activity' OR 'motor activ*' OR MH 'Movement' OR movement* OR distanc* OR MH 'Cardiorespiratory Fitness' OR MH 'Exercise' OR exercis* OR MH 'High-Intensity Interval Training' OR 'High-Intensity Interval Training' OR HIIT OR MH 'Physical Exertion' OR exertion* OR MH 'Resistance Training' OR 'energy expend*' OR 'metabolic equivalent*' OR 'heart rate*' OR MH 'Sedentary Lifestyle' OR MH 'Healthy Lifestyle+' OR sedentar* OR inactiv* |
| #2 | MH 'Cell Phones' OR mobile* OR phone* OR iPhone* OR smartphon* OR smart-phon* OR 'smart phon*' OR MH 'Smartphone' OR MH 'Computers, Handheld+' OR MH 'Mobile Applications' OR app OR apps OR MH 'Fitness Trackers' OR wearable* OR tracker* OR acceleromet* OR MH 'Accelerometry' OR pedomet* OR (step* AND count*) OR smartwatch* OR 'smart watch*' OR 'smart-watch*' OR 'apple watch' OR 'basis band' OR 'misfit shine' OR 'misfit flash' OR withings OR garmin OR jawbone OR samsung OR 'microsoft band' OR nike OR (polar AND watch*) OR fitbit OR ActiGraph OR ActiPal OR exergam* OR gamifi* OR 'serious gam*' OR 'mobile gam*' OR 'pokemon go' OR 'tablet PC*' OR 'tablet computer*' OR ipad* OR JITAI OR 'just-in-time-adaptive intervention*' OR monitor* OR 'quantified sel*' OR quantified-sel* |
| #3 | accept* OR expectation* OR impress* OR thought* OR think* OR subjectiv* OR perspective* OR prefer* OR feel* OR felt OR feasib* OR usab* OR engag* OR satisf* OR experienc* OR perceiv* OR believ* OR intent* OR believ* OR attitude* OR MH 'Attitude' OR MH 'Attitude to Computers' OR MH 'Attitude to Health' OR MH 'Health Knowledge, Attitudes, Practice' OR barrier* OR motivat* OR facilitat* OR user-experienc* OR 'human computer interaction' OR 'human-computer interaction' OR 'computer-human interaction' OR 'computer human interaction' OR HCI OR 'user centered' OR 'user centred' OR 'user-centred' OR 'user-centered' OR 'human-centred' OR 'human-centered' OR 'human factor*' |
| #4 | 'framework analysis' OR 'framework synthe*' OR 'framework theory' OR qualitativ* OR MH 'Qualitative Research' OR MH 'Grounded Theory' OR 'grounded theory' OR multimethod* OR multi-method* OR 'multi method*' OR 'mixed method*' OR mixed-method* OR 'mixed design*' OR 'mixed-design*' OR MH 'Interviews as Topic' OR MH 'Motivational Interviewing' OR MH 'Interview, Psychological' OR MH 'Interview' OR interview* OR MH 'Focus Groups' OR 'focus group*' OR narrat* OR MH 'Narration' OR MH 'Personal Narratives as Topic' OR MH 'Personal Narratives' OR phenomenol* OR discourse* OR theme* OR subtheme* OR sub-theme* OR thematic OR 'think aloud' OR 'think-aloud' OR 'cognitive walkthrough' OR ethnograph* OR realist OR 'documentary analys*' OR participatory OR 'action research' OR 'audio record*' OR 'video record*' |
| #5 | TI (child* OR adoles* OR girl* OR boy* OR youth* OR teen* OR kid OR kids OR paediat* OR pediat* OR preschool* OR pre-school* OR nurser* OR kindergart* OR kindergard* OR school* OR 'young people' OR infant* OR toddler*) |
| #6 | #1 AND #2 AND #3 AND #4 |
| #7 | #6 NOT #5 |

