BMC Sports Science, Medicine and Rehabilitation

REVIEW

Open Access

Studies of physical activity and COVID-19 during the pandemic: an updated scoping review

Eduardo L. Caputo[1,2*], Danylo J. S. Costa[1], Igor M. Mariano[5], Leticia G. Lobo[6], Ana L. A. Ribeiro[5], Julia C. Gonçalves[1], Matheus P. Freitas[1], Priccila Zuchinali[3], Jeferson S. Jeronimo[1], Paula A. B. Ribeiro[3,4†] and Felipe F. Reichert[1†]

Abstract

Background This review is an update of the previous study aiming to identify the available evidence related to physical activity (PA) in the context of the coronavirus disease (COVID-19) pandemic.

Methods We searched 6 databases (PubMed, Embase, SPORTDiscus, Scopus, Web of Science, and CINAHL) in April 2024. Medical subject headings and keywords related to PA and COVID-19 were combined to conduct the online search, which covered the period from July 2020 to April 2024.

Results Overall, 49,579 articles were retrieved. After duplicate removal and title, abstract, and full-text screening, 1,976 articles were included in this update. Most of the studies were observational with a cross-sectional design (68.0%). Most of COVID-19 and PA studies came from high-income countries. Most studies explored the changes in PA levels due to the COVID-19 pandemic and its effects on mental health outcomes.

Conclusion Research on PA and COVID-19 prioritized online approach and cross-sectional designs. Most of the evidence identified a decrease in PA levels due to social distancing measures.

Keywords COVID-19 pandemic, Mental health, Behavior change, Exercise

Background

The COVID-19 pandemic has raised numerous concerns within our society [1]. The worldwide actions recommended to mitigate infection risk impacted not only the risk of having COVID-19 but also several other aspects of individuals' lives. In many ways, while measures such as social distancing were important to tackle coronavirus, it caused several health consequences. For example, studies from different countries have documented that the prevalence of mental health issues such as anxiety and depression have sharply increased during the pandemic, and also, the management of chronic diseases was impaired [2, 3].

Physical activity (PA) and exercise practice during pandemic times was highly impacted, not only sports

†Paula A. B. Ribeiro and Felipe F. Reichert equally supervised this work.

*Correspondence:
Eduardo L. Caputo
caputo.edu@gmail.com
[1]Postgraduate Program of Physical Education, Federal University of Pelotas, Pelotas, Brazil
[2]Center for Evidence Synthesis in Health, Brown University, Providence, USA
[3]Research Center of the CHUM, Montreal, QC, Canada
[4]Research Institute of the McGill University Health Centre, Montreal, QC, Canada
[5]Laboratory of Cardiorespiratory and Metabolic Physiology, Physical Education Department, Federal University of Uberlândia, Uberlândia, MG 38400-678, Brazil
[6]Núcleo Interno de Regulação, Hospital de Clinicas de Porto Alegre, Porto Alegre, Brazil

facilities and community centers were closed, but distancing prevented people from keeping their routines. Further, amid pandemic, these practices surge as tools for rehabilitation during and post infections (i.e., long COVID-19 and its symptoms), and these intervention modalities are still to be fully understood. Sallis et al. proposed various research avenues on PA to be pursued in conjunction with the pandemic [4]. These avenues ranged from establishing links between PA and COVID-19 to develop interventions aiming to increase PA levels during the pandemic [4].

In the previous scoping review of the literature, we have demonstrated that in the first months, most studies focused on observational designs and population-based PA practice and its impact on mental health outcomes [5]. Our first study included articles published from the inception to July 2020, therefore, the onset of the pandemic [5]. The current study is an update and shows a broader picture of what has been studied on PA and COVID-19. In this update, we aimed to provide a more comprehensive understanding of the PA research produced throughout the pandemic, along with insights into the number and methodological characteristics including the studies design, methodological approach, and ways of data collection of the studies that have investigated PA during the COVID-19 pandemic.

Methods

Protocol and registration

This is an update of a previous scoping review on PA studies within the COVID-19 pandemic [5] designed based on the Preferred Reporting Items for Systematic Reviews and Meta-analyzes statement (PRISMA-ScR) [6]. A protocol was prospectively registered within the Open Science Framework (https://osf.io/en2kc/).

Eligibility criteria

Following the same criteria adopted in the first review, we included studies regardless of their target population (e.g., adults, children, patients with chronic conditions) and setting (e.g., hospital, community). Also, studies evaluating PA as an outcome or exposure, and reporting objective or subjective measures of PA were included. Narrative reviews, panel experts, and opinion papers were excluded.

