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Methods and Digital Technology Solutions to Monitor Physical Activity in Paediatric Oncology Patients: A Scoping Review Protocol

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Abstract

Physical activity (PA) plays a critical role in supporting recovery and improving overall health outcomes in paediatric oncology patients, who commonly experience cancer and treatment related side effects such as fatigue, reduced muscle strength, decreased cardiorespiratory fitness, and an increased risk of long-term chronic conditions. Despite well-established PA guidelines, many children and adolescents undergoing or recovering from cancer treatment fail to achieve recommended activity levels. Barriers include physical limitations, psychological distress, treatment-related symptoms, and limited availability of structured PA programmes integrated within clinical care. These challenges underscore the need for accessible, feasible, and engaging PA interventions tailored to this vulnerable population. In recent years, digital health solutions have emerged as promising tools to support PA promotion and monitoring. Technologies such as augmented reality, gamification, wearable activity trackers, and mobile health applications offer opportunities for remote monitoring, personalised feedback, and increased motivation. These tools may help overcome traditional barriers by enabling flexible, home-based PA engagement and facilitating real-time data collection. However, the extent to which such digital instruments effectively capture PA behaviours and influence activity levels in paediatric oncology remains unclear. This scoping review aimed to address existing gaps in the literature by systematically identifying and mapping the instruments used to monitor PA in paediatric oncology patients during active cancer treatment. Both conventional methods, including questionnaires and observational measures, and digital approaches, such as wearables and app-based monitoring systems, were examined. By synthesising current evidence, this review seeks to provide an overview of available PA monitoring tools, highlight methodological trends and limitations, and inform future research and intervention development in paediatric oncology care.

Keywords: Paediatric oncology; cancer; physical activity monitoring; augmented reality; digital solutions; gamification

1. INTRODUCTION

Every year, approximately 400,000 children and adolescents aged 0–19 are diagnosed with cancer (World Health Organization, 2021). Advances in treatment have significantly improved survival rates, with over 80% surviving at least five years beyond diagnosis (Armstrong et al., 2009; Gatta et al., 2014). However, childhood cancer survivors remain at risk for recurrence, chronic disorders, and functional impairments (Fidler et al., 2016; Landier et al., 2018). Identifying these burdens is critical to informing local policymakers and stakeholders (Wu et al., 2022).

Physical activity (PA) is essential for cancer survivorship, yet less than 50% of paediatric patients meet PA guidelines (Winter et al., 2010). Many experience cancer-related fatigue, which contributes to sedentary lifestyle and challenges in daily activities, especially for those with specific cancers like clear cell sarcoma. Evidence supports implementing PA interventions to mitigate these effects, as exercise is shown to be safe during and after treatment, it can help mitigate and alleviate these side effects (Gauß et al., 2021; Morales et al., 2018; Morales et al., 2020).

Current approaches to monitor and support PA include both conventional assessment methods and structured clinical programmes led by healthcare professionals, such as physiotherapists and occupational therapists. These practitioners guide patients through tailored physical activities designed to maintain and enhance their functional abilities during hospital stays. However, paediatric oncology rehabilitation services are underutilised, and there is a noted lack of specialised facilities and resources (Ospina et al., 2023; Siegel et al., 2023).

Digital technology is increasingly incorporated into paediatric care, offering innovative solutions through augmented reality and the Internet of Things (IoT) to enhance patient engagement and health monitoring (Devine et al., 2018; Sween et al., 2014). Gamification techniques and feedback in mobile health applications have been effective in increasing PA levels, suggesting that these tools can facilitate behaviour change and improve health outcomes for paediatric oncology patients (Domin et al., 2021; Lee et al., 2019). Although these technologies provide individualised real-time feedback, their effect on the PA of paediatric oncology patients remains uncertain. This scoping review aimed to address existing research gaps by identifying the instruments – both conventional and digital – used to monitor PA in paediatric oncology patients during treatment. In addition, this study examined PA monitoring methods, identified the variables collected, and explored the applicability of digital health solutions in their role in monitoring and assessing PA engagement among paediatric cancer patients. Parent-reported (proxy) measures of PA have been included where relevant, especially for younger children unable to provide accurate self-reports.

