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The influence of online physical activity interventions on children and young people's engagement with physical activity: a systematic review

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ABSTRACT

Background: Most children and young people (CYP) worldwide are classified as inactive because they fail to meet the World Health Organisation recommendations for physical activity. Online interventions that use devices like exergames, smartphones, social media, and wearables have the potential to improve physical activity engagement because of their extensive reach and opportunities for learning and use across contexts.

Purpose: The objectives of this systematic review were to update the evidence-base on online physical activity interventions for CYP since 2015, analyse the outcomes associated with online interventions across physical, cognitive, social and affective domains, and assess the mechanisms (i.e. pedagogical strategies) of online interventions that resulted in outcomes related to physical activity.

Methods: A systematic search of the literature was conducted across 4 databases (MEDLINE, PudMed, EBSCO and EMBASE) using key words related to online interventions, physical activity and CYP. The inclusion criteria were: CYP aged 5–18 years in the general population; use of an online-based medium to deliver an intervention related to physical activity; outcomes related to changes to physical activity, and in physical, cognitive, social and affective domains; and quantitative, qualitative and mixed methods studies. A modified version of the Quality Assessment Tool for Studies with Diverse Designs was used to assess study quality. A mixed methods approach was used to analyse and synthesise all evidence.

Results: 26 papers were identified as meeting the inclusion criteria, including randomised control trials (n=8), non-randomised interventions (n=12), observational studies (n=3) and qualitative papers (n=3). The target population of most studies was children (<12 years) where data collection mostly took place in a school setting, in elementary schools, and in physical education lessons. The interventions reported on positive changes to CYP's physical activity behaviours, through increases in physical activity levels and emotions, attitudes and motivations toward physical activity. Gamification and personalisation were the main mechanisms of online interventions that elicited positive changes in behaviours.

Conclusions: The studies in this review provide a convincing rationale for the use of online interventions to support CYP's engagement with physical activity, due to the positive effects on physical and affective outcomes. New evidence is provided on the key mechanisms of online

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interventions (gamification and personalised learning) and the contexts in which online interventions are likely to be effective (elementary school PE) that can be used by health and education practitioners, organisations, policy makers and/or researchers to reach and engage CYP in physical activity. This study had some limitations that mainly relate to variation in study design, over-reliance of self-reported measures, and sample characteristics, that prevented comparative analysis. Registration number: PROPSERO; CRD42020215597.

Introduction

Most children and young people (CYP) (85%) worldwide are classified as inactive because they fail to meet the World Health Organisation (WHO) recommendations for physical activity (Guthold et al. 2020). Online interventions that use devices like exergames, smartphones, social media, and wearables have the potential to improve physical activity engagement because of their extensive reach and opportunities for learning and use across contexts (Koekoek and van Hilvoorde 2018; Chambers and Sandford 2019; Marttinen et al. 2019). In the UK, for example, 93% of children (age 8-11) spend over 13 h a week online, and 99% of adolescents (age 12-15) spend over 20 h a week online (Ofcom 2019). Evidence has also established positive links between CYP's uses of digital technologies in formal (e.g. school, physical education [PE]) and informal (e.g. home, leisure time) contexts, and the development of knowledge, skills and behaviours related to physical activity (Casey, Goodyear, and Armour 2016; Koekoek and van Hilvoorde 2018). Notably, previous systematic reviews have identified positive effects of online interventions on physical activity behaviours and attributed positive outcomes to the opportunities for online education, goal setting, self-monitoring and parental involvement (Lau et al. 2011; Hieftje et al. 2013; Turner et al. 2015; Direito et al. 2017; Rose et al. 2017; Ludwig et al. 2018; Böhm et al. 2019). Accordingly, there has been a high level of advocacy in international policy and research for the use of online interventions to improve CYP's physical activity engagement (Rich and Miah 2017; WHO 2018).

Recent societal challenges, including a global pandemic and rising levels of precarity, have provided further evidence on the potential benefits of online interventions for physical activity engagement (Kirk 2020; Varea, González-Calvo, and García-Monge 2020). During COVID-19 lockdown periods, online workouts delivered via social media and targeted at CYP and their families – e.g. PE with Joe[1] – were reported to support physical activity engagement, with positive outcomes associated with the accessibility of real-time information and interaction, the feasibility of completing exercises in the home, and the creation of personalised experiences (Goodyear et al. 2021). Research has also reported on the power of online mediums to reach and engage vulnerable and disadvantaged CYP in health and physical activity, through providing access to information at low-cost, and private spaces for interaction with peers and/or professionals (Casey, Goodyear, and Armour 2016; Kessel, Hardardottir, and Tyrefors 2020; Kirk 2020).

