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ORIGINAL ARTICLE

Only half of the authors of overviews of exercise-related interventions use some strategy to manage overlapping primary studies—a metaresearch study

Ruvistay Gutierrez-Arias[a,b,c,d,*], Dawid Pieper[e,f], Carole Lunny[g], Rodrigo Torres-Castro[h], Raúl Aguilera-Eguía[i], Maria-Jose Oliveros[j], Pamela Seron[j]

[a]*Department of Pediatrics, Obstetrics and Gynecology, Preventive Medicine and Public Health, Universitat Autònoma de Barcelona, Barcelona, Spain*
[b]*Departamento de Apoyo en Rehabilitación Cardiopulmonar Integral, Instituto Nacional del Tórax, Santiago, Chile*
[c]*Exercise and Rehabilitation Sciences Institute, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, 7591538, Chile*
[d]*INTRehab Research Group, Instituto Nacional del Tórax, Santiago, Chile*
[e]*Faculty of Health Sciences Brandenburg, Brandenburg Medical School (Theodor Fontane), Institute for Health Services and Health Systems Research, Rüdersdorf, Germany*
[f]*Center for Health Services Research, Brandenburg Medical School (Theodor Fontane), Rüdersdorf, Germany*
[g]*Knowledge Translation Program, Dalla Lana School of Public Health, University of Toronto, Toronto, Canada*
[h]*Department of Physical Therapy, University of Chile, Santiago, Chile*
[i]*Departamento de Salud Pública, Facultad de Medicina, Universidad Católica de la Santísima Concepción, Concepción, Chile*
[j]*Universidad de La Frontera, Facultad de Medicina, Departamento de Ciencias de la Rehabilitación & CIGES, Temuco, Chile*

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Abstract

Objectives: The conduct of systematic reviews (SRs) and overviews share several similarities. However, because the unit of analysis for overviews is the SRs, there are some unique challenges. One of the most critical issues to manage when conducting an overview is the overlap of data across the primary studies included in the SRs. This metaresearch study aimed to describe the frequency of strategies to manage the overlap in overviews of exercise-related interventions.

Study Design and Setting: A systematic search in MEDLINE (Ovid), Embase (Ovid), Cochrane Library, Epistemonikos, and other sources was conducted from inception to June 2022. We included overviews of SRs that considered primary studies and evaluated the effectiveness of exercise-related interventions for any health condition. The overviews were screened by two authors independently, and the extraction was performed by one author and checked by a second. We found 353 overviews published between 2005 and 2022 that met the inclusion criteria.

Results: One hundred and sixty-four overviews (46%) used at least one strategy to visualize, quantify, or resolve overlap, with a matrix (32/164; 20%), absolute frequency (34/164; 21%), and authors' algorithms (24/164; 15%) being the most used methods, respectively. From 2016 onwards, there has been a trend toward increasing the use of some strategies to manage overlap. Of the 108 overviews that used some strategy to resolve the overlap, ie, avoiding double or multiple counting of primary study data, 79 (73%) succeeded. In overviews where no strategies to manage overlap were reported (n = 189/353; 54%), 16 overview authors (8%) recognized this as a study limitation.

Conclusion: Although there is a trend toward increasing its use, only half of the authors of the overviews of exercise-related interventions used a strategy to visualize, quantify, or resolve overlap in the primary studies' data. In the future, authors should report such strategies to communicate more valid results.

Keywords: Overviews of systematic reviews; Umbrella review; Overlap; Review methods; Exercise; Rehabilitation

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* Corresponding author. Departamento de Apoyo en Rehabilitación Cardiopulmonar Integral, Instituto Nacional del Tórax, José Manuel Infante 717, Santiago 750 1144, Chile.
E-mail address: ruvistay.gutierrez@gmail.com (R. Gutierrez-Arias).

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Plain language summary

One of the issues that authors of overviews (review of reviews) should consider is whether primary studies included in one systematic review were also included in others (overlap). We conducted a study that looked at whether authors of overviews of exercise-related interventions used any methods to identify overlapping studies (visualization), determine the level of overlap (quantification), and avoid double or multiple counting of data from overlapping studies (resolution). We found 353 overviews published between 2005 and 2022. We could see that while authors have used more strategies in recent years, only half of them do so. Future studies should assess the consequences of not considering overlap in overview results and using different methods to handle it.

1. Introduction

Systematic reviews (SRs) have multiplied exponentially in recent years [1], publishing almost 80 SRs per day between 2000 and 2019 [2]. This has occurred despite the preregistration of SRs [3] and efforts to introduce concepts such as "evidence-based research" to reduce research waste [4,5]. The increase in published SRs makes it difficult for clinicians to keep up to date and inform their practice [6,7]. Overviews can help clinicians and decision-makers with the multitude of SRs by using explicit methods to analyze their results and resolve methodological issues and conflicting findings related to their duplication [8].

The conduct of SRs and overviews share several similarities, such as duplicate and independent screening, data extraction, and risk of bias assessment of the included studies. However, because the unit of analysis for overviews is the SRs, there are some unique challenges [8]. One of the most critical issues to manage when conducting an overview is the overlap of data across the primary studies included in the SRs [9]. Pooled analyses of the effects estimated by different SRs, ie, meta-analyses that use the effects estimated by multiple meta-analyses to calculate a metaeffect estimate (also known as meta-meta-analyses) [10], may result in overprecise intervention effects [11,12].