Information sources

The following databases assessed in July 2020 were reassessed in April 2024: PubMed, EMBASE, SPORTDiscus, Scopus, Web of Science, and CINAHL. The PCC mnemonic was used to guide the search strategy: humans (Population), physical activity (Concept), and COVID-19 (Context) [6]. We combined MeSH terms and keywords related to PCC concept (e.g., exercise) and context (e.g., COVID-19 pandemic) items to conduct the search as previously described [5]. We applied a date limit from July 22nd 2020, aiming to gather studies published since the date of the first search.

Selection process

Due to the volume of retrieves, in this version, we have a team of eight reviewers and extractors. For the new members of our team, we conducted two rounds of pilot screening to test reviewers' agreement in 200 retrieves total. The pilot was used to standardize members and clarify possible residual discrepancies across the team. When analyzing the Alpha Cronbach from the new team members and senior members, kappa ranged from 0.7 to 0.8. Team members with kappa < 0.8 received extra training. Eight authors independently screened data from titles/abstracts and full-texts for eligibility in a single-reviewer fashion.

Data management and extraction

All retrieved records were imported to Zotero to merge the datasets and remove duplicates. Afterwards, the final dataset was imported to SRDR platform for title/abstract screening [7]. The same reviewers extracted data from the full-text of included studies, in a single extraction fashion, that was reviewed by a second reviewer. An excel standardized spreadsheet was built for data extraction. Information such as the first author's name, year, country, methodological approach, sample characteristics (e.g., age), and study aims were extracted following the first review. In addition, research main topic (e.g., PA/exercise science), data collection approach (e.g., online), study population (e.g., chronic condition patients), and context (e.g., school) were extracted.

Data synthesis

Due to the high number of studies, we could not provide a more detailed description of studies' aims and main findings as can be found in the first version. Studies were described based on continent, study design, methodological approach, targeted population, and main research topic. The studies' research topic was coded according to title and aims; in general, all studies must have described a relationship between PA and COVID-19, but not as the primary objective. Therefore, to better characterize the studies retrieved we coded this variable according to seven research topics: Behavioral Sciences/Behavior Change, Mental Health, Nutritional, Sleep, Cognition, Multiple topics (e.g., multiple topics seem to be the center of the study), and Exercise/Physical Activity. This coding was used to describe the studies where the association

was central to the study and no other was identified as central. Data were reported as total and/or absolute frequencies.

Results

Overall, we found 49,579 retrieves and after excluding duplicates 30,559 were screened for titles/abstract. Full text assessment was performed in a total of 3,918