Despite evidence on the value of online interventions for physical activity engagement, online interventions have the potential to negatively impact on CYP's knowledge, attitudes and behaviours related to physical activity, if used uncritically (Öhman et al. 2014; Rich and Miah 2017; Chambers and Sandford 2019). Evidence suggests that online interventions can promote behaviouristic forms of physical activity engagement, through a narrow focus on physical activity outcomes and through promoting reductionist relationships between body image, physical activity and wellbeing (Öhman et al. 2014; Rich and Miah 2017). In contrast, to promote longer-term and lifelong engagement with physical activity, it has been argued that holistic learning experiences should be created that focus on physical, cognitive, social and affective outcomes (Quennerstedt 2019; Kirk 2020). Furthermore, evidence suggests that engagement with physical activity is accelerated when pedagogy foregrounds the use of digital technologies and there is a clear pedagogical alignment between learners/learning,

teachers/teaching and knowledge in context (Casey, Goodyear, and Armour 2016; 2017; Koekoek and van Hilvoorde 2018). In this sense, it is important to consider outcomes related to physical, cognitive, social and affective domains, and aspects of pedagogy in evaluations of online interventions.

While systematic reviews on online interventions for physical activity in CYP have been published (Lau et al. 2011; Hieftje et al. 2013; Turner et al. 2015; Direito et al. 2017; Rose et al. 2017; Ludwig et al. 2018; Böhm et al. 2019), they provide little information on outcomes related to physical activity across physical, cognitive, social and affective domains, and/or the mechanisms (i.e. pedagogical strategies) of online interventions that are associated with these diverse outcomes. Furthermore, most of the published reviews focus on clinical settings and/or clinical population groups, and there is little evidence across non-clinical groups, ages and other demographic factors (Hieftje et al. 2013; Turner et al. 2015; Ludwig et al. 2018). Finally, previous systematic reviews on online interventions tend to be published pre-2015 and/or focused primarily on websites (Lau et al. 2011; Hieftje et al. 2013; Turner et al. 2015; Rose et al. 2017).

To address these limitations in the published literature, the objectives of this systematic review were to update the evidence-base on online physical activity interventions for CYP since 2015, analyse the outcomes associated with online interventions across physical, cognitive, social and affective domains, and assess the mechanisms (i.e. pedagogical strategies) of online interventions that resulted in outcomes related to physical activity. The research question was: do online physical activity interventions influence CYP's engagement with physical activity, and how? The findings from this review can be used to inform the development of robust guidance on the design and use of online interventions to increase their potential to elicit positive changes in physical activity for CYP. An additional benefit of this review is that it will provide evidence to help physical educators make informed decisions about the value and role of PE in CYP's health and physical activity in the digital age.

Methods

Protocol and registration

The protocol was registered with the International Prospective Register of Systematic Reviews (PROPSERO; CRD42020215597) and was informed by the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines (Page et al. 2021). See Supplementary File A for the PRISMA 2020 Checklist that was followed.

Inclusion and exclusion criteria

For inclusion in this review, studies fulfilled the following PICOT statement:

- P (Participants): children aged 5–18 years and in the 'general population' (i.e. non-clinical groups)
- I (Intervention): use of an Online-Based medium to deliver an intervention related to physical activity: for example, exergames, social media, smartphones, mobile applications
- C (Comparison): no engagement with or use of Online-Based medium; or no comparison (such as in cross-sectional or qualitative research designs)
- O (Outcomes): changes to physical activity, including behaviours (physical), knowledge or understanding (cognitive), interactions (social) and attitudes or feelings (affective) (see Table 1 for further examples of the outcomes across the four domains that were included in this review, that were identified from literature that has conceptualised the learning domains in relation to learning outcomes associated with models-based practice, the concept of physical literacy,

Table 1. Outcomes Assessed Across Four Learning Domains

Learning Domain	Example Outcomes
Physical *Movement behaviours*	Physiological (e.g. heart rate, endurance performance, muscle strength); Metabolic (e.g. BMI*, weight); Behavioural (time spent exercising, sedentary time); Fundamental movement skills (i.e. throwing, catching, skill improvement)
Cognitive *Intellect or mental abilities*	Health/Physical Activity Knowledge (how to engage with physical activity, importance/ guidelines); Strategies, tactics, decision making
Social *Communicative behaviours*	Individual (listening, communicating, leadership, responsibility); Group (cooperative, collaborative, teamwork)
Affective *Feelings and emotions*	External (care, concern, respect, empathy for others); Internal (motivation, confidence, self-esteem, self-worth, attitudes); mental health/mental wellbeing (anxiety, depression, feelings)

*BMI=Body Mass Index;

assessment and previous reviews on learning in physical education and sport pedagogy – (Casey and Goodyear 2015; Dudley, Goodyear, and Baxter 2016; Kirk 2020; Teraoka et al. 2020).

