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Physical activity and physical fitness among children and adolescents after the onset of the COVID-19 pandemic in the WHO European Region: a systematic review protocol

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ABSTRACT

Introduction The implementation of COVID-19 pandemic-related restrictions resulted in limitations for physical activity (PA) opportunities, which may have initiated a longer-term behavioural change. The protocol describes the methodology for a planned systematic review that aims to summarise changes in PA and physical fitness (PF) in children and adolescents in the WHO European Region after the onset of the COVID-19 pandemic.

Methods and analysis The protocol adheres to the 'Preferred Reporting Items for Systematic Review and Meta-Analysis for Protocols' (PRISMA-P) statement. Using a peer-reviewed search strategy according to the evidence-based checklist 'Peer Review of Electronic Search Strategies' (PRESS), we will perform a systematic literature search in seven databases. Inclusion criteria are all primary studies that gathered data on children and adolescents ≤19 years living in the WHO European Region and made a comparison to pre-pandemic data. Primary outcomes are PA and PF. We will assess the risk of bias with the 'Risk of Bias Instrument for Non-Randomized Studies of Exposures' (ROBINS-E). The 'Grading of Recommendations Assessment, Development and Evaluation' (GRADE) approach will be used for the evaluation of the certainty of evidence. Also, subgroup analyses will be performed (eg, for gender, age, stringency of pandemic restrictions).

Ethics and dissemination Ethical approval is not required, as primary data will not be collected in this study. The results will be presented in a peer-reviewed publication and at congresses relevant to the research field.

PROSPERO registration number CRD42023395871.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The protocol adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols (PRISMA-P) guidelines.
⇒ We will adhere to methodological recommendations of the Cochrane Handbook, including searches in multiple databases with a peer-reviewed search strategy, independent screening and risk of bias assessments, risk of bias assessment using a validated tool and using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach.
⇒ Broad subgroup analyses are intended, allowing identification of effects specific to age and gender, vulnerability due to socioeconomic factors and the impact of COVID-19 restrictions.
⇒ The included studies measure the physical activity and physical fitness with validated tools, which likely improves data quality and homogeneity.
⇒ The study can present only short-term and medium-term effects of pandemic-related restrictions, not long-term effects because of lack of data.

INTRODUCTION

Physical activity (PA) and physical fitness (PF) in children and adolescents are accompanied by a variety of physical, mental and cognitive health benefits.[1–3] This comprises, most importantly, improved cardiometabolic health, mental health, cognitive function, school achievement as well as reduced risk for metabolic syndrome and adiposity.[3–8] PA and PF—positively influencing each other—in pre-adult years are strongly related to levels in adulthood.[3 9 10] Hence, they have an immediate impact on health[2 11] and disease burden[12] later in life. In the updated global guidelines, the WHO has given a strong recommendation of at least an average of 60 min daily of moderate-to-vigorous PA for children and adolescents.[1] Looking at PA before the COVID-19 pandemic, both globally and for European children and adolescents, it has been concluded that the vast majority of children (71%[13 14]) and adolescents (75%–86%[13 15 16]) do not undertake sufficient PA in their daily lives; thereby females, older children and adolescents were

more often physically inactive.[13 15–17] Meanwhile, physical inactivity has been designated as global pandemic,[18] with an enormous long-lasting disease burden in later life[12] and a high overall economic burden.[19] In response, in 2019, the WHO published a global action plan to increase PA.[20] One of its main goals is to reduce physical inactivity among adolescents and adults by 15% by 2030. The WHO also highlighted schools and access to green and public spaces as important components in the implementation and stabilisation of an active lifestyle among children and adolescents.[20]

With the onset of the COVID-19 pandemic, numerous public health and social measures (PHSM)[21] were implemented to minimise the spread of the virus. The measures focused mainly on a reduction of social contacts, which led to major restrictions and adaptations in the daily life of the children and adolescents. This included closure of kindergartens, schools and public places, the halting of youth sports and school-based PA, restriction of contact with peers, modifications in family life due to home office and quarantine regulations,[22] resulting in limited access and opportunities for PA.[23] Some of these restrictions, such as school and kindergarten closures, persisted for many months, with broad variability among European countries. Global systematic reviews have documented a decline in total PA during the COVID-19 pandemic ranging from 11 to 91 min/day,[24 25] respectively, a reduction of 20% for total PA or 28% for moderate-to-vigorous PA[26] and also named relevant subgroups (eg, older youth, lower social status, girls/females). There are indications that PHSM-related school closures could have intensified the decline,[27] and other public health relevant behaviours were suboptimally influenced.[28] Also, comparisons in primary studies of PF before and during the COVID-19 pandemic show a decline in youths' PF skills.[29 30]