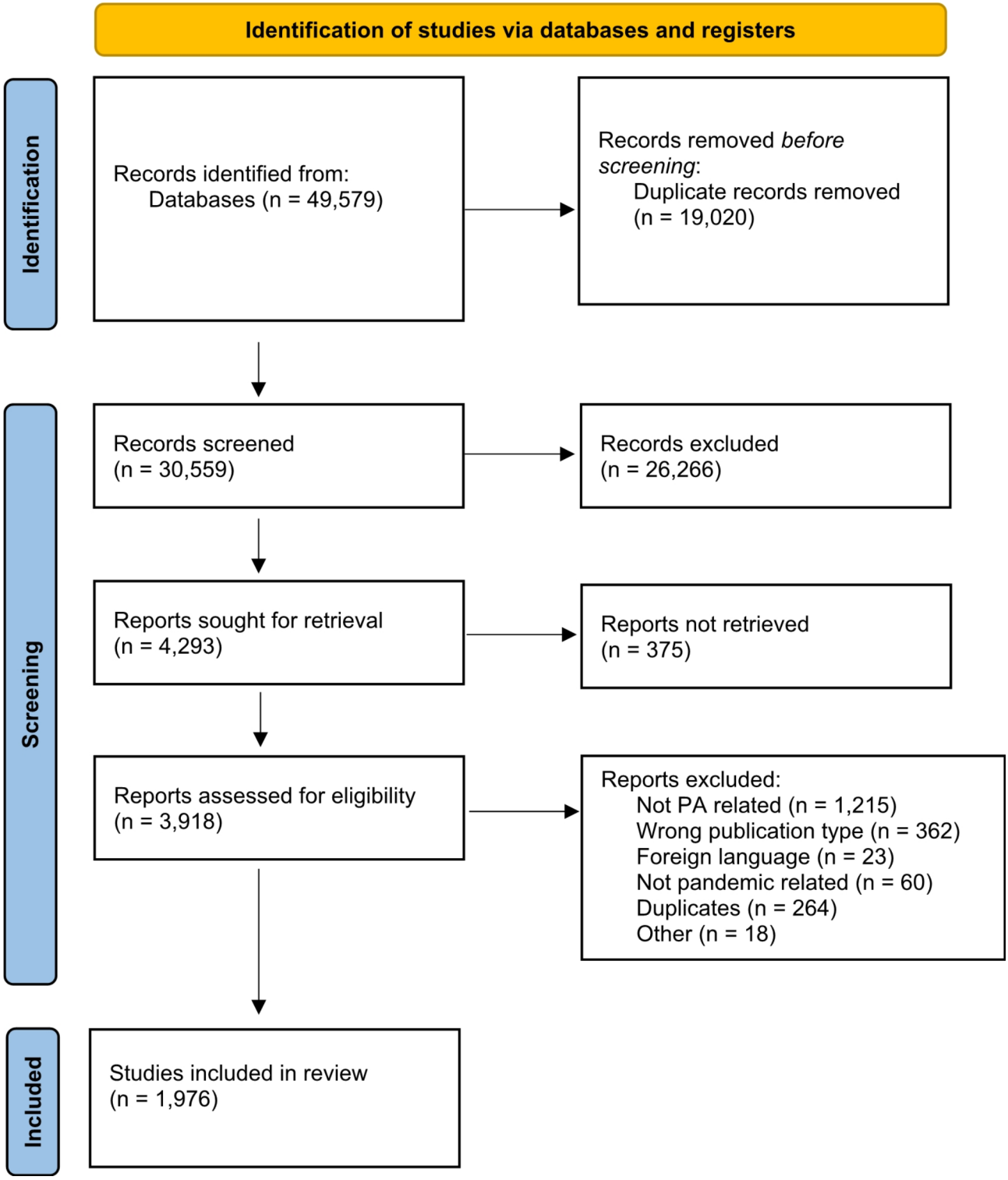

Fig. 1 Flow diagram of included studies

studies and after elegibility assessment 1,976 studies were included in this update (Fig. 1). Reasons for exclusion were mostly PA not evaluated as outcome/exposure ($n=1,215$) and not publication type of interest ($n=362$). The complete list of included studies can be found in Supplementary Material 1.

The characteristics of studies included in this review are summarized in Table 1. A quantitative approach was adopted in 94.5% of the included studies. In terms of design, the majority were observational, with cross-sectional studies being the most prevalent (68.0%), while randomized controlled trials (RCTs) constituted 4.5%. Additionally, we identified 72 systematic reviews.

Notably, 35.1% of the studies focused on adults, while specific populations such as athletes, COVID patients, and individuals with chronic conditions represented frequencies ranging from 1.8% to 6.3%. Studies targeting children and adolescents comprised 18.1% of the included studies, while those focused on the aged population constituted 8.6%. Most of the included studies were conducted in community settings (53.8%), followed by universities (14.8%), and hospital/clinical settings (12.9%) (Table 1).

Table 1 Characteristics of the included studies ($n=1,976$)

Methodological approach	*n*	%
Mixed methods	35	1.8
Qualitative	73	3.7
Quantitative	1,868	94.5
Design		
Observational (n = 1, 817)		
Case-control	20	1.1
Cohort (prospective/retrospective)	381	19.3
Cross-sectional	1,344	68.0
Systematic reviews	72	3.6
Experimental (n = 159)		
NRCS	21	1.1
Pre-post	49	2.5
RCT	89	4.5
Study population		
Adolescent (13–18 y)	145	7.3
Adults (18–65 y)	692	35.1
Aged (65 >)	169	8.6
Child (< 12 y)	127	6.4
Children and adolescents (< 18y)	87	4.4
General population (> 18y)	279	14.1
Athlete	36	1.8
COVID-19 patient	67	3.4
Chronic condition patient	124	6.3
Young adults (18–35 y)	250	12.6
Setting		
Community	1,063	53.8
Hospital / Clinical	256	12.9
School	191	9.7
University	295	14.8
Work environment	41	2.0
Other	94	4.7
Unclear	36	2.1

Figure 2 shows the number of studies published from 2020 to 2024 according to design. Cross-sectional studies comprised the higher volume of publications until 2023, even decreasing from 2021 to 2022. Also, in all periods analyzed, experimental studies remained a small proportion of the total. As expected the number of studies published reduced in 2024. Observational studies commonly employed methods such as online questionnaires, phone calls, mail, or the assessment of existing datasets. In contrast, experimental studies predominantly gathered data in-person or by assessing the electronic medical records (Fig. 3).

