

## Motivational effects of digital media on students in physical education: a scoping review.

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### Abstract:

**Introduction & study purpose** Current research indicates that digital media (DM) may positively impact students' motivation in physical education (PE). However, the theoretical details behind such motivational effects remain to be established. This scoping review provides an overview of the research on the motivational effects of DM in PE and discusses the results in the context of self-determination theory as a suitable basis for PE. **Methods** This scoping review was conducted according to the PRISMA-ScR guidelines. Six databases (Eric, Psynindex, Pubmed, PsycInfo, SportDISCUS, Web of Science) were searched using the following inclusion criteria: (1) peer-reviewed publication, (2) empirical study, (3) English, (4) published in the last 15 years, and (5) deals with the motivational effects of DM on students in PE. **Results** In total, 14 studies were included in this review. The studies aimed to measure motivational effects of DM use in PE in three categories: intrinsic motivation, behavioral regulation, and basic psychological need (BPN) satisfaction. Eleven studies reported positive motivational changes in at least one of the three categories. Based on the included studies, five uses of DM in PE were identified: instruction, feedback, monitoring, knowledge transfer, and entertainment. **Discussion & Conclusion** Overall, the use of DM in PE can decrease controlled and increase self-determined forms of behavioral regulation, and enhance BPN satisfaction. However, this scoping review shows that further research is needed to investigate which processes lead to motivational effects and how these can be explained by psychological theories. Furthermore, it is important to examine the differences between DM uses and the sustainability of motivational effects.

**Key Words:** children, motivation, self-determination theory, physical activity, technology, digital devices

### Introduction

Physical activity (PA) is an important protective factor in the health of children and adolescents (Saunders et al., 2016). However, children and adolescents do not exercise enough, and the lack of PA among children and adolescents has been an international problem for many years (Guthold et al., 2020). This lack of PA is associated with the growing prevalence of overweight and obesity (Hills et al., 2011), which is associated with secondary diseases and places a major burden on healthcare systems (Oldridge, 2008).

School-based physical education (PE) is a suitable setting for promoting PA among children and adolescents (Taylor & Ntoumanis, 2007). One reason is that due to the obligation to participate in PE, all children and adolescents can be reached (Hills et al., 2015). Furthermore, PE is well suited for promoting PA because of the transferability of PA motivation to everyday life. More specifically, children and adolescents who are highly motivated to engage in PE tend to be physically active in their leisure time (Bagoien et al., 2010; Hao & Yang, 2022; Laroche et al., 2019). For these reasons, the motivation of children and adolescents to engage in PA should be promoted in PE, thus increasing the prevalence of PA in children's and adolescents' lives.

To explain and investigate motivation in PE, self-determination theory (SDT), developed by Deci and Ryan (2000, 2008), provides a suitable theoretical basis. SDT is a macrotheory that includes different subtheories, among which organismic integration theory (OIT) and basic psychological needs (BPN) theory (BPNT) are particularly useful for PE research. OIT explains motivational processes through different forms of behavioral regulation, which range from no self-determination to complete self-determination on the following continuum: Amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic motivation. Amotivation, external regulation, and introjected regulation are seen as controlled forms of behavioral regulation, whereas identified regulation, integrated regulation, and intrinsic motivation are self-determined forms of behavioral regulation (Deci & Ryan, 2008). In addition, BPNT states that people strive to satisfy the three innate BPNs of autonomy, competence, and relatedness (Deci & Ryan, 2008), which are considered basic prerequisites for achieving self-determined forms of behavioral regulation (Deci & Ryan, 2000).