Exercise is a complex nonpharmacological intervention [13]. Due to their different modalities and dosages, exercise interventions are likely to be heterogeneous. In addition, they are often accompanied by other pharmacological and nonpharmacological interventions. These issues, coupled with the frequent confusion in the definitions of exercise and physical activity [14], can result in varying degrees of overlap, which should be assessed when conducting an overview.

Methodological studies have indicated that between 30% and 63% of overviews authors have used some strategy to deal with overlapping primary studies [9,15,16]. These studies included overviews from different medical disciplines found by searching a single database and analyzed a sample of all identified overviews. Our metaresearch study focuses on the overviews of a specific type of intervention which were searched in four databases, with all identified overviews being analyzed. We aimed to describe the frequency of strategies to manage overlap of primary study data in overviews of exercise-related interventions.

2. Methods

A metaresearch study was conducted. The protocol for this study was registered in the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) under the number INPLASY202250161. Further details are available in the published version of the protocol [17]. This protocol included the objective of assessing the congruence between the methods used to conduct the overviews reported in the protocols and those that were finally used. However, this metaresearch study did not address that objective, which will be addressed in a future study. Other deviations from protocol were specified at different stages of this metaresearch study.

2.1. Eligibility criteria

We included overviews of SRs with or without meta-analyses that considered primary studies of any study design (eg, Randomized Clinical Trials [RCTs] and non-RCTs) and assessed the effectiveness and safety/harms of exercise-related interventions in any health condition.

We included overviews that: 1) synthesized general information, methods and outcome data from SRs, 2) clearly articulated the inclusion and exclusion criteria for SRs, 3) reported a search strategy for the SRs, and 4) examined the effectiveness and safety of health interventions [18]. We did not limit the inclusion of the overviews by the definition of SR adopted by the authors of the overviews [19], or whether the authors decided to screen and include primary studies in addition to SRs [8]. Overviews conducted using a "rapid review" methodology [20] were excluded.

We included both overviews that considered only SRs of exercise-related interventions and those that included other SRs with pharmacological and nonpharmacological interventions. Exercise-related interventions were defined as a subcategory of physical activity ie planned, structured, repetitive and purposefully focused on improving or maintaining one or more components of physical fitness [14]. To differentiate between exercise-based and physical activity-based interventions, the exercise, together with its structure and dosage (frequency, intensity, time, and type), must have been prescribed or delivered by a physical training/rehabilitation professional [21].

What is new?

Key findings

- One of the most challenging methodological issues when conducting an overview is the overlap of primary studies across systematic reviews.
- Methodological studies have indicated that between 30% and 63% of overviews authors have used some strategy to deal with overlapping primary studies. These studies included overviews from different medical disciplines found by searching a single database.
- Our metaresearch study aimed to describe the frequency of strategies to manage the overlap of primary study data in overviews of exercise-related interventions.

What this adds to what was known?

- Our study findings show that although there is a trend toward increasing its use, only half of the authors of the overviews of exercise-related interventions used a strategy to visualize, quantify, or resolve overlap in the primary studies.

What is the implication and what should change now?

- In the future, authors should report strategies to visualize, quantify, and resolve the overlap of primary study data to communicate more valid results.

We did not limit the inclusion of the overviews by language or date of publication. However, we excluded overviews if they were not published in full (eg, conference proceedings abstracts) and/or not peer-reviewed (eg, preprints).

2.2. Search strategy

A systematic search of different electronic databases and other sources was conducted. MEDLINE (Ovid), Embase (Ovid), the Cochrane Database of Systematic Reviews (Cochrane Library), and Epistemonikos databases were searched from inception to June 2022. In addition, a search was carried out in protocol registries of SRs namely, INPLASY (https://inplasy.com/), PROSPERO (https://www.crd.york.ac.uk/PROSPERO/), OSF Registries (https://osf.io/registries), and protocols published in scientific journals (namely, BMC Systematic Reviews Journal, BMJ Open, PLOS ONE). The search strategy included controlled language and keywords (full search strategies can be found in Supplementary Material 1). The MEDLINE (Ovid) search strategy was first developed using a published filter for identifying overviews [22]. This search algorithm was adapted for the other databases and platforms (Supplementary Material 1). No limits were applied related to language or date of publication.

In addition, the references of the included overviews were checked by performing a backward search using the Citationchaser tool [23].

2.3. Study selection

Two reviewers screened the citations independently at the title and abstract reading stage and in full text. Disagreements were resolved by consensus or a third reviewer. The Rayyan® application was used to facilitate screening [24].

2.4. Data extraction

Originally the data extraction was planned to be performed in duplicate; however, due to the number of overviews identified, it was done by one reviewer and checked by a second. Disagreements were resolved by consensus or a third reviewer.

A data extraction form was used that considered: 1) bibliometric characteristics of the overviews, including title, DOI, journal, year of publication, number of authors, research topic (type of disease), and journal impact factor; 2) methodological aspects of the overviews, such as research objectives, the existence of protocol, eligibility criteria, databases and search dates, tools to assess the risk of bias or methodological quality of the SRs; 3) outcomes reported by the overviews, including the number of SRs and primary studies included; and 4) the strategies used by the authors of the overviews to visualize, quantify and manage the overlap of primary studies (see Data Synthesis section below for more details).

The 2022 journal impact 2-year factor for the year of publication was extracted from Web of Science (https://www.webofscience.com/).

In addition, we identified whether the authors of the overviews that did not use an overlap strategy reported this as a limitation of their study. This was checked in the discussion section of the articles, particularly in the paragraphs reporting the strengths and limitations of the study, and in the conclusion section.