Figure 4 shows the distribution of studies across continents. Europe, Asia, and North America had the highest number of publications ranging from 323 to 784. Studies conducted in Africa, South America, and Oceania ranged from 32 to 221. In addition, 94 studies were conducted in multiple countries.

Regarding the main topic of research, 42.8% of the studies focused on PA/exercise sciences purely, 14.4% on its relationship with mental health, 11.2% on health-related behavior change, and 27.8% focused on multiple topics (Fig. 5). The proportions of research topic per population can be found in Supplementary Material 2.

Discussion

Our first scoping review encompassed a comprehensive analysis of 41 studies. Results showed a higher number of observational studies using online approaches, focused mostly on general population surveys, and were related to PA/exercise science or mental health. This updated review demonstrated a significant surge in scientific production on this topic, with 1,976 studies now available. This represents a 4,720% increase in a 4-year time window in research output during the pandemic [5]. Notably, both assessments highlighted a high prevalence of observational studies using online approaches. During the early months following the World Health Organization (WHO) declaration of the pandemic, research ethics committees commonly restricted in-person data collection, prompting a reliance on online methodologies. With the commencement of vaccination and the gradual relaxation of social restrictions, researchers were subsequently permitted to resume in-person data collection. While there was an evident rise in the utilization of in-person approaches compared to our initial review, online data collection methods continued to be widely employed. A noteworthy illustration of this trend is evident in studies including the PAMPA