PsycINFO search strategy in EBSCOhost

| | |
|----|---|
| #1 | (physical* AND activ*) OR sit OR sits OR sat OR sitting OR DE 'Physical Activity' OR DE 'Physical Fitness' OR fitness OR DE 'Walking' OR walk* OR (stair AND climb*) OR DE 'Physical Mobility' OR 'physical mobility' OR sport* OR DE 'Sports' OR cycling OR cycle* OR bicycle* OR jog* OR DE 'Running' OR run* OR movement* OR 'motor activ*' OR distanc* OR DE 'Exercise' OR exercis* OR 'High-Intensity Interval Training' OR HIIT OR exertion* OR 'energy expend*' OR 'metabolic equivalent*' OR 'heart rate*' OR DE 'Sedentary Behavior' OR sedentar* OR inactiv* |
| #2 | DE 'Cellular Phones' OR mobile* OR phone* OR iPhone* OR smartphon* OR smart-phon* OR 'smart phon*' OR DE 'Mobile Devices' OR app OR apps OR wearable* OR tracker* OR acceleromet* OR pedomet* OR (step* AND count*) OR smartwatch* OR 'smart watch*' OR 'smart-watch*' OR 'apple watch' OR 'basis band' OR 'misfit shine' OR 'misfit flash' OR withings OR garmin OR jawbone OR samsung OR 'microsoft band' OR nike OR (polar AND watch*) OR ActiPal OR ActiGraph OR fitbit OR exergam* OR gamification OR 'serious gam*' OR 'mobile gam*' OR 'pokemon go' OR 'tablet PC*' OR 'tablet computer*' OR ipad* OR JITAI OR 'just-in-time-adaptive intervention*' OR monitor* OR 'quantified sel*' OR quantified-sel* |
| #3 | accept* OR expectation* OR impress* OR thought* OR think* OR subjectiv* OR perspective* OR prefer* OR feel* OR felt OR feasib* OR usab* OR accept* OR engag* OR satisf* OR experienc* OR perceiv* OR believ* OR intent* OR believ* OR attitude* OR DE 'Attitudes' OR barrier* OR motivat* OR facilitat* OR user-experienc* OR 'computer human interaction' OR 'human computer interaction' OR 'computer-human interaction' OR 'human-computer interaction' OR HCI OR 'user centered' OR 'user centred' OR 'user-centred' OR 'user-centered' OR 'human-centred' OR 'human-centered' OR 'human factors' |
| #4 | 'framework analysis' OR 'framework synthe*' OR 'framework theory' OR qualitativ* OR DE 'Qualitative Research' OR DE 'Grounded Theory' OR 'grounded theory' OR multimethod* OR multi-method* OR 'multi method*' OR 'mixed method*' OR mixed-method* OR 'mixed design*' OR 'mixed-design*' OR DE 'Motivational Interviewing' OR DE 'Interviews' OR interview* OR 'focus group*' OR narrat* OR DE 'Narratives' OR phenomenol* OR discourse* OR theme* OR subtheme* OR sub-theme* OR thematic OR 'think aloud' OR 'think-aloud' OR 'cognitive walkthrough' OR ethnograph* OR realist OR 'documentary analys*' OR participatory OR 'action research' OR 'audio record*' OR 'video record*' |
| | TI (child* OR adoles* OR girl* OR boy* OR youth* OR teen* OR kid OR kids OR paediat* OR pediat* OR preschool* OR pre-school* OR nurser* OR kindergart* OR kindergard* OR school* OR 'young people' OR infant* OR toddler*) |
| #5 | #1 AND #2 AND #3 AND #4 |
| #6 | #6 NOT #5 |