However, there are still important research gaps concerning PA and PF of children and adolescents.[1] At present, no systematic review addresses the changes during COVID-19 pandemic in the WHO European Region for PA and PF among children and adolescents. A preliminary investigation revealed several primary European studies with indifferent results for PA.[31–33] Further, the study results varied in methodological approach, the change magnitude and the diagnostic instruments used.[31–33] For PF, there is no summary of primary studies at all.[2] Additionally, the measures chosen to control the COVID-19 pandemic varied (greatly) depending on the country. From previous meta-analyses, it is known that the stringency of measures had an essential influence on the health of children and adolescents.[34 35] Therefore, the inclusion and consideration of the stringency of measures is an imperative determinant for indicating possible consequences on PA and PF. Also, the length of lockdown measures and the time period after lifting PHSM could be important determinants for youths' PA and PF. Considering the WHO European Region, different stringencies and lengths can be compared in geographical proximity, which allows for a quasi-experimental design.[3] Further, previous reviews have mainly investigated the immediate impact of the COVID-19 pandemic on PA due to limited data availability.[26 36] However, it is of high public health relevance to know how the pandemic restrictions have affected the PA and PF behaviour of children and adolescents in a medium-term perspective.[4] There is limited evidence to date concerning the various subgroups in the population of children and adolescents (eg, gender, age, social status, time of measurement) who are particularly affected by pandemic-related restrictions. Addressing these research gaps has major public health relevance in providing a basis for investigators, providers and policy makers to guide decision-making, as well as to improve the health and well-being of children and adolescents.

Therefore, we intend to conduct a systematic review that aims to critically synthesise the evidence regarding the impact of the COVID-19 pandemic on PA and PF among children and adolescents in countries of the WHO European Region compared with a pre-pandemic baseline, differentiating the following research objectives:

1. Estimation of the change of PA and PF among children and adolescent in countries of the WHO European Region (with published data) after the onset of the COVID-19 pandemic compared with a pre-pandemic baseline.
2. Evaluation of the impact of the PHSM stringency and length during the COVID-19 on PA and PF among children and adolescents in countries of the WHO European Region (with published data).
3. Determination of the effect changes of PA and PF over time, allowing for the analysis of possible recovery effects after the end of most restrictions during 2021, under consideration of studies until January 2023 (date of publication).
4. Analyses of changes in PA and PF for central demographic and socioeconomic subgroups.

METHODS AND ANALYSIS

This systematic review protocol followed the Preferred Reporting Items for Systematic Review and Meta-Analysis for Protocols (PRISMA-P) statement[37] (online supplemental table S1) and was registered on the International Prospective Register of Systematic Reviews (PROSPERO; CRD42023395871).[38] The final systematic review will be conducted according to the PRISMA statement[39] and will follow the guidelines of the actual *Cochrane Handbook for Systematic Reviews*.[40]

Eligibility criteria

We formulated the eligibility criteria in accordance with the Population Exposure Comparison and Outcome (PECO) scheme,[41] presented in table 1.

Information sources

We will search in seven electronic databases (PubMed, Embase, Sports Medicine & Education Index, PsycINFO, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL) and WHO COVID-19 Research

Table 1 Inclusion and exclusion criteria according to the Population Exposure Comparison and Outcome (PECO) scheme