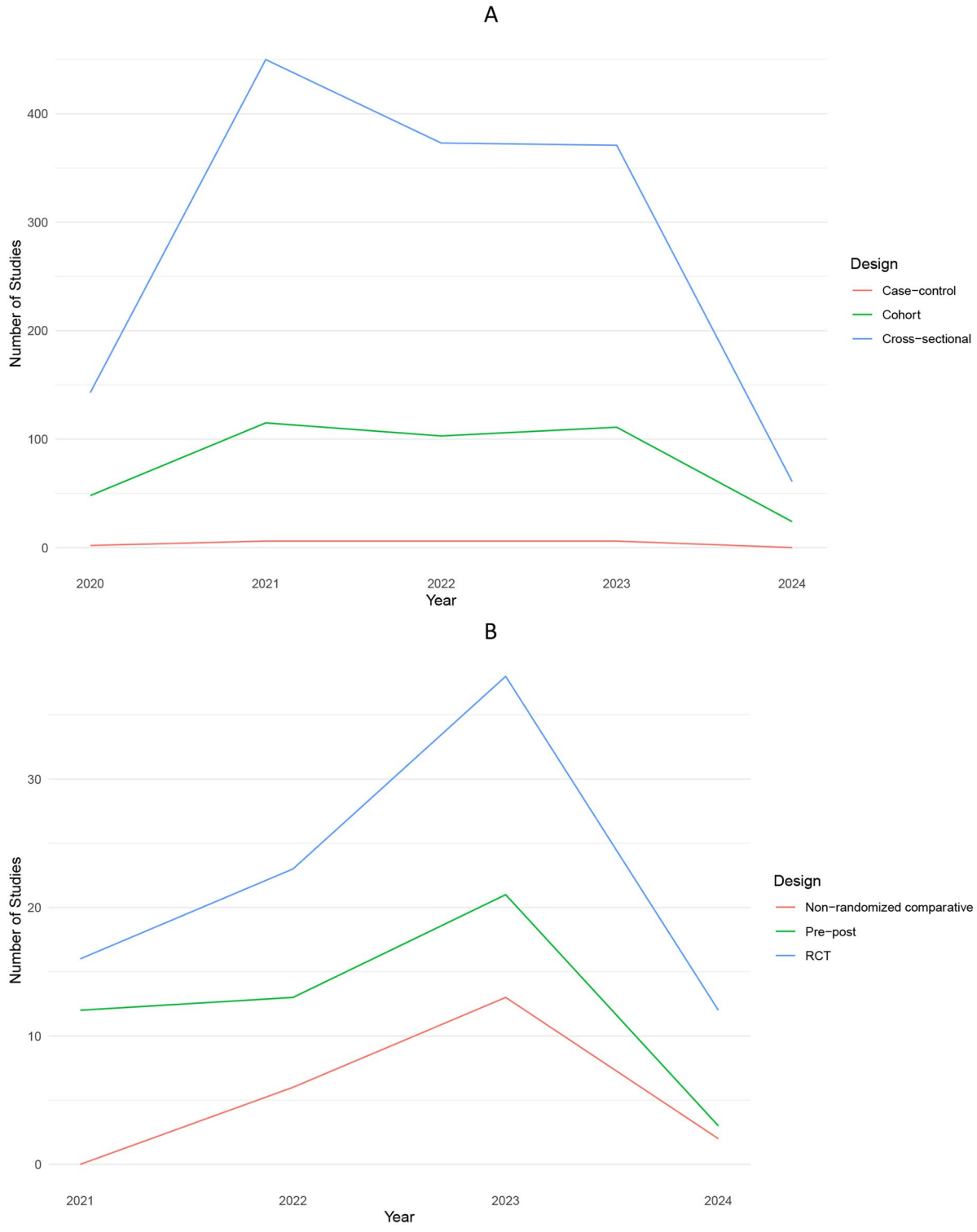

Fig. 2 Number of studies published per design and year of publication. (**A**) Number of observational studies per year of publication. (**B**) Number of experimental studies per year of publication

Cohort and the iCare [8, 9]. Despite the resumption of in-person data collection options, the researchers deliberately opted to maintain online approaches consistently across all waves of data collection.

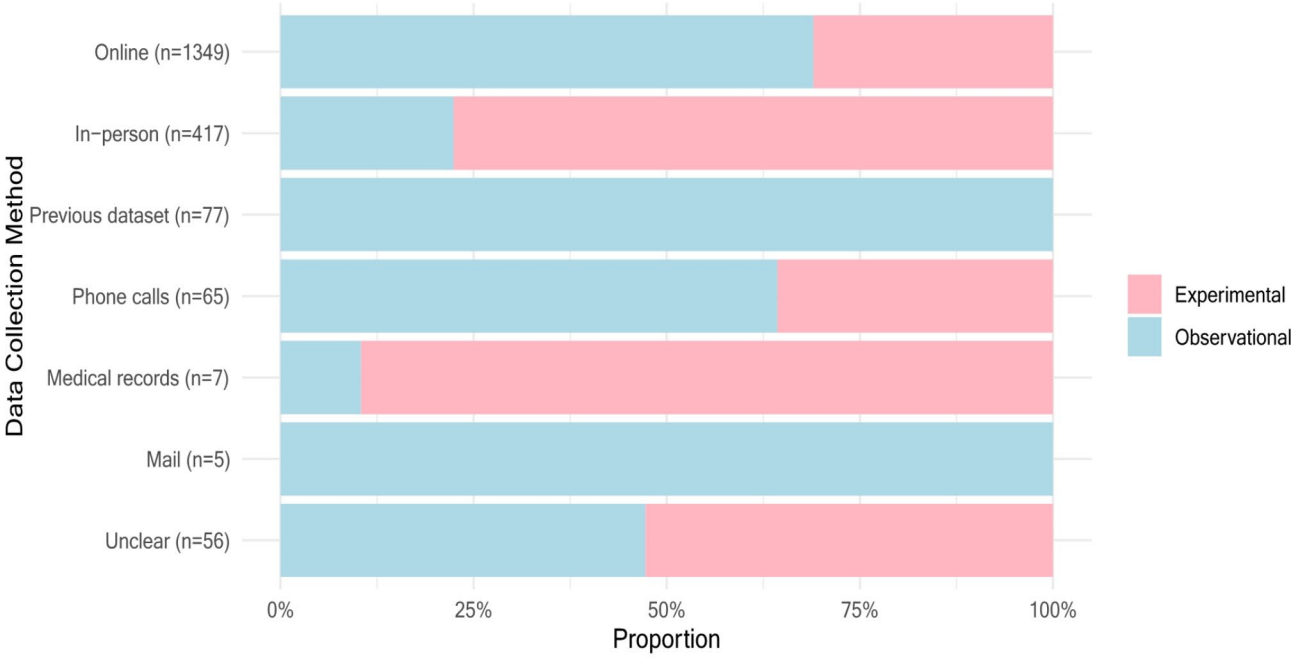

Fig. 3 Proportion of data collection approach by methodological design

Most of the studies comprised samples from the general population. Although it is important to have population-based estimates, the concern for specific populations, especially those with chronic conditions, emerged early in the pandemic [10]. Beyond the heightened risk of complications due to the COVID-19 infection, prolonged homestays raised additional concerns in patients with chronic diseases. Cancer, kidney, pulmonary, and heart conditions patients reported difficulties when managing their health status, assessing health care services, and fear of infection or severe disease episodes [11, 12]. More studies on PA or behavioral changes in this population would help understand the best strategies to self-help manage their conditions during pandemic times. Our review identified only 124 out of 1,976 studies with chronic condition patients,