2. METHODS

Following the Joanna Briggs Institute Manual for Evidence Synthesis, data on publication year, country, study design, participants, and PA monitoring will be extracted. Searches will cover the following databases: ProQuest, Web of Science, EBSCO Complete, Google Scholar, Science Direct, Scopus, MEDLINE (PubMed), and Cochrane, focusing on studies from 2000 to March 2024. Screening and data extraction will involve multiple reviewers using Rayyan software to manage duplicates and streamline to review process.

The scoping review will be conducted in accordance with the Joanna Briggs Institute (JBI) methodology for scoping reviews (Peters et al., 2022, Peters et al., 2024) and reported in accordance with PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, extension for

Scoping Reviews) guidelines (Tricco et al., 2018). We will follow the 6-stage framework for a scoping review proposed by Arksey and O'Malley (2007).

The review will be registered on Open Science Framework and aims to systematically identify, analyse, and map PA monitoring tools, including digital solutions, used is paediatric oncology. This approach will allow for the synthesis of available evidence, help identify existing gaps in the literature and provide recommendations for future research and clinical applications in this field.

3. RESULTS

Through weekly team meetings, we developed and refined the inclusion and exclusion criteria. To ensure alignment with our research questions: (1) What methods, both conventional and digital, are used to monitor PA in children and adolescents with cancer? (2) What variables from conventional and digital health instruments are collected to monitor PA in children and adolescents with cancer? (3) What is the applicability of different conventional and digital health instruments for monitoring PA levels in children and adolescents with cancer? (4) How are digital health solutions and PA monitoring tools incorporated into interventions aimed at improving PA in children and adolescents with cancer? Only studies addressing at least one of these questions will be retained for further analysis.

3.1. Inclusion criteria

Based on recommendations from the Joanna Briggs Institute (JBI) (Peters et al., 2022, Peters et al., 2024) and research questions to refine the focus of our scoping study and develop an effective search strategy, we defined the criteria for **Population, Concepts, and Context (PCC)** (Peters et al., 2024). Inclusion criteria keywords will be used to interactively develop a robust search strategy.

Population: Children and adolescents with cancer

- Children and adolescents with cancer during treatment or two years after treatment. Based on studies, this two-year period, including active treatment and early recovery, is used because it allows researchers to assess how PA supports the restoration of cardiorespiratory fitness and muscle strength while helping to alleviate lingering post-treatment fatigue and physical limitations (Gauß et al., 2021).
- Study includes children and adolescents aged 7–19 years old. This decision was based on the age group that corresponds to the category of children with cancer. Younger children cannot complete the questionnaire or PA independently. Older age groups would correspond with the category of adults with cancer. The children were selected because this age group can effectively engage in self-directed activities and structured exercise programmes. Older adolescents face unique physical and psychological challenges during the transition to adulthood, making their inclusion vital for understanding the impact of PA during and after cancer treatment (Winter et al., 2010).

Concepts: Digital health solutions such as wearable sensors, gamification, and mobile applications

- Recent digital health solutions used for monitoring PA include wearable activity trackers, smartphone-based applications, remote monitoring platforms, and data-driven or AI-supported systems, in addition to gamification and augmented reality approaches (Devine et al., 2018).
- The incorporation of augmented reality and gamification in paediatric cancer is justified by their proven effectiveness in enhancing PA levels among children and adolescents (Lee et al., 2019; Sween et al., 2014).
- Digital health solutions enable objective, data-driven monitoring of PA patterns, allowing healthcare professionals to tailor interventions and evaluate treatment-related functional outcomes (Devine et al., 2018).

Context: PA

- PA encompasses the overall bodily movement that allows individuals to perform daily activities effectively and engage in exercise.
- The term 'physical activity' includes all forms of bodily movement done in educational, recreational, home, and/or community settings, including but not limited to aerobic exercises, resistance training, flexibility, endurance exercises, and stretching routines.
- Key parameters for evaluating PA include frequency, intensity, duration, type of activities, and distance completed, for example, in paediatric cancer, assessing a child's engagement in daily PA can provide valuable insights into their recovery and health outcomes after treatment.