SPORTDiscus search strategy in EBSCOhost

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|----|--|
| #1 | (physical* AND activ*) OR sit OR sits OR sat OR sitting OR DE 'PHYSICAL activity' OR DE 'PHYSICAL fitness' OR fitness OR DE 'WALKING' OR walk* OR (stair* AND climb*) OR DE 'STAIR climbing' OR 'physical mobility' OR sport* OR DE 'SPORTS' OR DE 'PHYSICAL fitness for people with disabilities' OR cycling OR cycle* OR bicycle* OR DE 'JOGGING' OR jog* OR DE 'RUNNING' OR run* OR 'motor activit*' OR movement* OR distanc* OR DE 'CARDIOVASCULAR fitness' OR DE 'EXERCISE' OR exercis* OR 'High-Intensity Interval Training' OR HIIT OR exertion* OR DE 'RESISTANCE training (Physical training & conditioning)' OR 'energy expend*' OR 'metabolic equivalent*' OR 'heart rate*' OR DE 'SEDENTARY behavior' OR DE 'SEDENTARY people' OR DE 'SEDENTARY lifestyles' OR sedentar* OR inactiv* |
| #2 | DE 'Cellular Phones' OR mobile* OR phone* OR iPhone* OR smartphon* OR smart-phon* OR 'smart phon*' OR DE 'Mobile Devices' OR app OR apps OR wearable* OR tracker* OR acceleromet* OR DE 'ACCELEROMETERS' OR pedomet* OR (step* AND count*) OR smartwatch* OR 'smart watch*' OR 'smart-watch*' OR 'apple watch' OR 'basis band' OR 'misfit shine' OR 'misfit flash' OR withings OR garmin OR jawbone OR samsung OR 'microsoft band' OR nike OR (polar AND watch*) OR fitbit OR ActiGraph OR ActiPal OR exergam* OR gamifi* OR 'serious gam*' OR 'mobile gam*' OR 'pokemon go' OR 'tablet PC*' OR 'tablet computer*' OR ipad* OR JITAI OR 'just-in-time-adaptive intervention*' OR monitor* OR 'quantified sel*' OR quantified-sel* OR |
| #3 | accept* OR expectation* OR impress* OR thought* OR think* OR subjectiv* OR perspective* OR prefer* OR feel* OR felt OR feasib* OR usab* OR engag* OR satisf* OR experienc* OR perceiv* OR believ* OR intent* OR believ* OR attitude* OR DE 'ATTITUDES toward health' OR barrier* OR motivat* OR facilitat* OR user-experienc* OR human computer interaction' OR 'computer human interaction' OR human-computer interaction' OR 'computer-human interaction' OR HCI OR 'user centered' OR 'user centred' OR 'user-centred' OR 'user-centered' OR 'human-centred' OR 'human-centered' OR 'human factor*' |
| #4 | 'framework analysis' OR 'framework synthe*' OR 'framework theory' OR qualitativ* OR 'grounded theory' OR multimethod* OR multi-method* OR 'multi method*' OR 'mixed method*' OR mixed-method* OR 'mixed design*' OR 'mixed-design*' OR DE 'MOTIVATIONAL interviewing' OR interview* OR 'focus group*' OR narrat* OR phenomenol* OR discourse* OR theme* OR subtheme* OR sub-theme* OR thematic OR 'think aloud' OR 'think-aloud' OR 'cognitive walkthrough' OR ethnograph* OR realist OR 'documentary analys*' OR participatory OR 'action research' OR 'audio record*' OR 'video record*' |

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| #5 | TI (child* OR adoles* OR girl* OR boy* OR youth* OR teen* OR kid OR kids OR paediat* OR pediat* OR preschool* OR pre-school* OR nurser* OR kindergart* OR kindergard* OR school* OR 'young people' OR infant* OR toddler*) |
| #6 | #1 AND #2 AND #3 AND #4 |
| #7 | #6 NOT #5 |