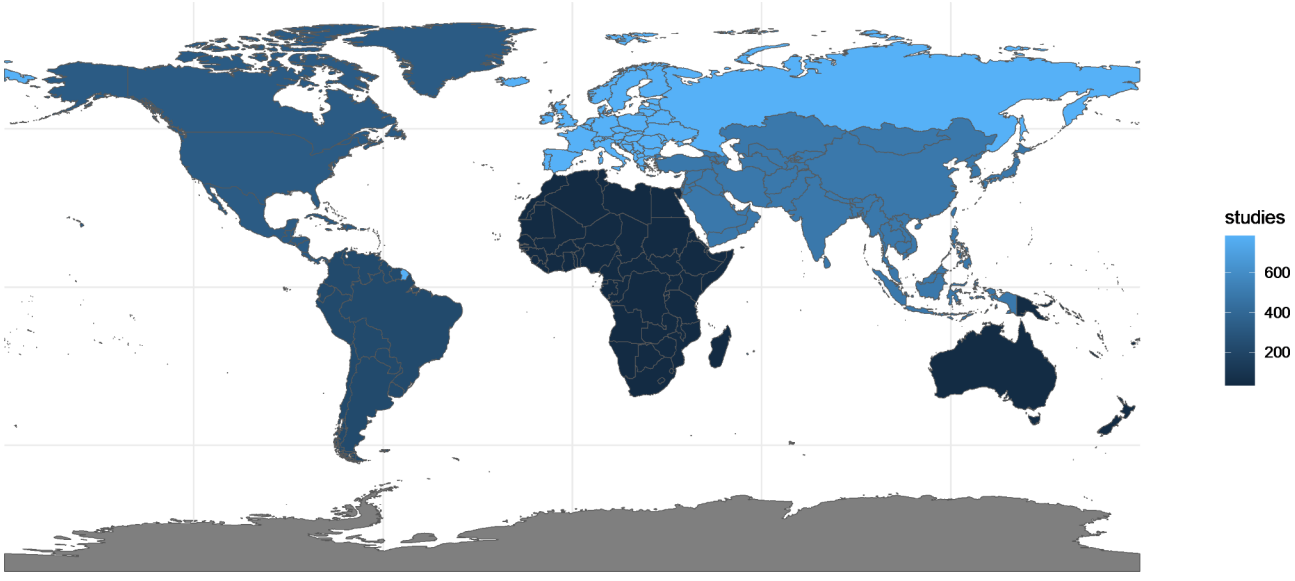

Fig. 4 Number of studies published per continent

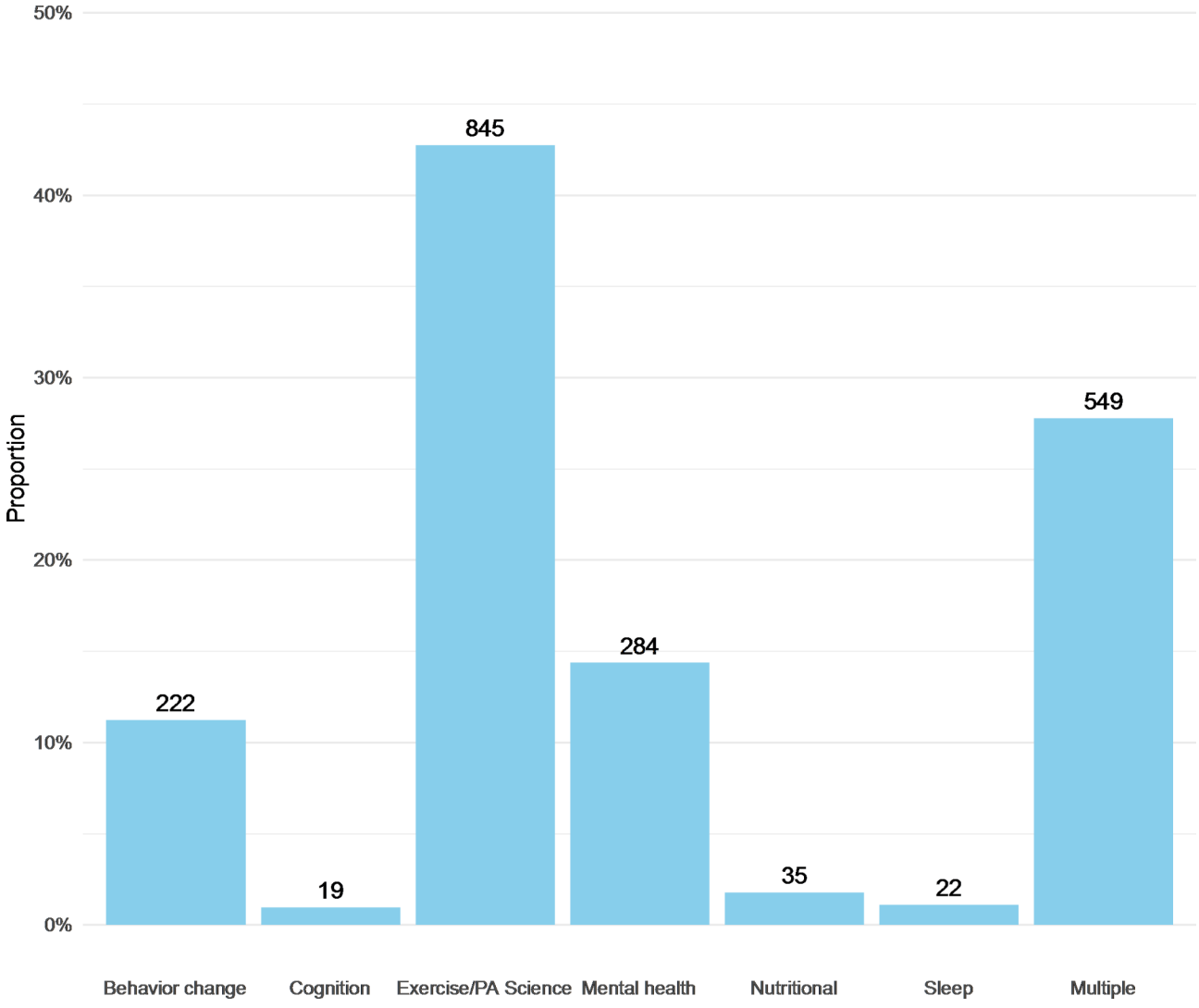

Fig. 5 Relative and absolute frequencies of studies per research topic

representing a substantial decrease in the proportion from our initial review which included 13 out of 41 studies with these populations. Furthermore, not all the conditions were comprehensively assessed, and the primary research emphasis remained on the general population.

Despite the WHO's endorsement of PA to alleviate pandemic impacts, only a limited number of countries integrated PA promotion into their control strategies [9]. Also, a notable concentration of research and development investments is observed in Europe, North America, and Asia, accounting for 90% of the global value [13]. Data from the Global Observatory for Physical Activity showed that between 2015 and 2020 research in PA increased or remained at the same levels in middle- and high-income countries, and decreased in low-income countries [14]. This corroborates our findings since most studies were conducted in countries with high research investments. Also, many low-income people did not have internet access and/or limited indoor spaces to engage in at-home PA during social restrictions, regardless of world region. In summary, we believe that the PA burden due to social restrictions might be even higher than that reported by observational studies using online approaches due to selection bias.