- T (Type of Study): Quantitative, Qualitative or Mixed Methods, including randomised controlled trials (RCTs), non-randomised interventions, and observational studies.

Studies were included if they were peer-reviewed publications and were written in English language. The exclusion criteria for this review included grey literature and articles reporting on clinical population groups. Furthermore, articles were excluded if they included interventions partially implemented offline.

Search strategy

A formal literature search, using bibliographic search databases, was the primary method of identifying relevant texts. The electronic databases MEDLINE, PudMed, EBSCO and EMBASE were searched for publications relating to online-based mediums and physical activity interventions using MeSH terms and free text to capture relevant research. Core keywords used in the search included 'social media' OR 'smartphone' OR 'mobile application' AND 'physical activity' OR 'active play' OR 'physical education'. Supplementary File B provides a full list of the search terms used. A manual search for relevant articles, including article reference lists, was conducted to ensure all relevant texts were identified. Database and manual searches included texts from January 2015 to November 2020.

Data extraction

The data extraction approach adopted is consistent with previous systematic reviews in related fields (see Smith et al. 2018; Teraoka et al. 2020). The four databases were searched for relevant literature using the defined keywords and papers were collated using Zotero (5.0.95.3). The screening process were completed independently by three reviewers (authors BS, JM and a research assistant), with conflicts or undecided articles reviewed by a fourth reviewer (author VG) for their inclusion or exclusion. Titles were initially screened, followed by abstract screening and articles were excluded if they did not meet the inclusion criteria. References of included studies were checked to identify any relevant papers not captured in the search. Full text reviews of articles were then completed with the reasons for exclusion recorded (Figure 1). To ensure the inclusion/exclusion criteria were applied consistently across both title/abstract and full text screening, one reviewer (author BS) screened 100% of titles/abstract and full texts, and two reviewers (author JM, research assistant) screened 50% each, where disagreements regarding eligibility of studies were resolved by discussion and consensus when needed with the fourth reviewer (VG). For the articles that met the inclusion criteria, data extracted included: participant demographics (e.g. number, age, population), study

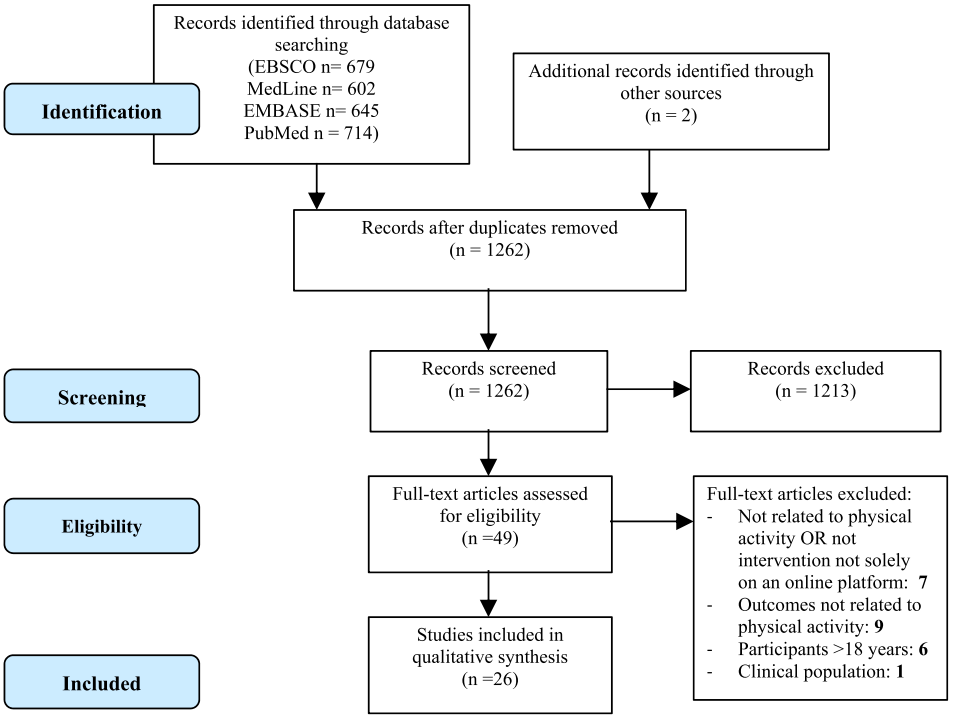

Figure 1. PRISMA-P flow diagram

characteristics (e.g. protocol), intervention characteristics (e.g. exergame), outcome measures (e.g. time spent exercising), and results.