CINAHL Complete search strategy in EBSCOhost

| | |
|----|---|
| #1 | (physical* AND activ*) OR sit OR sits OR sat OR sitting OR MH 'Physical Fitness+' OR fitness OR MH 'Walking+' OR walk* OR MH 'Stair Climbing' OR ('stair*' AND 'climb*') OR MH 'Physical Mobility' OR 'physical mobility' OR sport* OR MH 'Sports+' OR MH 'Sports, Disabled' OR cycling OR cycle* OR bicycle* OR MH 'jogging' OR jog* OR MH 'Running+' OR MH 'Running, Distance' OR run* OR MH 'Motor Activity' OR 'motor activ*' OR MH 'Movement' OR movement* OR distanc* OR MH 'Cardiorespiratory Fitness' OR MH 'Exercise' OR exercis* OR 'High-Intensity Interval Training' OR HIIT OR exertion* OR MH 'Resistance Training' OR 'energy expend*' OR 'metabolic equivalent*' OR 'heart rate*' OR MH 'Life Style, Sedentary' OR sedentar* OR inactiv* |
| #2 | mobile* OR phone* OR iPhone* OR smartphon* OR smart-phon* OR 'smart phon*' OR MH 'Smartphone' OR MH 'Mobile Applications' OR app OR apps OR MH 'Fitness Trackers' OR wearable* OR tracker* OR acceleromet* OR MH 'Accelerometry' OR pedomet* OR (step* AND count*) OR smartwatch* OR 'smart watch*' OR 'smart-watch*' OR 'apple watch' OR 'basis band' OR 'misfit shine' OR 'misfit flash' OR withings OR garmin OR jawbone OR samsung OR 'microsoft band' OR nike OR (polar AND watch*) OR ActiPal OR ActiGraph OR fitbit OR exergam* OR gamifi* OR 'serious gam*' OR 'mobile gam*' OR 'pokemon go' OR 'tablet PC*' OR 'tablet computer*' OR ipad* OR JITAI OR 'just-in-time-adaptive intervention*' OR monitor* OR 'quantified sel*' OR 'quantified-sel*' |
| #3 | accept* OR expectation* OR impress* OR thought* OR think* OR subjectiv* OR perspective* OR prefer* OR feel* OR felt OR feasib* OR usab* OR accept* OR engag* OR satisf* OR experienc* OR perceiv* OR belief* OR intent* OR believ* OR attitude* OR MH 'Attitude' OR MH 'Attitude to Computers' OR MH 'Attitude to Health' OR barrier* OR motivat* OR facilitat* OR user-experienc* OR 'computer human interaction' OR 'human computer interaction' OR 'computer-human interaction' OR 'human-computer interaction' OR HCI OR 'user centered' OR 'user centred' OR 'user-centred' OR 'user-centered' OR 'human-centred' OR 'human-centered' OR 'human factor*' |
| #4 | 'framework analysis' OR framework synthe** OR 'framework theory' OR qualitativ* OR MH 'Qualitative Studies+' OR MH 'Grounded Theory' OR 'grounded theory' OR multimethod* OR multi-method* OR 'multi method*' OR 'mixed method*' OR mixed-method* OR 'mixed design*' OR 'mixed-design*' OR MH 'Motivational Interviewing' OR MH 'Interviews+' OR interview* OR MH 'Focus Groups' OR 'focus group*' OR narrat* OR MH 'narratives' OR phenomenol* OR discourse* OR theme* OR subtheme* OR sub-theme* OR thematic OR 'think aloud' OR 'think-aloud' OR 'cognitive walkthrough' OR ethnograph* OR realist OR 'documentary analys*' OR participatory OR 'action research' OR 'audio record*' OR 'video record*' |
| #5 | TI (child* OR adoles* OR girl* OR boy* OR youth* OR teen* OR kid OR kids OR paediat* OR pediat* OR preschool* OR pre-school* OR nurser* OR kindergart* OR kindergard* OR school* OR 'young people' OR infant* OR toddler*) |
| #6 | #1 AND #2 AND #3 AND #4 |
| #7 | #6 NOT #5 |