Category	Inclusion criteria	Exclusion criteria
Population	General population ≤19 years* of any gender† in the WHO European Region[76] without exclusion studies with specific populations (eg, chronically ill children)	Studies with population samples with >19 years or mixed population samples of children, adolescents and/or adults Studies with any population group outside of the WHO European Region Countries that are not included in the WHO overview[76]
Exposure	At least one data collection within COVID-19 pandemic	Previous pandemics
Comparison	Pre-pandemic baseline included in the study (eg, same population, similar population, cross-sectional population sample)	No comparison Only comparisons of two time points within the COVID-19 pandemic
Outcome	1. Physical activity (PA) – In time specifications (minutes or hours) per day or week – In scores (eg, instrument 'PA Questionnaire for Adolescents') measured with validated instruments 2. Physical fitness (PF) measured with validated instruments.	Measures of any other outcomes or using any non-validated instruments
Effect measures	All effect measures	–
Study design‡	Primary studies analysing pre-pandemic and pandemic data on PA with no limitations regarding study design including primary and secondary data analyses	Reviews, systematic review, meta-analysis, case studies
Language	No restrictions	–
Timeframe	From 1 November 2019§	Before 1 November 2019
Publication status	Published studies, grey literature, pre-prints, congress abstracts‡	Other publication status
Species	Human studies	Animal studies

*The cut-off of ≤19 years was chosen in accordance with the WHO report.[77]
†In accordance with the Sex and Gender Equity in Research (SAGER) guideline, we assume the term 'gender' which refers to socially constructed roles, behaviours and identities of females, males and gender-diverse people.[78]
‡According to the recommendations of the *Cochrane Handbook for Systematic Reviews*.[51]
§According to the PubMed COVID-19 article filter.[43]
¶For example, International Society for Behavioural Nutrition and Physical Activity, World Congress on Public Health, European Public Health Conference.

Database (including pre-prints)) for articles published between 1 November 2019 and 31 January 2023. Further, we will perform forward citation tracking and check cited references of all included studies and related systematic reviews and meta-analyses. We will also check study registers (eg, PROSPERO, clinicaltrials.gov; see online supplemental table S2), conference submissions and websites of key organisations (online supplemental table S3). We will contact study authors to receive information of study status or data, if applicable.

Search strategy

The search strategy combined terms related to (1) children and adolescents, (2) PA and PF and (3) the COVID-19 pandemic, using the Boolean operator terms. No limits on language will be imposed. Reviews, systematic review, meta-analysis and case studies will be excluded from the systematic search. Development of the database-specified search strings occurred using validated or recommended search filters where possible (eg, for identifying paediatric studies in PubMed,[42] search strings for COVID-19 records in PubMed[43 44] and search filters offered by the InterTASC Information Specialists' Subgroup Search Filter Resource[45]; in parts modified) and adapted search strategies from Cochrane systematic reviews concerning PA and PF.[46–48] The developed search strategy for PubMed was peer reviewed by an expert for systematic reviews in health sciences prior to execution considering the evidence-based Peer Review of Electronic Search Strategies (PRESS) checklist.[49] Afterwards, the search strategy was slightly modified and translated to the other databases. The search strategies for all databases are presented in online supplemental table S4.

Study records

Data management

The results of the literature search will be uploaded to the recommended *EPPI-Reviewer Web software*[50] and screened automatically for duplicates. All screening steps will be conducted in *EPPI-Reviewer*, afterwards an export of the final studies to *Citavi, V.6.4.0.35*, will be performed.

Selection process

In accordance with the inclusion and exclusion criteria (table 1), we will conduct study selection in a two-stage process. First, all publications will be screened at title

and abstract level. For publications that appear to meet the inclusion criteria or where there is uncertainty, the study's full text will be obtained. Second, the full texts will be screened for a final selection of the studies to be included. Publications will be screened independently in teams of two reviewers (HL-W, ID, SH), any discrepancies will be discussed and, if necessary, resolved by a third author (MB). In the case of duplicate publications or multiple reports of a study, we will maximise information yield by collecting all available data and using the most complete data set.[51] Publications with the same study population with several pandemic measurement points will be considered individually. We will report reasons for full-text study exclusion in the online supplemental information. The screening process will be illustrated using the PRISMA flow diagram.[39]

Data collection process

A data extraction form will be developed predicated on previous reviews[26 34–36 52] and pilot tested. Two reviewers (HL-W, SH) will extract the data independently and compare it afterwards, any discrepancies will be resolved by discussion or with the involvement of a further reviewer (MB). If the provided data in the published studies are insufficient, authors will be asked to provide further information.