Quality Assessment

Three reviewers (authors BS, JM, VG) applied a modified version of the Quality Assessment Tool for Studies with Diverse Designs (QATSDD) to assess study quality (Sirriyeh et al. 2012). This tool is validated for assessing both quantitative and qualitative studies. That said, one measure on the QATSDD for qualitative research – inter-rater reliability – has been consistently shown to be ineffective and thus recommended to be no longer used for qualitative research (Smith and McGannon 2018). As such, inter-rater reliability was excluded from the assessment. The reviewers (authors BS, JM, VG) also independently graded the level of evidence each study provided, using the level of evidence tool by Smith et al. (2018). The criteria for each level of evidence is reported in Table 2. Of

Table 2. Criteria for the Assessment of the Level of Evidence

Level 1 (High)	Level 2 (Moderate)	Level 3 (Low)
A control group was used	Pre-/post and/or repeated measures design was used	Post-test only OR cross-sectional design was used
A pre-/post- or repeated measures design was used	A control or comparison group may have been used, but was not required	Case studies (individual or very small cohort)
Groups were randomised	Groups were not required to be randomised	Uncontrolled study
Example: Randomised Control Trial	A retrospective design may have been used	A retrospective design may have been used
	Examples: Cohort, Case-Control, Time series studies	Example: Cross-sectional study

*Developed from (Smith et al. 2018)

the included studies reported in this paper, one author (BS) assessed 100% of full texts for quality and level of evidence, and author VG assessed 58% of articles and author JM assessed 42% of articles. The average score between the two reviewers was used, and a 15% range of difference was considered acceptable (Smith et al. 2018). Supplementary file C outlines the scores provided by the reviewers for each included paper, of which none of the scores exceeded 15% and there were no discrepancies recorded in the scores for the level of evidence.

Data Synthesis and Analysis

The study designs, outcome measures and variables for physical activity and diet varied across the studies. As such, it was not possible to perform a meta-analysis. A narrative synthesis approach was adopted to explore the study designs and outcomes, and to understand similarities, differences and overall outcomes. Findings from quantitative and qualitative studies were described numerically and/or textually to provide a summary of evidence on the: (i) characteristics of the online interventions; and (ii) outcomes. Relationships were then qualitatively examined between studies with the aim of identifying factors that related to intervention effectiveness, such as characteristics of use, intervention design, and variability in populations.

Results

Description of studies and Quality Assessment

Twenty-six papers were reviewed and the findings are summarised in Supplementary File D. 8 studies were RCT, 12 were non-randomised interventions, 3 observational and 3 qualitative. Seventeen papers reported on data collected from children (≤12 years) where data collection mostly took place in the USA (10 of 26). Study duration was predominantly 2–6 weeks (10 of 26) and took place in a school setting (16 of 26) and in the context of elementary schools (15 of 26). In the interventions delivered in a school context, these were mainly delivered in PE lessons (10 of 26), with the remaining school-based studies focused on the intervention within general classes, during recess or free time and/or as part of an optional in-school activity (6 of 26). Most of the studies targeted the general population of children and young people (20 of 26), with few studies targeting specific groups, such as overweight/obese groups (4 of 26), unmotivated or disengaged groups (1 of 26) and inactive groups (1 of 26).

The level and quality of evidence is reported in Figure 2, where the strength of the evidence was coded as grey, white, or black. Grey outcomes reflect strong evidence-base, where there was a sufficient level of high quality evidence (13 of 26). White outcomes reflected a moderate evidence-base, where evidence came from level 2 studies that had a moderate level of evidence (3 of

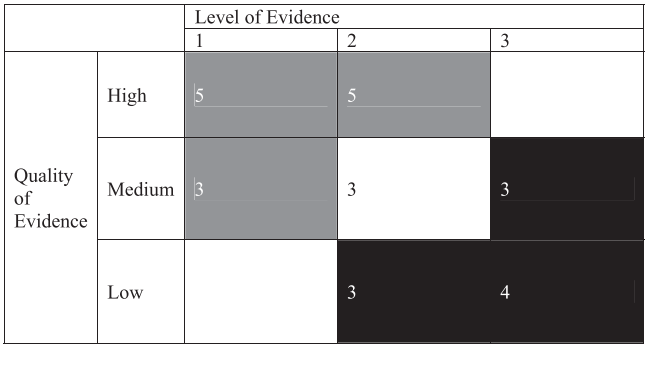

Figure 2. The level and quality of evidence of included studies.