2.5. Data synthesis

The selection of overviews is presented using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart. In addition, the characteristics of the included overviews are reported through descriptive statistics and in narrative form using tables and figures.

The number of overviews that used some strategy to manage the overlap of primary studies was quantified. These were presented separately according to whether a strategy was used to visualize overlapping (eg, matrix

[25]), to quantify overlapping (eg, corrected covered area or a similar measure [9]), and to manage/resolve overlap (eg, Jadad algorithm [26]) (Table 1). Furthermore, we reported whether the strategies were used at the SR or outcome level. Strategies were used at the SR level if the overview authors visualized, quantified, or resolved the overlap when considering the totality of primary studies included in each SR. In contrast, strategies were used at the outcome level if the overview authors considered overlap for each specific outcome reported, and only those primary studies that contributed to that outcome.

Although we did not initially set out to analyze any strategy for handling overlap according to the year of publication of the overviews, this was done as several methodological aspects related to this topic have been introduced recently. This analysis was also performed for strategies aimed at resolving the overlap.

In addition, we reported the stage in the conduct of the overview at which the strategy was applied (eg, eligibility criteria, data extraction, synthesis), and whether the strategy was successful in resolving this potential problem. Overlap was considered to be resolved if the authors used a strategy to avoid double or multiple counting of data from primary studies, for example, using Jadad's decision algorithm to choose one SR only [26] or conducting a new meta-analysis (Table 1), without considering whether the strategies used are the most appropriate to achieve this objective.

The frequency with which the authors recognized this as a limitation of their study was reported for overviews that did not use any strategy for handling overlapping primary studies.

In addition, to assess whether journals with an impact factor considered overlap management of primary studies in a

Table 1. Examples of strategies to visualize, quantify and resolve overlapping primary studies

Strategy type		Examples
Visualization	Citation matrix	Diagram cross-linking SRs (columns) with all primary studies included in them (rows). Primary studies are only included once in the diagram, regardless of whether they are included by two or more SRs. In the area where SRs intersect with a primary study, a tick is placed to indicate that the SR in that column included the primary study in the row [9].
	Venn and Euler diagram	Diagrams that use circular or elliptical areas to represent intersections. The Venn diagram shows all possible intersections between SRs, while the Euler diagram shows only those intersections that are not empty, ie, where there is overlap of primary studies [25].
Quantification	Absolute frequency	Number of studies that were included in two or more SRs.
	Relative frequency	Percentage of overlapping studies, considering as a total all primary studies included in SRs, including those included in two or more SRs.
	Covered area (CA)	A measure calculated by dividing the frequency of included primary studies including double counting (N) by the product of the number of rows (r) and columns (c) of a citation matrix [9]: $CA = N/r \times c$
	Corrected covered area (CCA)	A measure calculated by dividing frequency of included primary studies including double counting (N) by the product of unique primary studies (r) and reviews (c). N and the product of r x c is reduced by the number of rows (r) [9]: $CCA = N - r/(r \times c) - r$
Resolution	Jadad's decision algorithm	Decision algorithm for interpreting discordant reviews when they address a similar research question [26].
	Conducting new meta-analyses	A strategy in which overview authors select primary studies from the SRs that meet the eligibility criteria and conduct new meta-analyses.
	Selecting the most comprehensive SR	From a set of SRs addressing a similar research question, select the SR with the highest number of primary studies.
	Selecting the best quality SR	From a set of SRs addressing a similar research question, select the SR with the best methodological quality.
	Decision algorithm developed by the authors of the overviews	Decision algorithms developed by review authors to select the 'best SR' from a group of SRs that address a similar research question. These algorithms may include criteria such as quality, timeliness, comprehensiveness, selection of Cochrane over non-Cochrane SRs, etc.
	Overlap-corrected meta-meta-analysis	Meta-analysis of effect estimates from meta-analyses included in an overview. The effect estimate from the meta-meta-analysis is corrected for overlapping primary studies. This can be done by using the effect estimate from the most comprehensive meta-analysis and then removing the overlapping primary studies from the other meta-analyses [12].

SR, systematic review.

higher proportion, we compared the proportion of overviews that reported any overlap visualization, quantification, and resolution strategies between journals with and without an impact factor using the X2 test. In our protocol, we reported that we would compare the frequency of use of any strategy according to the value of the impact factor, separating the studies into two or four equal groups [17]. However, this analysis was not performed because the impact factor value is highly dependent on the study area, and the overviews included in our metaresearch study were published in journals from different areas. A statistical significance threshold of 0.05 was used. The calculation was done with the JASP program (JASP Team (2022), Version 0.16.3).

3. Results

3.1. Search results

The electronic search identified 17,211 unique records, of which 16,355 were excluded at the title and abstract screening stage. Of the 840 reports reviewed in full text, 344 met the eligibility criteria. In addition, 16,774 unique records were identified through the backward search of the included overviews, of which 102 were assessed for inclusion, identifying ten additional reports. Thus, this metaresearch included 353 overviews published in 354 reports (Fig 1), as listed in Supplementary Table 1.

Most of the studies excluded at the full-text screening stage were due to study design, as they did not have a reported search strategy and/or did not describe the SRs included (see Supplementary Table 2).

3.2. Description of the included overviews

The number of overviews of exercise-related interventions published annually has increased exponentially since 2005, with 2020 and 2021 being the years with the most overviews published (n = 58 and n = 47, respectively), considering that overviews published only up to June 2022 were searched (Fig 2A). Half the overviews were conducted by five or more authors (interquartile range [IQR] 3−8). In addition, five overviews were conducted by a single author, and the overview with the largest number of authors included 23 (Fig 2B) (see Supplementary Table 3).