Studies on motivation in PE show that the theoretical postulates of SDT can be applied to empirical situations related to motivation in PE. In a systematic review and meta-analysis, Vasconcellos et al. (2020)

summarized research on motivation in PE using 265 studies. The authors showed that BPN satisfaction correlates strongly with self-determined behavioral regulation. The review also revealed that teachers play a major role in satisfying students' BPNs. More specifically, teachers can strongly influence BPN satisfaction through lesson designs that facilitate BPN satisfaction (e.g. exercise options with different difficulty levels and cooperative tasks) (Vasconcellos et al., 2020). White et al. (2021) found similar results in their systematic review of 34 qualitative studies in the PE context. The qualitative studies showed that novelty, choice, and challenge are highly important characteristics for BPN satisfaction and can produce positive affect in PE and increase PE participation (White et al., 2021).

One option for promoting self-determined motivation in PE is to use the opportunities provided by digital media (DM) in terms of choice, challenge, and novelty to enhance BPN satisfaction during PE lessons. The use of DM during PE lessons seems to be especially potential due to the immediate and controllable link to the students' PA. Thus, DM during PE lessons is an important addition to DM as online or blended learning (Killian et al., 2019) and flipped learning in PE (Østerlie et al., 2023). Generally, DM should be understood as an umbrella term for devices such as smartphones, tablets, consoles, computers, televisions, and other visual display media and corresponding applications (Navarra et al., 2021). This definition indicates the diversity of DM and thus suggests that DM can be used in a variety of ways and settings (more than the use of digital platforms, videos etc. in learning contexts). For example, children and adolescents use DM in their leisure time for entertainment, gaining knowledge, and staying in touch with peers (Reid Chassiakos et al., 2016). These multiple possibilities and functions may also be useful in PE by providing options for greater choice, creating tailored and individual challenges and therefore helping satisfy the BPNs and create self-determined PA-motivation in PE. This assumption of the effect of DM on PA-motivation has already been investigated in other contexts and with other target groups (e.g. Durau et al., 2022; Sankaran et al., 2019).

In terms of DM use in PE, systematic reviews have highlighted the broad potential of DM in the context of PE (e.g. Jastrow et al., 2022; Killian et al., 2019; Modra et al., 2021; Østerlie et al., 2023). Nevertheless, the research mainly focusses on the general aspects of learning with DM and does not highlight the psychological, particularly the motivational potential of DM for PA promotion and the special role of PE as a relevant setting. Some findings in terms of motivational effects have been provided by Jastrow et al. (2022) and Modra et al. (2021), who reported positive effects regarding, for example, situational interest, enjoyment and self-efficacy. However, research on the motivational effects of DM in PE has been superficial and general, and it remains unclear how motivational effects emerge and what their theoretical explanations could be.

Overall, it is reasonable to assume that DM can increase PA motivation in PE. Research exists on the motivational effects of DM in PE. However, this research has not been systematically reviewed and linked to psychological theories, and thus there is a research gap regarding the theoretical explanation of motivational effects of DM in PE. Therefore, the purpose of this scoping review is to provide an overview of the research on the motivational effects of DM in PE. In particular, with this scoping review we are looking for links between the use of DM in PE and possible effects on motivation. The motivational effects and their theoretical explanations will be discussed in the context of the SDT framework. Finally, further research implications will be defined.

## Material & methods

This scoping review was carried out based on Arksey and O'Malley (2005) and the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews" guidelines (Tricco et al., 2018). A study protocol was uploaded to the Open Science Framework on August 25, 2022 and is available at the following link: <https://osf.io/n5tr2>.

### *Inclusion Criteria*

To be included in this scoping review, studies had to meet the following criteria: (1) peer-reviewed publication, (2) empirical study, (3) English language, (4) published in the last 15 years (period chosen, because DM as defined in this review have been increasingly used in the last 15 years), and (5) deals with the motivational effects of DM on students in PE.