Scopus search strategy

((TITLE-ABS-KEY((physical* AND activ*) OR sit OR sits OR sat OR sitting OR fitness OR walk* OR (stair* AND climb*) OR 'physical mobility' OR sport* OR cycling OR cycle* OR bicycle* OR jog* OR run* OR movement* OR 'motor activ*' OR distanc* OR exercis* OR 'High-Intensity Interval Training' OR HIIT OR exertion* OR 'energy expend*' OR 'metabolic equivalent*' OR 'heart rate*' OR sedentar* OR inactiv*))) AND ((TITLE-ABS-KEY(mobile* OR phone* OR iPhone* OR smartphon* OR smart-phon* OR 'smart phon*' OR app OR apps OR wearable* OR tracker* OR acceleromet* OR pedomet* OR (step* AND count*) OR smartwatch* OR 'smart watch*' OR 'smart-watch*' OR 'apple watch' OR 'basis band' OR 'misfit shine' OR 'misfit flash' OR withings OR garmin OR jawbone OR samsung OR 'microsoft band' OR nike OR (polar AND watch*) OR fitbit OR ActiPal OR ActiGraph OR exergam* OR gamifi* OR 'serious gam*' OR 'mobile gam*' OR 'pokemon go' OR 'tablet PC*' OR 'tablet computer*' OR ipad* OR JITAI OR 'just-in-time-adaptive intervention*' OR monitor* OR 'quantified sel*' OR 'quantified-sel*'))) AND ((TITLE-ABS-KEY(accept* OR expectation* OR impress* OR thought* OR think* OR subjectiv* OR perspective* OR prefer* OR feel* OR felt OR

feasib* OR usab* OR accept* OR engag* OR satisf* OR experienc* OR perceiv* OR belief* OR intent* OR believ* OR attitude* OR barrier* OR motivat* OR facilitat* OR user-experienc* OR 'human computer interaction' OR 'computer human interaction' OR 'human-computer interaction' OR 'computer-human interaction' OR HCI OR 'user centred' OR 'user centered' OR user-centred OR user-centered OR human-centered OR human-centred OR 'human factor*')) AND ((TITLE-ABS-KEY('framework analysis' OR 'framework synthe*' OR 'framework theory' OR qualitativ* OR 'grounded theory' OR multimethod* OR multi-method* OR 'multi method*' OR 'mixed method*' OR mixed-method* OR 'mixed design*' OR 'mixed-design*' OR interview* OR 'focus group*' OR narrat* OR phenomenol* OR discourse* OR theme* OR subtheme* OR sub-theme* OR thematic OR 'think aloud' OR 'think-aloud' OR 'cognitive walkthrough' OR ethnograph* OR realist OR 'documentary analys*' OR participatory OR 'action research' OR 'audio record*' OR 'video record*')))) AND NOT (TITLE(child* OR adoles* OR girl* OR boy* OR youth* OR teen* OR kid OR kids OR paediat* OR pediat* OR preschool* OR pre-school* OR nurser* OR kindergart* OR kindergard* OR school* OR 'young people' OR infant* OR toddler*)) AND (LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2017) OR LIMIT-TO (PUBYEAR,2016) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR,2014) OR LIMIT-TO (PUBYEAR,2013) OR LIMIT-TO (PUBYEAR,2012)) AND (LIMIT-TO (LANGUAGE, 'English'))