Most overviews did not focus on a specific health problem (n = 104/353; 29.5%). Of the remainder, most focused on musculoskeletal (n = 77/353; 21.8%) and neurological (n = 71/353; 20.1%) health problems (Table 2). One hundred and sixty-two journals published a single overview between 2005 and 2022. The five journals that published the most overviews in this period were PLOS ONE (n = 12), Cochrane Database of Systematic Reviews (n = 11), BMJ Open (n = 9), British Journal of Sports Medicine (n = 9), and Physical Therapy (n = 8). Of the 353 overviews, 288 (81.6%) were published in journals with an impact factor. Of these 288 overviews, half were published in journals with impact factors between 2.2 and 4.6 (Fig 2C) (see Supplementary Table 3). One hundred and thirty-three overviews (37.7%) had published or registered protocols, with PROSPERO being the most used platform (82.7%) (Table 2) (see Supplementary Table 4).

The primary objective most often reported in the overviews was the effectiveness and safety of different

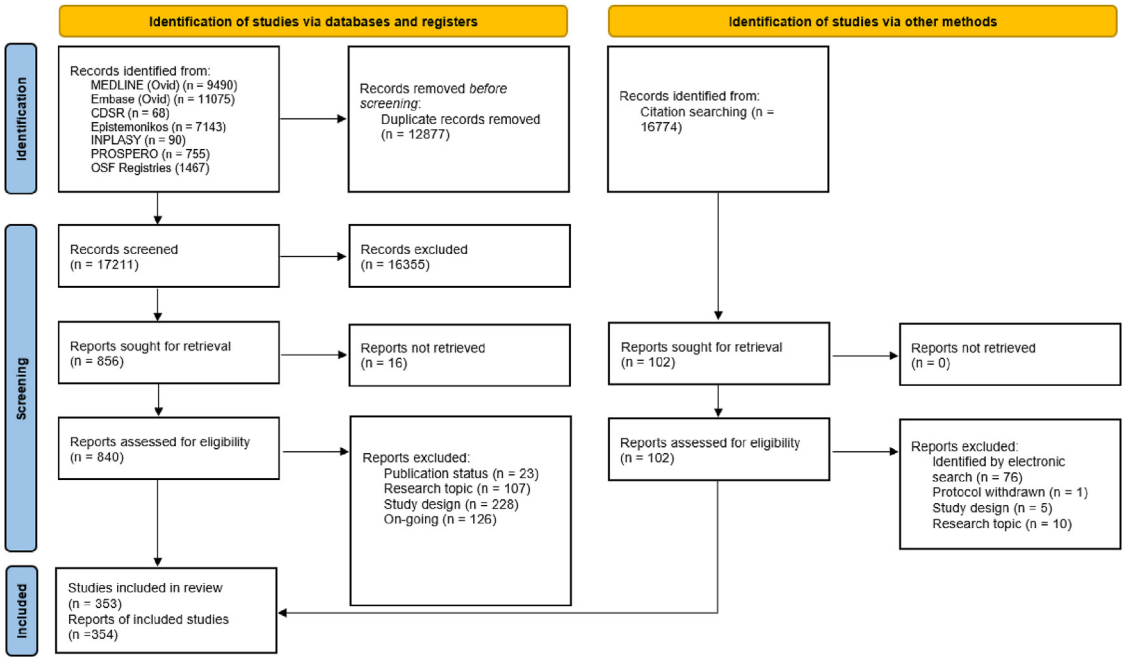

Figure 1. Study selection flowchart. CDSR: Cochrane Database of Systematic Reviews; INPLASY: International Platform of Registered Systematic Review and Meta-analysis Protocols; PROSPERO: International Prospective Register of Systematic Review; OSF: Open Science Framework. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