### *Literature search*

The literature search ran from May to November 2022 and consisted of three phases. First, an initial search with a preliminary search strategy was conducted in May 2022 using PubMed, PsycINFO, and Web of Science. PE was linked to different search terms in the field of DM (for details, see the study protocol). This preliminary search yielded 255 hits, of which 11 were identified as possibly suitable for inclusion. These 11 studies provided additional keywords and terms that were used for the search strategy of the second research step. The second step was conducted in August 2022 using ERIC, PubMed, PsycINFO, Psynindex, SportDiscus, and Web of Science. The search limitation functions of these databases were used to examine only the titles, abstracts, and keywords of publications. The following search query was used: ("digital media" OR "technolog\*" OR "internet\*" OR "device\*" OR "tablet\*" OR "laptop\*" OR "computer\*" OR "iphone\*" OR "i-phone\*" OR "ipad\*" OR "i-pad\*" OR "mobilephone\*" OR "mobile-phone\*" OR "smartwatch\*" OR "fit-bit\*" OR "wearable\*" OR "android" OR "ios" OR "software\*" OR "gamification\*" OR "exergame\*" OR "robot\*" OR "social media" OR "virtual realit\*" OR "augmented realit\*" OR "360 degree\*") AND ("physical education\*").

The search results were filtered via blockers to exclude publications according to the inclusion criteria. Third, in November 2022, a manual search of the reference lists of the included studies was carried out.

#### Publication selection

Search results were collected in Citavi. Duplicates and incorrect publication types (e.g. conference abstracts and handbook chapters) were removed by Citavi and manually checked. The search results were imported into the review program Rayyan. Rayyan was used as a collaborative review platform. The possibilities of the Rayyan artificial intelligence to support the review process were not used. The titles and abstracts of all publications were screened manually by two independent reviewers. Under blinded conditions, the reviewers decided whether to exclude or further consider the search results. Disagreements were discussed in the review team and, when necessary, with a third rater. Subsequently, the selected full texts were added to Rayyan. In the case of unavailable full texts, the full texts were obtained either by contacting the corresponding authors via email and ResearchGate or by ordering them via the Subito-Doc service. Once all full texts were added to Rayyan, they were screened by the two reviewers. Inclusion and exclusion decisions were made under blinded conditions using Rayyan. Disagreements were discussed and, if necessary, resolved by involving a third person. The literature lists of the included articles were searched for further suitable studies by the two reviewers.

#### Publication analyses and data extraction

The extraction scheme described in the study protocol was tested and modified in a pilot analysis based on three included studies. The final extraction scheme considered study information, study aims, study design, intervention characteristics, variables and instruments, and main findings. Data were extracted by the two authors. Disagreements were discussed, and a full extraction table was developed (Table 1).

#### Results

The final database search identified 3447 publications (Figure 1). After duplicate exclusion, 2287 publications remained. 2177 studies were excluded in title and abstract screening, and 110 studies were kept for full text screening. During full text screening, 97 studies were excluded based on the following two exclusion criteria: (1) no identifiable motivational variables ( $n = 62$ ) and (2) no use of DM during PE ( $n = 35$ ). The manual search of the reference lists of the included publications led to one further match. Ultimately, 14 studies published from 2012 to 2022 were included in this scoping review.