26). Black outcomes were studies where there is not enough evidence to make definitive claims about relations between online/internet-based interventions and CYP's engagement with physical activity (10 of 26).

Characteristics of online interventions

There was much heterogeneity across the 26 papers regarding the type of physical activity intervention. The main aim of the studies reported in this review were related to using an online intervention to improve engagement in physical activity and/or motor skills (23 of 26). Nineteen studies used exergame consoles, 6 used smartphone/mobile apps and 1 study focused on the use of a website. Of the 6 studies that used smartphones/mobile apps 4 of these studies focused on mobile location-based exergames, 2 studies focused on the delivery of educational material and social networking. The website based intervention was used to deliver personalised physical activity manuals.

The analysis identified three overarching mechanisms used within the online interventions to influence outcomes related to physical activity. Drawing on previous literature these were defined as: (i) Gamification – progressing through levels of achievement, interactive experiences (e.g. multi-player, team play), and/or competition (Fernandez-Rio et al. 2020); (ii) Personalisation – tailored and/or direct feedback from the screen or game and rewards or goals based on performance/progress (Ghanvatkar, Kankanhalli, and Rajan 2019); and (iii) Information – educational materials and/or guidance to encourage changes to behaviours (Goodyear and Armour 2019). Most of the interventions focused on gamification (22 of 26), several studies focused on personalisation (14 of 26), with information least prevalent (7 of 26).

Most of the gamification interventions used exergames on consoles (18 of 19) and tended to use commercial mediums, such as Nintendo Wii or Playstation, focused on one type of sport/movement, such as fitness, dance, cycling, or motor skills. Eight of the exergame studies reported on using a range of different types of console/computer based exergames to either sustain young people's interest and engagement, or compare the differences between game types (e.g. competitive and individual). Most of the exergame interventions focused on multi-player or group based games (8 of 19), with few focused on single player (4 of 19). It was relatively balanced in the interventions as to whether young people were permitted to choose the exergame they played (9 of 19) or whether they were given a pre-determined game (8 of 19).

Most of the studies used a combination of gamification, personalisation and/or information (14 of 26). Three exergame studies used a combination of all characteristics (i.e. gamification, personalisation, and information). For example, one intervention focused on an immersive smartphone running app (Zombie run) that featured a game-theme design whereby the training programme was embedded within a story where the user is trained to collect supplies and protect towns from zombies (gamification); participants could also track their progress and receive guidance on running and technique (personalisation); and participants received audio instructions on how to perform the training components (information) (Direito et al. 2015). Ten of the 26 studies reported on using gamification and personalisation. In these interventions personalisation was often applied through direct feedback from the game, and the combination of gamification and personalisation tended to occur in line with reward systems. For example, in a location-based smartphone intervention game rewards were adapted based on individuals improvements in distance, speed and game difficulty level (Robertson et al. 2016). Two studies focused on information and personalisation. One of these studies used a smartphone app and aimed to improve physical activity, sedentary behaviour, food intake, and water consumption amongst adolescents through providing educational videos and narratives (information) and tailored bi-weekly messages on their behaviours (personalisation) (Chen, Guedes, and Lung 2019). The other intervention focused on the delivery of activity manuals (information) that were matched to participants' current level of motivational readiness for physical activity participation (personalisation) (Larsen et al. 2018).

Relationship between intervention and outcomes

Interventions reporting increases and/or improvements in outcomes related to physical activity

There were 18 studies reporting on increases and/or improvements in outcomes related to physical activity. Most of these studies reported on the use of exergames (15 of 18). The online interventions mainly took place in the context of elementary school settings (12 of 18), and of those in a school setting, the majority were in PE class (9 of 12). Most interventions focused on the physical domain (16 of 18), that involved playing games for a specified time period to improve engagement in physical activity and/or motor skills. A combination of gamification and personalisation was the main way (8 of 18) through which the games were planned to influence behaviour.