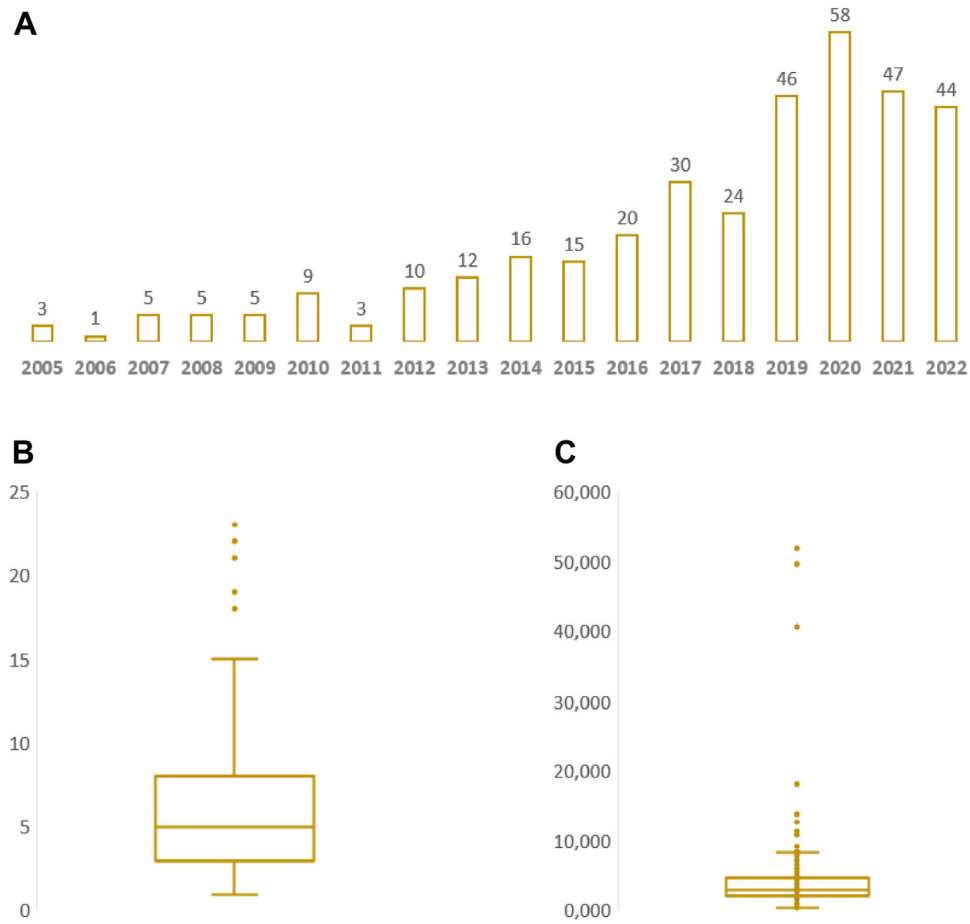

Figure 2. Characteristics of the overviews included. 2A. Trend in the publication of overviews of exercise-related interventions. *The year 2022 included overviews published only up to June; 2B. Distribution of the number of authors involved in conducting overviews of exercise-related interventions; 2C. Impact factor distribution of journals that published overviews of exercise-related interventions. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

interventions in the same population (56.1%) (Table 2). One hundred and thirty overviews (36.8%) included only SRs from exercise-related interventions and 27 (7.7%) included primary studies (see Supplementary Table 4).

Three hundred and thirty-two overviews (94.1%) reported the date the search was conducted, of which 245 (73.8%) reported only the upper limit of the search date. Half of the overviews searched a median of 5 (IQR 3−7) or more databases. MEDLINE (92.1%), via PubMed or Ovid, were the most frequently searched databases (see Supplementary Table 5).

Three hundred and twelve (88.4%) overviews reported the results in narrative form, in 28 (7.9%) a new meta-analyses was conducted, and in one (0.3%), a network meta-analysis was performed. In the remaining 12 (3.40%), the authors conducted meta-meta-analyses (meta-analyses of meta-analyses). In addition, 339 (96.0%) overviews reported having assessed the risk of bias or methodological quality of the included SRs, with AMSTAR/AMSTAR 2 being the most widely used tool (65.2%). Furthermore, 123 (34.8%) overviews reported the certainty of the evidence, with GRADE being the most used framework (90.2%) (see Supplementary Table 4).

Three hundred and forty-nine explicitly reported the number of SRs included, of which half included a median of 16 (IQR 9−31) or more SRs (see Supplementary Table 4).

3.3. Strategies used for the management of overlapping primary studies

One hundred and sixty-four (n = 164/353; 46.5%) overviews of exercise-related interventions used one or more strategies to visualize, quantify or resolve primary study overlap (Table 3). Strategies were mostly applied only at the SR level (84.0%) rather than at the outcome level (11.0%) (Fig 3A). One hundred and eighty-nine (n = 189/353; 53.5%) of the overviews used no strategies to manage overlap. Sixteen of these (n = 16/189; 8.5%) reported this as a methodological limitation of their study (see Supplementary Table 6).

Table 2. Characteristics of overviews of exercise-related interventions

Category	Number
Type of health problem or disease, *n* (%)	
Cancer	22 (6.23)
Cardiac	11 (3.12)
Mental health	26 (7.37)
Metabolic	35 (9.92)
Musculoskeletal	77 (21.81)
Neurological	71 (20.11)
Respiratory	7 (1.98)
Other	104 (29.46)
Protocol published/registered, *n* (%)	
Cochrane Database of Systematic Reviews	11 (8.27)
JBI Evidence Synthesis	3 (2.26)
BMJ Open	2 (1.50)
PROSPERO	110 (82.70)
INPLASY	4 (3.01)
OSF	3 (2.26)
Type of primary objective, *n* (%)	
Assessing the causes of discrepancies in systematic reviews	1 (0.29)
Determine the effectiveness of an intervention in the same population	58 (16.43)
Determining the effectiveness of an intervention in different populations	48 (13.60)
Determining the effectiveness of different interventions in the same population	198 (56.09)
Determining the effectiveness of different interventions in different populations	34 (9.63)
Mapping the evidence	10 (2.83)
Other	4 (1.13)

INPLASY, International Platform of Registered Systematic Review and Meta-analysis Protocols; JBI, Joanna Briggs Institute; OSF, Open Science Framework; PROSPERO, International Prospective Register of Systematic Review.

Thirty-seven (n = 37/164; 22.6%) overviews used some strategy to visualize the overlap, with the citation matrix being the most frequently used (86.5%) (Table 3). For example, Agostini et al. (2020) investigated different rehabilitation interventions in patients with idiopathic facial palsy, and used a citation matrix to visualzse the overlap, which included a column reporting the type of primary study [27]. Other less common methods of visualizing overlap were the use of bar charts, tables and network visualization (Table 3). In the overview by Khambalia et al. (2012) of school-based behavioral interventions to control and prevent obesity, the overlap was represented using bar charts separated by SRs with and without meta-analyses [28]. Heslehurst et al. (2020), in their overview of different behavior change interventions during pregnancy, presented tables of included primary studies for each SR and a table of individual primary studies, ie, not counting duplicates [29]. In contrast, Cheng et al. (2022) used a visualization network to visualize which primary studies were or were not shared between SRs on interventions for depressive symptoms in people with chronic pain [30]. This visualization network is like Venn and Euler plots but allows the identification of studies that overlap or do not overlap. These last two overviews presented the visualization of overlap as supplementary material. All the strategies used to visualize the overlap of the included overviews are shown in Supplementary Table 6.