Data items

It is planned to extract and summarise the study data in three tables: (1) characteristics of included studies, (2) summary of effect estimates and (3) summary of findings. In the table 'Characteristics to be extracted from included studies', information from five categories will be extracted for a descriptive study overview. The categories are outlined in table 2.

We will place a particular focus on the impact of PHSM stringency during the COVID-19 pandemic on PA and PF changes among children and adolescents (research objective 2) by using the validated Oxford COVID-19 Stringency Index.[22] The index is computed using nine metrics of social distancing policy: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements and international travel controls; it has a total score estimate that ranges from 0 (no restrictions) to 100 (most stringent restrictions). A mean score will be calculated for each study measurement period during the COVID-19 pandemic. In accordance with the COVIDSurg Collaborative,[53] we will specify three cut-off points: light restrictions (index <20), moderate lockdowns (index 20–60) and full lockdowns (index >60). Further, we will specifically consider the School Closure Index, also implemented in the Oxford COVID-19 Stringency Index, which records closings of schools and universities. The index range is from 0 to 3: 0 for no measures, 1 for recommended closings or changes in school operations, 2 for partially school closures and 3 for closing of all school levels.[22 54] Therefore, we will define the following cut-offs: no or few alterations compared with a pre-COVID-19 situation (index <2) and partial or full school closure (index ≥2).[34 35] In addition, we will also look at the total length of the restriction measures and, if possible, the time period from removing restrictions.

The 'Summary of effect estimates' table will include the effect estimates for before and during COVID-19

Table 2 Characteristics to be extracted from included studies

Category	Planned data for extraction
Study information	► First author ► Year of publication ► Country ► Study type
Population and setting	► Sample size (% female) at pre-pandemic baseline and during COVID-19 pandemic ► Age (mean or median; SD or range)
COVID-19 determinants	► Time point (month/year) of data measurement ► Policy restrictions in the measurement period, described by using the Oxford COVID-19 Stringency Index and the School Closure Index[22] as a proxy indicator ► Length of restriction measures, if applicable ► Time period of removed restrictions, if applicable ► Duration of follow-up
Pre-pandemic baseline	► Time point (month/ year) of data measurement ► Link between pre-pandemic and during pandemic population (same population, similar population, cross-sectional population sample)
Outcome	Physical activity (PA) ► Self-reported/parent-reported diagnostic instrument Name of used instrument Estimated time frame (weekday/weekend) Predefined cut-off points, if applicable Symptom reporter (self-reported or parent-report) Validation information ► Device-based measurement (based on Tanaka *et al*[79]) Brand of used instrument Number of days worn Weekend capture (yes/no) Predefined cut-off points, if applicable Validation information Physical fitness (PF) ► Physical fitness assessment instrument ► Name of used instrument ► Setting (e.g., school, sports club) ► Symptom reporter (e.g., teacher, research staff) ► Validation information

pandemic, change of PA or PF, adjustment variables (if reported), considered subgroups and the risk of bias for each study. In a 'Summary of findings' table according to GRADE, we will present the main findings of the review and the certainty of evidence per effect estimate of each outcome.[55]

Outcomes

The primary outcomes will comprise PA and PF. In accordance with the WHO, we will define PA as any bodily movement that requires energy expenditure during leisure time (either structured or unstructured by an organisation), at school/other settings or for getting from one place to another.[1] Changes in the duration of daily PA will be (1) transferred (or calculated) in minutes per day and SD or (2) differences between scores with SD will be calculated. If possible, we will further separate the outcome in total PA and moderate-to-vigorous intensity PA (according to the definition of the WHO[1] and the Centers for Disease Control and Prevention[56]). The outcome PF is defined as attributes that children and adolescents achieve that relates to the ability to perform PA (eg, cardiorespiratory endurance, muscular endurance/strength, flexibility).[57]

In a preliminary analysis of the literature, we found that both PA and PF were measured with a variety of instruments. In order to ensure a high-quality analysis, we decided to include only validated instruments in this review. No restrictions will be defined on measurements number during the COVID-19 pandemic. If various pre-pandemic measurement dates will be available, we will consider the most appropriate or the latest time point for effect estimate calculation. We will extract adjusted values; if these are not available, we will select unadjusted results. Effect estimate will be reported with a 95% CI.