Sallis et al. advocated for a research agenda aiming to enhance policy and practice in PA [4]. Recently, they provided a list of topics and their status regarding current knowledge. Among the non-well-studied topics, authors highlighted PA interventions during the pandemic, by the time their paper was published comprising 2.5% of the studies on PA and COVID-19 [15]. We identified 8,0% of intervention studies, aligning with Sallis et al.'s concern that investigations into the effects of PA on diverse populations and scenarios,

as well as studies promoting PA in varied populations were scarce during this period [4, 15].

The research topic classification took into consideration the analyses of the title and studies' main objectives. We are aware that this classification might reflect interpretation and therefore must be taken with caution. However, aside from focus on PA and exercise sciences, there was a clear interest from the scientific community to investigate its association with mental health. Depression and anxiety hit record numbers across all ages, due to multiple reasons (e.g. isolation, economic insecurity, health concerns, etc.). PA has been proven to be an excellent coping resource and impacts both major conditions. Not only should future guidelines consider the effects of PA on physical health, but also the direct impact on mental health as part of a holistic perspective on pandemic impacts [16, 17].

Regarding the methodological aspects of the current review, we highlighted that the literature search was carried out in several databases and followed a systematic strategy, such as the one employed before [5]. Thus, we strongly believe that the current findings reflect what has been studied throughout the COVID-19 pandemic in terms of PA since 2020. Also, to the best authors' knowledge, this is the only study assessing the state of the art of PA research during the COVID-19 pandemic and we hope it helps drive future studies design and guidelines.