Seventy-one (n = 71/164; 43.3%) overviews used some strategy to quantify overlap, with the absolute frequency being the most used method (47.9%) (Table 3). For example, in the overview of the effects of exercise on reducing cancer-related fatigue by Bellone et al. (2021), 11 of the 149 primary studies included in the SRs were duplicated [31]. Other less frequently reported methods were the calculation of the percentage of overlapping studies and the CCA (Table 3). Reis et al. (2019) reported in their overview of exergames for motor rehabilitation in older adults that 42.0% of primary studies were included in two or more of the 26 SRs that met their eligibility criteria [32]. On the other hand, Zhou et al. (2022) reported a 3.0% CCA in their overview of the effects of exercise interventions on breast cancer-related fatigue, which would indicate a slight overlap of primary studies [33]. All the strategies used to quantify the overlap of the included overviews are shown in Supplementary Table 6.

One hundred and eight (n = 108/164; 65.9%) overviews used their own decision rule as strategy to resolve overlap. The strategy of combining of methodological quality criterion, comprehensiveness, and most recent year of the publication to select one SR amongst multiple on the same topic

Table 3. Strategies used to visualize, quantify, and manage overlap

Category	Number
Strategies used to visualize overlap, *n* (%)	
Bar chart	1 (2.70)
Matrix	32 (86.49)
Network visualization	1 (2.70)
Table	3 (8.11)
Strategies used to quantify overlap, *n* (%)	
CCA	23 (32.39)
Absolute frequency	34 (47.89)
Percentage	12 (16.90)
CCA and Percentage	1 (1.41)
Absolute frequency and percentage	1 (1.41)
Strategies used to manage overlap, *n* (%)	
Conducting new meta-analyses	23 (21.29)
Inclusion only Cochrane reviews	19 (17.59)
Inclusion of better-quality SRs	19 (17.59)
Inclusion of the most comprehensive SRs	3 (2.78)
Inclusion of more up-to-date SRs	3 (2.78)
Description of better-quality SRs	2 (1.85)
Description of more up-to-date SRs	3 (2.78)
Description of the most comprehensive SRs	2 (1.85)
Jadad's decision algorithm	6 (5.55)
Overlap-corrected meta-meta-analysis	1 (0.93)
Selection of the SR that reported direct outcome measures	1 (0.93)
Narrative description of RCTs meeting the eligibility criteria for the overview	1 (0.93)
Inclusion of SRs with larger sample size	1 (0.93)
Authors' own decision algorithms	24 (22.22)
Stages in the conduct of the overviews in which the strategies were implemented, *n* (%)	
Study selection (Eligibility criteria)	53 (32.32)
Data extraction	10 (6.10)
Data synthesis	92 (56.09)
Study selection and data extraction	1 (0.61)
Study selection and data synthesis	7 (4.27)
Data extraction and data synthesis	1 (0.61)

CCA, corrected covered area; RCTs, randomized clinical trials; SRs, systematic reviews.

was one of the most used strategies ($n = 24/108$; 22.2%), as well as conducting a new meta-analyses ($n = 23/108$; 21.3%) to resolve overlap (Table 3). For example, in their overview on primary prevention of depression, Salazar de Pablo et al. (2021) used an algorithm that selects the most recent SR from a group of SRs that target the same intervention and population and have a score of 6/11 on the AMSTAR tool [34]. Mazuquin et al.'s (2018) overview which compared early with conservative rehabilitation in people with rotator cuff repair surgery performed a new meta-analysis from the primary studies included in the SRs [35]. Including only Cochrane SRs, selecting the highest quality SR, and using the Jadad decision algorithm are other less reported strategies (Table 3). For example, the Cochrane overview by Amatya et al. (2019) on rehabilitation of people with multiple sclerosis had Cochrane SRs as an eligibility criterion, so they only searched the Cochrane Database of Systematic Reviews [36]. On the other hand, the overview of self-management interventions for people with dementia by Huis (in het Veld et al.,2020) used the Quality Assessment Checklist for Reviews developed by Oxman and Guyatt, and excluded SRs of low methodological quality (two points or less) [37]. The overview by Wu et al. (2016), which aimed to determine whether surgical treatment is more effective than nonsurgical treatment for acute Achilles tendon rupture, used the Jadad decision algorithm to select the 'best SR' [38]. All the strategies used to resolve the overlap in primary studies are shown in Supplementary Table 6.

In seventy-nine (73.1%) of the overviews that used some strategy to deal with overlap, it was found that this potential problem was resolved (Fig 3B) (see Supplementary Table 6).