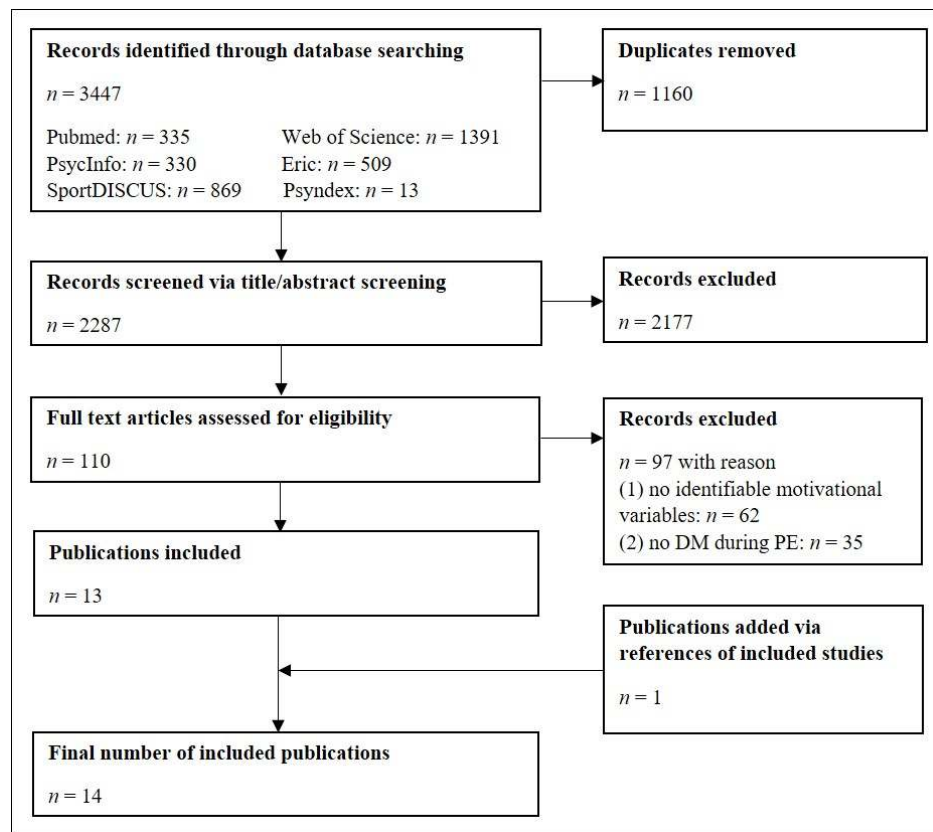


Table 1 provides an overview of the 14 publications in terms of study information, study aim, study design, sample characteristics, intervention characteristics, variables and instruments, and main findings.