The main outcome reported in the interventions were related to the physical domain (15 out of 18). Quantitative studies compared differences in intervention and control groups. Statistically significant increases and/or improvements were reported in relation to time spent in overall physical activity, light, moderate and vigorous physical activity, decreases in sedentary behaviour and motor skill performance. Qualitative and/or observational studies reported that exergames improved reaction time and coordination and movement skills. The qualitative studies supported evidence from quantitative studies that time spent in moderate to vigorous physical activity increased.

A number of the studies reported on increases and/or improvements related to the affective domain (13 of 18). Quantitative studies reported statistically significant increases and/or improvements to self-efficacy and enjoyment. Observational studies reported that the intervention was positively correlated with game enjoyment, mood experience, and attitude toward physical activity, and that attitude toward performance was positively correlated with a preference for future game play. Participants reported that they would prefer to play exergames during PE lessons. Qualitative studies reported that the interventions improved engagement in PE lessons and that goal setting had a positive impact on motivation to engage.

Interventions reporting on no change and/or no differences between intervention and control group

There were 5 studies reporting on no change and/or no differences between intervention and control group. Most of these studies reported on the use of exergames (3 of 5). The online interventions mostly took place in elementary schools (3 of 5), and of those in the school setting, the interventions took place in PE class (1 of 5), general class (1 of 5) and free time (1 of 5). The remaining interventions focused on smartphones (2 of 5) and took place in community settings (2 of 5). All of these 5 studies focused on the physical domain, that involved playing games for a specified time period to improve engagement in physical activity and/or cardiorespiratory fitness. Gamification was the main way through which all of these studies planned to influence behaviour. Two of the five studies also focused on gamification and personalisation characteristics. For example, one study used an exercise bike connected to multiple competitive games where participants could earn rewards and purchase upgrades through playing (Kaos et al. 2018).

The main outcome reported in the interventions were related to the physical domain (5 out of 5). All of these studies were quantitative and most reported on non-statistically significant differences between intervention and controls groups. For example, there was no observed differences in physical activity behaviours between an intervention group that used an immersive app (Zombie Run), a comparator group that used a non-immersive app (Get Running) and a control group that continued with usual behaviour (Direito et al. 2015). Similarly, there were no observed differences in time spent in physical activity and/or decreases in overall heart rate between single and multi-player exergames (Kaos et al. 2018). One study reported no significant differences between girls and boys in relation to time spent in moderate-to-vigorous physical activity, light physical activity and sedentary behaviour during an exergame intervention (Quan, Pope, and Gao 2018).

Interventions reporting on decreases in outcomes related to physical activity

Three studies that reported on a decline in outcomes related to physical activity. Two of these studies reported on exergames in the home setting and another on the use of a mobile application in secondary schools. The intervention by Benítez-Andrades et al. (2020) focused on the use of a social networking application with secondary school students to provide information on physical activity and offer rewards for improvements to their habits related to physical activity, whereby this non-randomised intervention reported on non-significant decreases in physical activity levels. This intervention was an optional activity within school, and was not assigned to a specific context, such as PE class or recess/breaks. The intervention by Rhodes et al. (2018) focused on a cycling exergame in the home setting and reported a decline in physical activity engagement, although participants reported that the exergame was enjoyable and fun. Key barriers to sustained engagement with exergames were reported to be related to lack of appealing games, bike discomfort and operational problems. The intervention by Rhodes et al. (2017) also reported on a cycling exergame in the home setting and reported on an overall decline in affective attitudes, instrumental attitudes, descriptive norms, perceived behavioural control and intention over the course of the intervention.

Discussion

The majority of studies included in this review broadly indicate that online physical activity interventions can influence positive changes in CYP's physical activity behaviours, through increases in physical activity levels and emotions, attitudes and motivations toward physical activity. The use of exergames in elementary PE lessons with a focus on improving physical activity levels and/or motor skills through gamification and personalisation were the main mechanisms of online interventions that elicited positive changes in behaviours related to physical activity. Hence, this review provides evidence that online physical activity interventions can have a positive impact on the health and wellbeing of contemporary CYP and that their use and adoption in PE warrants further consideration.