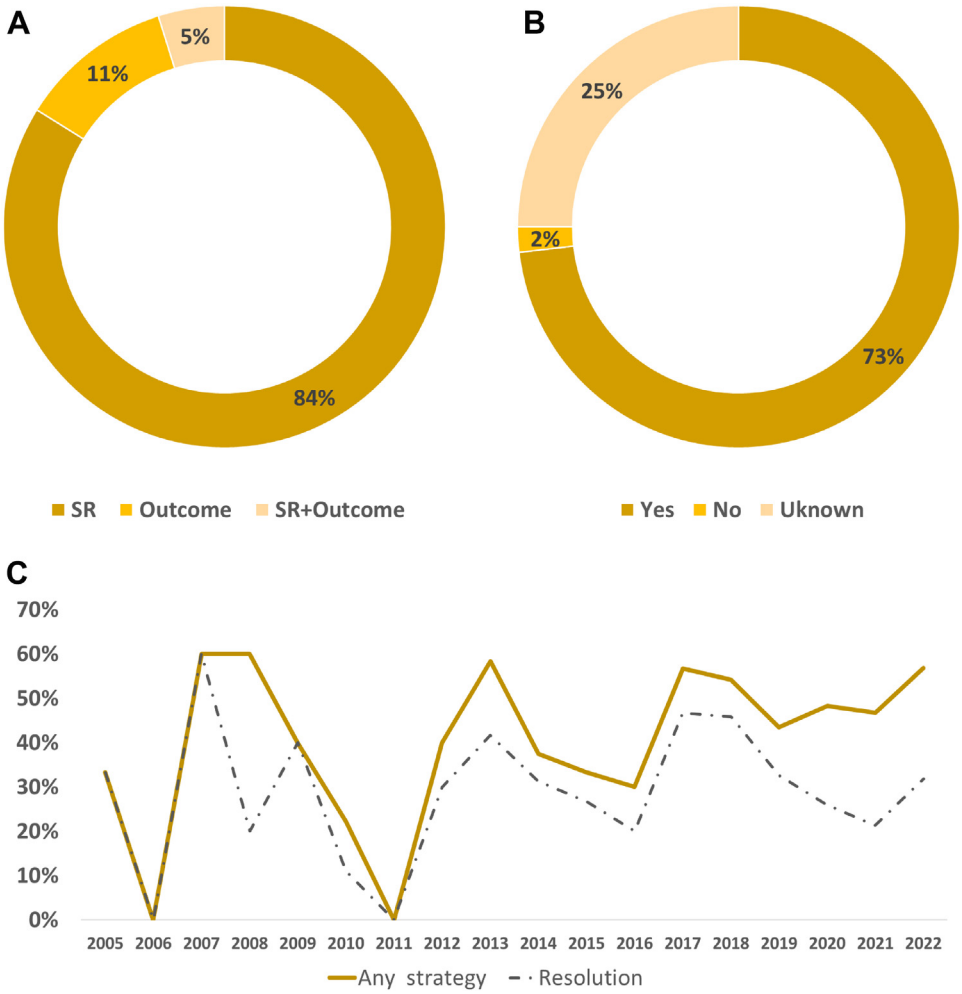

Figure 3. Managing overlap in overviews of exercise-related interventions. 3A. Level at which strategies to visualize, quantify and manage overlap were used; 3B. Percentage of overlap resolution; 3C. Proportion of overviews using any strategy to manage overlap and strategies to resolve overlap by year of publication. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

In terms of the proportion of overviews that used some strategy to manage overlap (visualization, quantification, or resolution) according to the year of publication, it is evident that there is a tendency to increase its use in recent years. However, in only 6 years, the proportion has exceeded 50%. Similar tendency occurs for strategies aimed at resolving overlap (Fig 3C). Strategies for visualizing, quantifying, and resolving overlaps were reported simultaneously in only five (3.1%) overviews. The stage of conducting the overviews where the most significant number of strategies were used to visualize, quantify, or resolve the overlap was in the data synthesis phase (56.1%) (Table 3).

Of the 288 overviews published in journals with an impact factor, 147 (51.0%) used some strategy for handling overlap. Of the 65 overviews published in journals without an impact factor, 17 (26.2%) used some strategy for overlap management ($P < .001$).

4. Discussion

This metaresearch found that only half of the authors of overviews of exercise-related interventions used a strategy to visualize, quantify or resolve primary study overlap across the included SRs. This should be improved in the future, to reduce error in precision [11,39].

While the most frequently used method to visualize overlap was the matrix that cross-references primary studies with SRs, a strategy that allows quantification of overlap [9], only about a third of the overviews included in this metaresearch used a strategy to depict overlap. Authors of future overviews should include this step in the conduct and reporting of their studies, choosing either Venn or Euler plots when there are few SRs, or upset plots, heatmaps, and node-link graphs when there are more SRs [25].

The most frequently used strategy to quantify the overlap between SRs included in an overview was absolute frequency. While this method is easy to understand, it does not validly reflect the degree of overlap. For example, is not the same to have two primary studies overlap across two SRs as across 10 SRs. Because of this, relative methods to quantify the overlap, such as the calculation of the "corrected area" (CA), should be considered. However, this measure can be influenced by a single SR containing many primary studies compared to the other SRs. Therefore, the CA should be corrected by the number of index primary studies, ie, by the number of rows in the citation matrix, resulting in the CCA [9]. In this context, future overviews should calculate the CCA to quantify the degree of overlap [9,40]. The calculation of the CCA must take into account the structural missingness due to the publication date (ie, the impossibility of overlapping a specific primary study between two SRs because this study was conducted after the search date of one of the SRs), uniqueness of included studies, type of primary study designs (eg, the impossibility of overlapping an observational study between two SRs because one of the SRs only included randomized clinical trials), and other characteristics of primary studies that may prevent their inclusion in an SR [41−43].