3.2. Information sources and search strategy

The search strategy combines keywords and controlled vocabulary (e.g. MeSH terms) for paediatric cancer, digital technologies, PA, and outcome measurement using Boolean operators. The final strategy will be adapted for each database. In the final search, only articles written in English will be selected excluding grey literature. After searching databases, the records will be imported into the Rayyan AI-assisted review tool, followed by the study selection process in three phases. First, titles and abstracts will be screened, followed by a full-text review to identify articles relevant to the research questions of our scoping review. In the final phase, a data extraction template will be created within the Rayyan AI-assisted review tool, to facilitate the systematic collection of key information from selected articles. All 11 co-authors will participate in the selection process at each stage, with each article reviewed by two team members. If the Rayyan AI-assisted review tool will detect a conflict regarding inclusion or exclusion, a third person will resolve it. Data extraction will be performed independently and cross-checked to enhance accuracy. Additionally, the team will meet regularly online to address any issues arising during the article selection phases. A preliminary search was conducted on the 18th and 19th of April, 2024 for ProQuest, Web of Science, EBSCO Complete, Google Scholar, Science Direct, Scopus, MEDLINE (PubMed), Cochrane databases, and 7,867 references before deduplication were found.

3.3. Study selection and eligibility criteria

Article eligibility will be determined by PCC criteria and other factors outlined below:

Inclusion criteria:

Eligibility criteria were defined according to the Population, Concept, and Context (PCC) framework described above. Additional criteria included publication in peer-reviewed journals, English language, and availability of full text. Studies not meeting these criteria or not addressing PA monitoring were excluded.

Exclusion criteria:

- Population: children and adolescents more than two years after cancer treatment.
- Study does not include patients aged 7–19.
- Concept: digital technologies not related to PA (e.g. for health management).
- Context: non-PA outcomes or monitoring; specific physical fitness measures.
- Setting: nonclinical.
- Study type: other study types (e.g. protocols, narrative reviews, or systematic reviews).
- Publication status: published without peer review, dissertations, books, conference papers, letters, or editorials.
- Publication language: written in a language other than English.
- Full-text not available.
- Excluded keywords: drug, in vitro, animal, mice, mouse, animals, bacteria, murine, rat, fish, canine, rodents, transgenic, rodent, piglets, rabbits.

- Mental health outcomes are excluded unless they are mentioned in combination with a PA outcome.
- Duplicate data: if studies provide overlapping data sets or are part of the same project without additional insights, they should be excluded to avoid repetition.

3.4. Data extraction

This review will outline a systematic approach to analysing data from studies focusing on PA monitoring in paediatric oncology patients. Extracted data from reviewed articles will be categorised and analysed based on a structured set of variables. Key elements of the analysis will include the paper ID, first author (name and surname), the name of the journal, and the title of the article, providing a bibliographic foundation for the review.

To contextualise the research geographically and demographically, the country of the study, study aim, and participant information (age and sex) will be detailed. Additionally, specifics regarding participant's diagnosis and treatment will be documented to understand the clinical context.

The methodology of each study will be assessed, including the study type (e.g. cross-sectional, longitudinal), applied methods, and specific tools used for monitoring. Particular attention will be paid to PA monitoring instruments and the use of digital technologies to facilitate monitoring. These insights are integral to identifying current practices, technological innovations, and gaps in measuring PA among paediatric oncology patients.

The year of publication will be extracted to assess the recency of the evidence (e.g. distribution of studies over time) and identify trends.

3.5. Data analyses and reporting results

This stage of our scoping review methodology is divided into three key steps:

1. Analysing research findings, which includes both a descriptive numerical summary and a qualitative thematic analysis.
2. Analysing the research findings to identify outcomes that align with the research question, which will be presented narratively.
3. Interpreting and discussing the findings in the context of additional research questions, practical applications, and policy implications.