Risk of bias

From reviews that have already been published[26 36] and our preliminary analysis, we expect primarily observational studies. Hence, two review authors (HL-W, SH) will independently assess the risk of bias using the instrument for non-randomised studies of exposures (ROBINS-E),[58] a modification of the risk of bias in non-randomised studies of interventions (ROBINS-I) tool.[59] This instrument includes seven items: (1) risk of bias due to confounding, (2) risk of bias arising from measurement of the exposure, (3) risk of bias in selection of participants into the study, (4) risk of bias due to post-exposure interventions, (5) risk of bias due to missing data, (6) risk of bias arising from measurement of the outcome and (7) risk of bias in selection of the reported result. The possible ratings for each risk of bias item include: 'low', 'some concerns', 'high risk of bias' or 'very high risk of bias'. Lastly, a complete risk of bias rating will be done for each study. We will not exclude studies with high or very high risk of bias from the further analyses. However, we will differentiate between studies that are rated as low/some concerns (=low) risk of bias and high/very high (=high) risk of bias in order to address potential confounding. The risk of bias ratings will be visualised as 'traffic light' plots of the domain-level judgements for each individual result and 'weighted bar plots' of the distribution of risk-of-bias judgements within each bias domain, using the tool *robvis*.[60]

Data synthesis

First, we will provide a 'Summary effect estimates' table for each study with absolute changes for PA and PF before and during the COVID-19 pandemic, grouped by country and risk of bias (see the Data items section). Second, if at least three of the included studies with different study populations are sufficiently homogeneous in terms of study design, participant characteristics (age, gender) and effect estimates, we will conduct meta-analyses. For this, equal effect estimates should be available or it should be possible to convert them into a common effect estimate. We will calculate standardised mean differences (SMD) to provide a pooled effect if the same outcome was measured with different instruments and to permit inter-study comparisons. SMD effect sizes will be considered as small, medium and large for 0.2, 0.5 and 0.8, respectively.[61] To estimate the pooled change in PA and PF, mean changes and SD of the change will be combined in random-effects meta-analyses using the inverse-variance method. If SD are missing, we will calculate them from p values, CIs or SEs, if available or contact the study authors.[40] To explore variations due to age, gender, social status, seasonality, measurement instrument and risk of bias in individual studies as possible effect modifiers,[17] we will conduct subgroup analyses. Also, the stringency of pandemic-related measures will be considered by conducting comparative analyses between full versus moderate lockdowns (Oxford Stringency Index >60 vs ≤60) and school closures versus no school closures (School Closure Index ≥2 vs<2) considering also the total length of PHSM and, if possible, the time period of removed restrictions. Results from adjusted analysis will get preference in the meta-analysis to provide a more conservative estimate (a sensitivity analysis will be performed when including unadjusted effect estimates). When both parent and self-rated data are provided, the self-rated data will be chosen for meta-analysis.[62] Results of the meta-analysis will be illustrated using forest plots.

We will assess heterogeneity across studies by visual interpretation of the forest plots, applying I^2 statistic,[63] and the calculation of prediction intervals when >3 studies are included in meta-analyses.[64–66] Heterogeneity will be interpreted as substantial if I^2 is greater than 50%.[64] If substantial heterogeneity is detected, we will make efforts to explain it by performing subgroup analyses, sensitivity analyses and/or meta-regressions.[64] For performing meta-regression analyses, a minimum of 10 studies will be assumed per examined variable.[64]

The analyses will be conducted with R Studio V.4.2.1[67] using the package *meta*.[68] If a statistical pooling (meta-analysis) appears to be inappropriate, for example, if

study designs differ considerably, a tabular, graphical or narrative synthesis will be provided.[69]

Sensitivity analysis

We will conduct sensitivity analyses to determine whether the pooled results are robust. Therefore, the meta-analysis will be repeated with different comparison categories,[40 70] for example, low versus high risk of bias, cohort versus cross-sectional studies (or randomized controlled trial, if available) and adjusted versus unadjusted effect estimates.