Among the strategies most used by overview authors to resolve overlap are the implementation of decision rules developed by the authors, which combine criteria of highest quality/low risk of bias, greatest number of included studies (ie, the highest number of included primary studies), and most recent, which result in the choice of only one SR being used in the main overview synthesis, as well as the conduct of new meta-analyses (re-analyses). Given that the unit of analysis in the overviews is the SR, conducting new meta-analyses should not be a first-choice strategy [8].

Another method used to resolve overlap is the Jadad decision algorithm (1997), which helps decision-makers to select an SR from among SRs with the same or similar PICO eligibility criteria and with discordant results [26]. However, this algorithm has been shown to be a nonreproducible tool, there is little guidance for its application, it does not consider the methodological quality of the SRs, and it needs to be updated based on recent advances in evidence synthesis [44]. Selecting one SR from a group of SRs to represent the totality of evidence on a topic has some advantages and limitations. If an overview's synthesis is based on a high-quality SR, but that SR is outdated, relevant information may be lost by not including more recent primary studies. Conversely, the SR with the highest number of primary studies may ensure that the overview's findings are based on the greatest number of studies, but if the SR is of low-quality, the overview's methods, results and conclusions may be flawed.

Our metaresearch study found that journals with an impact factor publish a significantly higher percentage of overviews that use strategies to address overlap than those without an impact factor. However, more than half of the authors of the overviews did not implement any method to deal with this overlap. This could affect the trustworthiness of the results of the overviews [45−47].

A special case is Cochrane overviews because most only include Cochrane SRs that only include single unique primary studies [8]. While this could ensure that there is no overlap, the authors of these overviews should declare that there was no overlap by checking it.

Like the study by Pieper et al. (2014) [9], our metaresearch study found that approximately half of the overviews analyzed reported using some form of strategy to visualize, quantify and resolve overlap. In contrast, a higher proportion of the overviews of exercise-related interventions that we analyzed used a strategy to resolve overlap, compared with the 12% reported by Lunny et al. (2020), which analyzed an older set of overviews between January 2015 to March 2017 [15].

A strategy used in the overviews to resolve overlap was to conduct a meta-meta-analysis. Twelve overviews determined the effectiveness and safety of one or more interventions through pooled analysis by aggregating the estimated effects of the included MAs. The results obtained using this method should be carefully assessed, as they may be flawed in magnitude and direction in the presence of different degrees of overlap [12], although this has not been tested in many studies.

Although the algorithm presented by Jadad et al. in 1997 outlined a method for the systematic selection of an SR from a set of SRs with disparate findings [26], the expected proportion of overviews incorporating any strategies to manage overlap is likely to have been limited in the following years, as can be seen in Figure 3C. This may be because Jadad's study does not explicitly delve into the potential pitfalls associated with multiple inclusions of data from the same primary studies. On the other hand, in the years after the publication of the Pieper et al. study in 2014, where the CCA index is entered [9], and the Cochrane Handbook for Systematic Reviews of Interventions in 2019, where a specific chapter is dedicated to guiding the conduct of overviews of reviews [48], it was to be expected that there would be a trend toward an increasing proportion of overviews using some strategy to manage overlap, as can be seen in Figure 3C. However, only in 3 years after 2014 did the proportion of overviews using some strategy to manage overlap exceed 50%.

In the future, authors should use guidelines to conduct more valid overviews, such as the Cochrane Handbook for Systematic Reviews of Interventions [48], and consider checklists, such as PRIO-harms [49] or the PRIOR statement [50], to achieve more adequate reporting.

4.1. Strengths and limitations of this metaresearch study

Our study has several strengths. Our eligibility criteria were broad in that, although overviews of exercise-related interventions were included, they could include SRs with nonexercise interventions, without regard to a specific definition of SR, the type of primary study design, and without language and publication date limitations. Furthermore, we adopted a systematic methodology including a comprehensive search strategy. In addition, we registered and published our study protocol, which increases the transparency of the methods used.

There are some aspects that may be considered limitations. We could have missed or made errors in data extraction, as extraction of data was not carried out independently and in duplicate. However, data from all overviews were reviewed by a second author. In addition, we did not contact the authors of the overviews when there was doubt or missing data identified.

4.2. Future research

Future research should assess the impact on the results of using different strategies for overlap resolution. In addition, the validity of conducting meta-meta-analyses and the impact of the degree of overlap on the effect estimate should be assessed.

5. Conclusion

Only half of the authors of the overviews of exercise-related interventions used a strategy to visualize, quantify or resolve overlap in the primary studies. The most overviews used methods to resolve the overlap, including using decision rules such as choosing the SRs with the highest quality, greatest number of included studies and most recent publication date. A low percentage of authors who did not use any strategy to manage overlap did, however, report this as a limitation in their discussion.

In the future, authors should report strategies to visualize, quantify and resolve overlap of primary study data to communicate more valid results.

CRediT authorship contribution statement

Ruvistay Gutierrez-Arias: Writing − original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Dawid Pieper:** Writing − review & editing, Methodology. **Carole Lunny:** Writing − review & editing, Methodology. **Rodrigo Torres-Castro:** Writing − review & editing, Formal analysis. **Raúl Aguilera-Eguía:** Writing − review & editing, Formal analysis. **Maria-Jose Oliveros:** Writing − review & editing, Formal analysis. **Pamela Seron:** Writing − review & editing, Methodology.

Data availability

All data are reported in the main document and supplementary material.

Declaration of competing interest

All authors declare no competing interests.

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Supplementary data

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