To determine how future online physical activity interventions can be designed and used, and the implications of online interventions for PE, the findings are analysed in relation to the concept of pedagogy and perspectives related to the 'art of teaching'. The concept of pedagogy as applied to digital technologies in health and physical education urges teachers to design practices that maximise the latent potential of technologies to accelerate learning through the alignment of three dimensions of pedagogy: (i) learners/learning; (ii) teachers/teaching; (iii) knowledge in context (Casey, Goodyear, and Armour 2017). The 'art of teaching' is informed by the work of Biesta (2013), and is concerned with making informed decisions about 'what works', alongside the responsibility to bring new beginnings to education. From this perspective, Quennerstedt (2019) argued that the art of teaching is about judgements and making choices regarding why, what and how concerning the content, purpose and relations in education. Accordingly, three questions emerge from these perspectives to direct practice and decision making: (i) 'what works'?; (ii) what gaps in learning exist?; and (iii) how can practitioners support and enrich the outcomes developed through online interventions? The remainder of this article addresses these questions using key findings from the review.

The majority of the studies provided evidence that online interventions support physical and affective outcomes, and this provides a convincing rationale for why PE practitioners should consider online interventions as part of their programmes. Notably, this evidence on outcomes adds to a body of literature that physical activity interventions in PE increase class time physical activity levels and improve motor skills (Fairclough 2004; Lonsdale et al. 2013; Errisuriz et al. 2018). Furthermore, this finding shows that online interventions have the potential to help practitioners address gaps in their practice to support affective outcomes. Indeed, there has been a growing awareness of the significance of affective outcomes related to youth mental health and wellbeing, but there are few well-established and widely practiced pedagogical approaches that influence

students' affective outcomes, with teachers reported to have limited skills and resources to facilitate affective learning (Kirk 2020; Teraoka et al. 2020). At the same time, there was not substantial evidence that online interventions supported cognitive and social outcomes, and neither were these domains a central and explicit focus of the interventions. It is plausible that the type of technology predominantly used (i.e. exergames) limited opportunities for cognitive and social learning and more social technologies like social media may have supported learning in these domains (Goodyear and Armour 2019). However, to prepare CYP for lifetime physical activity – the key purpose of PE – CYP need to gain the appropriate knowledge, understandings, and social skills to be active throughout their lifetime (Lonsdale et al. 2013; Kirk 2020). Accordingly, practitioners need to balance physical and affective outcomes developed through online interventions with further opportunities for social and cognitive learning, such as in offline (or face-to-face) activities or in other areas of the curriculum that use specific pedagogies focused on cognitive and/or social development (e.g. Teaching Games for Understanding or Cooperative Learning) (Casey and Kirk 2021). Alternatively, online interventions could be refined to accommodate all four learning domains and promote holistic learning experiences.

Personalisation was a key mechanism of the online interventions that elicited positive changes in behaviours related to physical activity. This is, perhaps, unsurprising. A central claim for the use of online interventions in education has been how learning can be mobile, accessible and personalised (Greenhow, Robelia, and Hughes 2009; Anders 2015; Sharples 2015). Indeed, it is through increased social connectivity that technology can facilitate personalised and self-regulated learning, by tailoring and customising digital processes based on individual preferences and behaviour (Littlejohn and Milligan 2015; Peters 2020). Evidence from the review clearly demonstrate how technology enabled personalisation through structured activities specific to learning needs by giving CYP choice and voice. Yet despite the fashionable use of the phrase (see Chiew 2018), researchers are critical of the term personalisation because it says nothing of the quality or direction of such preferences (Quennerstedt 2019). Biesta (2013), for instance, argues that personalised learning is an empty term unless questions of learning content, purpose and relations are addressed. While educational environments that promote personalised learning are a feature of effective teaching (Hattie 2010), the challenges for practitioners of applying personalisation in the context of large student classes and homogeneous expectations (e.g. grade/year-level assessments and proficiency benchmarks) are significant and complex (Daruwala, Bretas, and Ready 2020). Nonetheless, evidence from this review suggest practitioners might utilise technologies to address personalised learning if decisions about what (content) and how (practice) to apply technology in relation to the purpose of practice are addressed. For example, teachers could use technologies for data-driven decision making – systematic collection, analysis, examination and interpretation of data (both within the school and externally) – to inform the design of more meaningful and personalised PE practices. Evidence from this review provides insights into the ways in which Technology-Enabled Personalization might be structured to facilitate learning (i.e. content, practice, relations) and this presents broader challenges to the ways in which online and offline pedagogy is conceptualised and practiced.