Results will be reported descriptively and presented using tables with accompanying narrative synthesis.

4. DISCUSSION

This scoping review will highlight the growing interest in using digital solutions to monitor and improve PA among paediatric oncology patients. Similar findings were observed in studies by Lee et al. (2019) and Devine et al. (2018), which evaluated the effectiveness of digital health interventions in promoting PA for adolescents undergoing cancer treatment. The studies emphasised the potential of gamification and wearable devices in improving adherence to PA regimens and enhancing patient motivation. This review and previous studies (Devine et al., 2018; Lee et al., 2019) underscore the importance of tailoring interventions to the unique needs and preferences of paediatric populations to ensure engagement and sustained impact.

However, while Lee et al. (2019) and Devine et al. (2018) focused primarily on digital health applications, our review will expand the scope to include augmented reality and other novel digital tools. This broader approach will provide a more comprehensive understanding of the current landscape of

digital PA monitoring solutions. Both studies collectively highlight the need for further research into the long-term effects of these technologies on health outcomes and their integration into clinical practice.

5. CONCLUSIONS AND PERSPECTIVES

The scoping review protocol will focus on key concepts and aims to systematically chart the existing evidence regarding PA monitoring tools, including digital technologies used on paediatric oncology patients during their treatment period. By identifying the types of data sources, methodologies, and approaches employed in the field and aligning them with the research questions, the review will lay the groundwork for advancing research and clinical practices in personalised cancer care. This protocol will serve as a guide for conducting the literature search, extracting data, and synthesising the findings to meet the review's objectives.

Despite known benefits, research on PA specifically for paediatric oncology patients remains limited, leaving gaps in guidance on safe and effective exercise programmes for children and adolescents during and after treatment. Current studies point out that PA can reduce treatment-related fatigue, improve physical function, and enhance overall health, yet other research extrapolates findings from adult populations, which may not fully address the unique needs of younger patients. This gap persists partly due to challenges in designing age-appropriate PA interventions that consider developmental and treatment-specific factors. Increased focus on paediatric-specific studies could yield evidence-based protocols to support PA outcomes in this population (Nielsen, 2020; Siegel et al., 2023).

By focusing exclusively on paediatric oncology, the review will emphasise the unique developmental, clinical, psychosocial, and PA-related needs of children and adolescents. Additionally, the review will incorporate digital tools such as augmented reality and gamification, which have shown promise in engaging younger populations and overcoming traditional barriers to PA participation. The comprehensive approach – analysing methods, variables, and applicability of PA monitoring tools –will further ensure that the findings are relevant and practical for tailoring interventions to this vulnerable group. Increased focus on paediatric-specific studies, as demonstrated in this review, could yield evidence-based protocols to support PA outcomes in this population.

Author Contributions: All authors during the brainstorming session conceptualised and formulated the research questions. G.S., A.K., and E.D. led the data collection methods, but all authors were involved in data collection and analysis. K.A., K.B.-K., E.D., A.C., and G.F.J. conducted a 3-step search process to identify relevant peer-reviewed literature studies. To ensure that the search yielded relevant studies, variations of the search strategy were pilot-tested by authors: K.A., K.B.-K., and A.C., and refined before the final search was conducted. All authors during the brainstorming session conceptualised the eligibility criteria. K.A., A.C., K.B.-K., E.D., and G.F.J. developed the data charting form. All authors conducted data charting of the sample of studies selected for inclusion. K.A., E.D., K.B.-K., A.C., and G.F.J. synthesised the data, and D.B., M.B., E.S., and A.K. performed quality checks on the reported results. K.A., A.C., E.D., K.B.-K., G.F.J., and G.S. led the manuscript development. All co-authors had the opportunity to read, edit, and approve the final manuscript.

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Informed Consent Statement: There will be no involvement of humans, animals, patients, or the public in this review. This review will synthesise data from peer-reviewed studies that have been published. Thus, no ethical approval was required.

Conflicts of Interest: The authors declare no conflict of interest.

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