Cochrane Library search strategy

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| #1 | ((physical* and activ*) or sit or sits or sat or sitting or fitness or walk* or (stair* and climb*) or 'physical mobility' or sport* or cycling or cycle* or bicycle* or jog* or run* or movement* or distanc* or exercis* or 'High-Intensity Interval Training' or HIIT or exertion* or 'energy expend' or 'metabolic equivalent*' or 'heart rate*' or sedentar* or inactiv*):ti,ab,kw |
| #2 | MeSH descriptor: [Exercise] explode all trees |
| #3 | MeSH descriptor: [Physical Fitness] explode all trees |
| #4 | MeSH descriptor: [Physical Fitness] explode all trees |
| #5 | MeSH descriptor: [Walking] explode all trees |
| #6 | MeSH descriptor: [Walking] explode all trees |
| #7 | MeSH descriptor: [Sports] explode all trees |
| #8 | MeSH descriptor: [Metabolic Equivalent] explode all trees |
| #9 | MeSH descriptor: [Heart Rate] explode all trees |
| #10 | MeSH descriptor: [Sedentary Lifestyle] this term only |
| #11 | #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 |
| #12 | (mobile* or phone* or iphone* or smartphon* or smart-phon* or 'smart phon*' or app or apps or wearable* or tracker* or acceleromet* or pedomet* or (step* and count*) or smartwatch* or 'smart watch*' or 'smart-watch*' or 'apple watch' or 'basis band' or 'misfit shine' or 'misfit flash' or withings or garmin or jawbone or samsung or 'microsoft band' or nike or (polar and watch*) or fitbit or actipal or actigraph or exergam* or gamifi* or 'serious gam*' or 'mobile gam*' or 'pokemon go' or 'tablet PC*' or 'tablet computer*' or ipad* or jitai or 'just-in-time-adaptive intervention*' or monitor* or 'quantified sel*' or 'quantified-sel*'):ti,ab,kw |
| #13 | MeSH descriptor: [Cell Phones] this term only |
| #14 | MeSH descriptor: [Smartphone] this term only |
| #15 | MeSH descriptor: [Mobile Applications] this term only |
| #16 | MeSH descriptor: [Fitness Trackers] this term only |
| #17 | MeSH descriptor: [Computers, Handheld] this term only |

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| #18 | #12 or #13 or #14 or #15 or #16 or #17 |
| #19 | (accept* or expectation* or impress* or thought* or think* or subjectiv* or perspective* or prefer* or feel* or felt or feasib* or usab* or engag* or satisf* or experienc* or perceiv* or belief* or intent* or believ* or attitude* or barrier* or motivat* or facilitat* or user-experienc* or 'human computer interaction' or 'computer human interaction' or 'human-computer interaction' or 'computer-human interaction' or hci):ti,ab,kw or |
| #20 | MeSH descriptor: [Attitude] explode all trees |
| #21 | #19 or #20 |
| #22 | ('framework analysis' or 'framework synthe*' or 'framework theory' or qualitativ* or 'grounded theory' or multimethod* or multi-method* or 'multi method*' or 'mixed method' or mixed-method* or 'mixed design' or 'mixed-design' or interview* or 'focus group*' or narrat* or phenomenol* or discourse* or theme* or subtheme* or sub-theme* or thematic or 'think aloud' or 'think-aloud' or 'cognitive walk-through' or ethnograph* or realist or 'documentary analys*' or participatory or 'action research' or 'audio record' or 'video record'):ti,ab,kw |
| #23 | MeSH descriptor: [Qualitative Research] this term only |
| #24 | MeSH descriptor: [Grounded Theory] explode all trees |
| #25 | MeSH descriptor: [Interview] this term only |
| #26 | MeSH descriptor: [Interview, Psychological] this term only MeSH descriptor: [Interviews as Topic] this term only |
| #27 | MeSH descriptor: [Motivational Interviewing] this term only |
| #28 | MeSH descriptor: [Focus Groups] this term only |
| #29 | MeSH descriptor: [Narration] this term only |
| #30 | MeSH descriptor: [Personal Narratives as Topic] this term only |
| #31 | #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 |
| #32 | (child* or adoles* or girl* or boy* or youth* or teen* or kid or kids or paediat* or pediat* or preschool* or pre-school* or nurser* or kindergart* or kindergard* or school* or 'young people' or infant* or toddler*):ti |
| #33 | #11 AND #18 AND #21 AND #31 |
| #34 | #33 NOT #32 |

MeSH: medical subject heading.