Publication bias

We will also consider potential publication bias by visual interpretation of (contour-enhanced) funnel plots.[71 72] Further, we will apply the Egger's test, when a minimum of 10 studies are included in a meta-analysis.[73]

Certainty of evidence

We will evaluate the certainty of evidence for PA (min/day, scores) and PF using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach adapted to the use of non-randomised studies.[74] GRADE considers five domains for downgrading (risk of bias, inconsistency, indirectness, imprecision and publication bias) and also three domains for upgrading (large effects, dose response and opposing plausible residual bias and confounding).[75] The use of the risk of bias instrument for non-randomised studies will allow us to start at 'high' initial certainty of evidence within GRADE.[70] A detailed description of the downgrading and upgrading determinants will be provided in the publication of the final systematic review. Two reviewers (HL-W, WS) will independently evaluate the certainty of evidence and then compare the ratings; discrepancies will be resolved by discussion or by involving a third reviewer (MB). GRADE finally defines for each outcome four certainty-of-evidence levels: high, moderate, low or very low.[75] We will summarise the certainty of evidence in a 'Summary of findings' table, extended by evidence profiles with more detailed explanations in the online supplemental information.[75]

DISCUSSION

There is an urgent public health need to identify possible medium-term and longer-term changes in PA and PF of children and adolescents in the WHO European Region. These changes need to be analysed by gender, age group, time of measurement and socioeconomic characteristics. To our knowledge, this will be the first systematic review searching for and summarising the evidence regarding changes of PA and PF among children and adolescents in the WHO European Region after the onset of the COVID-19 pandemic in comparison to pre-pandemic baselines and using validated measurement instruments.

Some limitations and challenges of the intended review also need to be considered. A limitation may be the heterogeneity in reporting and measuring of outcomes. Especially the identification of validated measurements for PF is a foreseeable challenge of the review as the tools used in the literature are very heterogeneous. Although we chose clinically relevant subgroups, we are aware that subgroup analyses will be explorative and may result in false-positive findings due to multiple testing. The review will present only medium-term effects of pandemic-related restrictions, not long-term effects because of lack of data. Since we do not expect to consider studies meeting our strict criteria for all 53 countries of the WHO European Region, our findings will not be generalisable to all of Europe. But we aim to use the country-specific variation of PHSM measures and school closures in order to consider their association with PA and PF.

We intend to include heterogeneous study designs (eg, cohort, panel, cross-sectional, retrospective survey), therefore, different characteristics of these designs have to be considered. Cohort or panel studies examine the same individuals but cover a longer period between survey dates, so that children and adolescents are older and changes in PA and PF behaviour could result from this. This allows for comparison within as well as comparison between different individuals. Cross-sectional studies analyse individuals of the same age or in similar settings, but not the identical samples of respondents, which can bias the results. Retrospective surveys are subject to recall bias. We will address these limitations by applying the recommended ROBINS-E tool, considering especially four (from seven) domains: 'risk of bias due to confounding' (domain 1), 'risk of bias arising from measurement of the exposure' (domain 2), 'risk of bias in selection of participants into the study' (domain 3) and 'risk of bias due to missing data' (domain 5).[58]

The restrictive inclusion criteria regarding a pre-pandemic baseline and the utilisation of validated instruments may lead to a consideration of mainly quantitative panel studies. However, such a focus seems to be adequate for our research questions and for allowing meta-analysis. Although analyses of country-specific and time-specific contexts of PHSM are intended by using the Oxford Stringency Index and other subgroup comparisons (eg, age, gender, time of measurement, length of restriction, risk of bias, and measurement instruments), not entirely all factors influencing the change in PA and PF can be completely covered. The central strength of the review is the use of different state-of-the art approaches such as PRISMA, PRESS, ROBINS-E and GRADE. Additionally, we adhere to methodological recommendations of the Cochrane Handbook and the restrict data extraction to validated measurements. By highlighting country-specific differences and the impact of pandemic-related restrictions such as school closures on PA and PF, conclusions might also be drawn regarding the management of future crises or pandemics. The findings will close relevant evidence gaps and will provide implications for practitioners, policy makers, families and stakeholders.

Ethics and dissemination

Ethical approval is not required as no primary data will be collected for the systematic review. The results will be published in a peer-reviewed journal and presented at congresses relevant to the research field.

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