In summary, during the COVID-19 pandemic research on PA and exercise prioritized online methods and observational designs, and was mostly conducted in Europe, Asia, and North America, focusing on the general population. Future efforts should focus on developing exercise/PA interventions not only to understand their effect on persistent symptoms of COVID but also to support the development of strategies for PA promotion during pandemic scenarios.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13102-024-00967-6.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
Drs Fossati and Ribeiro equally supervised this work.

Author contributions
ELC and FFR conceive the study. DJSC, IMM, LGL, ALAR, JCG, MPF, PZ and JSJ did the screening and data extraction. ELC did the data analyses and the led the manuscript writing. FFR and PABR supervised the work and reviewed the manuscript.

Funding
This research did not receive any specific grant from funding agencies, including public, commercial, and non-profit sectors.

Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applied.

Consent for publication
Not applied.

Competing interests
The authors declare no competing interests.

Received: 6 February 2024 / Accepted: 12 August 2024
Published online: 21 October 2024

References

1. Kneip T, Börsch-Supan A, Andersen-Ranberg K. Social, health and economic impact of the COVID-19 pandemic from a European perspective. Eur J Ageing. 2022;19:789–92.
2. Salari N, Hosseinian-Far A, Jalali R, Vaisi-Raygani A, Rasoulpoor S, Mohammadi M et al. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. Global Health. 2020;16.
3. Delpino FM, da Silva CN, Jerônimo JS, Mulling ES, da Cunha LL, Weymar MK, et al. Prevalence of anxiety during the COVID-19 pandemic: a systematic review and meta-analysis of over 2 million people. J Affect Disord. 2022;318:272–82.
4. Sallis JF, Adlakha D, Oyeyemi A, Salvo D. An international physical activity and public health research agenda to inform coronavirus disease-2019 policies and practices. J Sport Health Sci. 2020;9:328–34.
5. Caputo EL, Reichert FF. Studies of physical activity and COVID-19 during the pandemic: a scoping review. J Phys Act Health. 2020;17.
6. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann Intern Med. 2018;169:467–73.
7. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev. 2016;5:1–10.
8. Durand H, Bacon SL, Byrne M, Kenny E, Lavoie KL, McGuire BE et al. Identifying and addressing psychosocial determinants of adherence to physical distancing guidance during the COVID-19 pandemic – project protocol. HRB Open Research 2020 3:58. 2020;3:58.
9. Feter N, Caputo EL, Doring IR, Leite JS, Cassuriaga J, Reichert FF, et al. Longitudinal study about the impact of COVID-19 pandemic in a southern Brazilian state: the PAMPA cohort. Acad Bras Cienc. 2022;94:e20201718.
10. Leite JS, Feter N, Caputo EL, Doring IR, Cassuriaga J, Reichert FF, et al. Managing noncommunicable diseases during the COVID-19 pandemic in Brazil: findings from the PAMPA cohort. Cien Saude Colet. 2021;26:987–1000.
11. Abraham SA, Agyare DF, Yeboa NK, Owusu-Sarpong AA, Banulanzeki ES, Doku DT et al. The influence of COVID-19 pandemic on the Health seeking behaviors of adults living with chronic conditions: a View through the Health Belief Model. J Prim Care Community Health. 2023;14.
12. Imeri H, Holmes E, Desselle S, Rosenthal M, Barnard M. The impact of the COVID-19 pandemic on self-reported management of chronic conditions. J Patient Exp. 2021;8.
13. Research and Development: U.S. Trends and International Comparisons | NSF - National Science Foundation. https://ncses.nsf.gov/pubs/nsb20225/cross-national-comparisons-of-r-d-performance. Accessed 13 Oct 2023.
14. Varela AR, Hallal PC, Grueso JM, Pedišić Ž, Salvo D, Nguyen A, et al. Status and trends of Physical Activity Surveillance, Policy, and Research in 164 countries: findings from the Global Observatory for physical Activity-GoPA! 2015 and 2020 surveys. J Phys Act Health. 2022;20:112–28.

15. Sallis JF, Adlakha D, Oyeyemi A, Salvo D. Public health research on physical activity and COVID-19: progress and updated priorities. J Sport Health Sci. 2023;12:553–6.
16. He J, Lin J, Sun W, Cheung T, Cao Y, Fu E et al. The effects of psychosocial and behavioral interventions on depressive and anxiety symptoms during the COVID-19 pandemic: a systematic review and meta-analysis. Sci Rep. 2023;13.
17. Wang C, Tian Z, Luo Q. The impact of exercise on mental health during the COVID-19 pandemic: a systematic review and meta-analysis. Front Public Health. 2023;11.

Publisher's Note