Gamification was another key mechanism of the online interventions that elicited positive changes in behaviours related to physical activity. There was evidence from the review that the use of game elements in the online interventions – such as levels, interactive experiences and competition – had a positive influence on physical and affective outcomes. This finding adds to a developing evidence-base on gamification in PE and youth sport coaching settings and provides further evidence on the reported benefits of using digital gaming in PE settings (Gibbs, Quennerstedt, and Larsson 2017) and digital game design principles in non-digital and non-game contexts to influence behaviours (Koekoek and van Hilvoorde 2018; Fernandez-Rio et al. 2020). It is interesting to note, that while games have tended to dominate most PE curricula since the 1950s (Kirk 2020), in formal and face-to-face PE settings games is a key content area that excludes many CYP from PE, because games can prioritise white, male, heterosexual and fit and technocratic views of health and the body

(Landi 2018; Kirk 2020). While these reductionist views on health and the body can also be promoted through exergames in PE (Öhman et al. 2014), the papers in this review suggest that digital gaming may be an optimal medium through which to engage some CYP in the content area of games.

The main context of the online interventions was elementary school PE, and this provides evidence that online interventions are effective in elementary school contexts and with primary age pupils. Furthermore, findings from this review illustrate how elementary PE provision can be improved to support CYP's engagement with physical activity through the use of online interventions. It is well-established that elementary PE is a key context to develop children's motor competence to help them progress into more complex activities in later life (Wainwright et al. 2020). However, generalist teachers are often the main deliverers of elementary PE, with teacher competency reported as a persistent concern (Randall 2020). Low subject status of PE in elementary schools, inadequate teacher professional development, low teacher confidence and curriculum outsourcing further compound the potential of elementary PE to develop children's motor skills (Mcveagh, Smith, and Randall 2020). Hence, online interventions have the potential to be a valuable inclusion into elementary school settings to enhance curriculum delivery. As reported in the article by Gibbs, Quennerstedt, and Larsson (2017), teachers could use exergames as a teaching and learning resource to facilitate the development of children's fundamental movement skills. Taking this further, by using digital technologies as a resource for fundamental movement skills, elementary teachers could enrich children's learning by using their expertise in other subject areas to make cross-curricula links and develop holistic learning experiences. For example, evidence has reported on the value of combined Dance and Reading interventions, in relation to enhancing elementary pupils reading comprehension, movement competence and creative skills (Makopoulou, Neville, and McLaughlin 2020; Neville and Makopoulou 2021).

Overall, this study illustrates the value of online interventions to influence positive changes in CYP's physical activity behaviours. However, this study has a few limitations. Diverse study designs were included in this review – RCT's, non-randomised interventions, observational and qualitative – where effects ranged from statistically significant and non-significant/no change. Most papers used self-reported questionnaires to measure physical activity behaviours, and these have recognised limitations, including unreliable estimates, recall bias and misinterpretation of questions (Prince et al. 2008; Kirkpatrick et al. 2019). Moreover, only half of the included studies were assessed to be high quality, with insufficient evidence provided in the remaining studies on the intervention, methods, and/or outcome measures. For these reasons, evidence on the effect and direction of the online interventions remain inconclusive. The focus of the interventions and the sample are further limitations. The papers included in this review were predominantly on exergames, and there were few interventions exploring other technologies that are used by contemporary CYP, such as, social media and virtual reality. The main target population and setting of most studies were primary schools, and this finding prevented any comparisons across different population groups and/or contexts. Across the papers there was also a lack of consistency in the reporting of ethnicity and socio-economic factors, although for the papers where ethnicity was reported, the samples were predominantly White. There is therefore a need to design studies that directly assess differences in online interventions and the impact of interventions for various ages, genders, ethnic groups, and levels of income. Future studies could take the form of targeted interventions for specific groups, as well as recruit large sample sizes that are representative of the population and/or the demographics of societal uses of various types of digital technologies.

Conclusions

This study provides new evidence to inform the development of robust guidance for health and education organisations on how they can design online interventions to reach and engage with CYP in physical activity. Notably, the studies in this review provide a convincing rationale for

the use of online interventions to support CYP's engagement with physical activity, due to the positive effects on physical and affective outcomes. Practitioners can use online interventions to support physical and affective outcomes through gamification and personalised learning. The contexts in which online interventions are likely to be most effective are in elementary schools settings, with primary age pupils and in PE lessons. Overall, the positive outcomes of this review suggest that online interventions are promising research agenda in CYP health, of which the PE profession could lead the way in the design of meaningful online interventions, the implementation of pedagogically informed online interventions and robust evaluations of the effects on learning and behaviours related to physical activity.

Note

1. https://www.thebodycoach.com/blog/pe-with-joe

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