**Table 1** Information on the included studies

| No. | study information                      | study aims                                                                                                             | study design                                                      | sample characteristics                                                          | intervention characteristics                                                                                                                                                         | variables and instruments                                                                                                                                                                                                                       | main findings                                                                                                                                                                                             |
|-----|----------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Gao et al. 2013<br>USA                 | Determine the differences in children's enjoyment in <i>DanceDanceRevolution</i> in comparison to aerobic dance in PE. | quasi-experimental design; wait-control design; repeated measures | $n = 53$ (29 female, 24 male); mean age = 10-11 years; primary education        | 9 months; 3 lessons per week (à 30 Min); Dancing; 15 Min.<br>DanceDanceRevolution; 15 Min. usual aerobic Dance                                                                       | Enjoyment: Enjoyment scale (based on Ommundsen et al., 2008)                                                                                                                                                                                    | significantly higher enjoyment in exergame condition compared to aerobic dance                                                                                                                            |
| 2   | Higginson et al., 2019<br>USA          | Examine the effects of listening to music or watching films on students' enjoyment while indoor cycling in PE.         | quasi-experimental design; EG/CG; repeated measures               | $n = 81$ (58 female, 23 male); age 15-18 Jahre; secondary education             | 3 weeks; 2 sessions per week (à 70-85 Min); indoor cycling; EG: videos on interactive screens; CG: usual PE                                                                          | Enjoyment: Enjoyment-questionnaire (self-developed)                                                                                                                                                                                             | no significant difference in enjoyment between EG or CG or over time                                                                                                                                      |
| 3   | Lee & Gao, 2020<br>USA                 | Investigate whether teacher-managed app-integration could improve children's enjoyment in PE.                          | quasi-experimental design; EG/CG; pre- and post-test              | $n = 157$ (73 female, 84 male); age 9-11 Jahre; primary education               | 6 weeks; different topics; EG: 5 sessions per week (à 50 Min) with tablets and apps (e.g. Coach's Eye, Education); CG: 1 or 2 sessions per week (à 50 Min); 6 weeks usual PE-lessons | Enjoyment: Enjoyment scale (based on Ommundsen et al., 2008)                                                                                                                                                                                    | no significant difference between EG and CG in enjoyment; higher enjoyment in EG and CG over time, but not significant                                                                                    |
| 4   | Legrain et al., 2015<br>France         | Examine the influence of ICT in PE on students' perceptions of perceived autonomy support and BPN satisfaction.        | quasi-experimental design; EG; pre- and post-test                 | $n = 96$ (52 female, 44 male); mean age: 12.4; no information about school type | 6 sessions (à 90 Min); gymnastics circuit training; EG: different devices/apps (e.g. interactive whiteboard); CG: usual PE                                                           | BPN satisfaction: Basic Psychological Needs in Sport Scale (Gillet et al., 2008)<br><br>Behavioral regulation: Physical Education Motivation Scale (Tessier et al., 2010)                                                                       | ICT supported BPN satisfaction, which lead to greater self-determined motivation                                                                                                                          |
| 5   | Maněnová et al. 2022<br>Czech Republic | Identify groups of pupils on basis of level of their motivation in PE with mobile devices and apps.                    | quasi-experimental design; EG/CG; pre- and post-test              | $n = 118$ (female 48, male 70); age: 11-16; primary and secondary education     | 10 weeks; 1 session per week (à 90 Min); different topics (e.g., dancing, football); EG: different devices/apps (e.g. GoogleFit); (CG: usual PE; not reported in results)            | Behavioral regulation: Situation Motivational Scale (Guay et al., 2000)                                                                                                                                                                         | EG reported increased intrinsic motivation and identified regulation and decreased amotivation over time                                                                                                  |
| 6   | Nation-Grainger, 2017<br>England       | Explore the impact of biofeedback on motivation to be physically active in PE.                                         | quasi-experimental design; EG/CG; pre- and post-test              | $n = 10$ (10 male); age 14-15; secondary education                              | 6 weeks; 1 session per week; EG: smartwatches; CG: usual PE                                                                                                                          | Behavioral regulation: Behavioral Regulation in Exercise Questionnaire (Markland & Tobin, 2004)                                                                                                                                                 | EG reported significant increased identified regulation over time                                                                                                                                         |
| 7   | Papastergiou et al., 2021<br>Greece    | Assess the impact of integration of tablets and a fitness app to students' intrinsic motivation for PE.                | cross-sectional quasi-experiment; EG/CG; post-test                | $n = 145$ (female 70, male 75); age 10-12; primary education                    | 1 session (à 25 Min); Fitness; EG: tablets, sworkit Kids; CG: usual PE                                                                                                               | Intrinsic Motivation: Intrinsic Motivation Inventory (Goudas and Papacharisis, 2005; Ryan, 1982)                                                                                                                                                | EG reported significant more enjoyment and interest in PE then CG                                                                                                                                         |
| 8   | Quintas et al., 2020<br>Spain          | Analyse the effects of an exergame intervention in PE on behavioral regulation and BPN satisfaction.                   | quasi-experimental design; EG/CG; pre- and post-test              | $n = 417$ (female 222, male 195); age 10-12; primary education                  | 4 weeks; 3 sessions a week (à 45 Min); Dancing; EG: JustDance exergame; ClassDojo; CG: usual PE                                                                                      | Behavioral regulation: Perceived locus of Causality Scale (Goudas et al., 1994; Moreno Murcia et al., 2009)<br><br>BPN satisfaction: Basic Psychological Needs in Exercise Scale (Moreno Murcia et al., 2008; Vlachopoulos & Michailidou, 2006) | EG reported increased BPN satisfaction over time, but not significantly; EG reported decreased external regulation and increased intrinsic motivation over time and compared to CG, but not significantly |
| 9   | Quintas & Bustamante, 2021<br>Spain    | Analyse the effects of an exergame intervention in PE in comparison to non-exergaming classes on enjoyment.            | see Quintas et al., 2020                                          | see Quintas et al., 2020                                                        | see Quintas et al., 2020                                                                                                                                                             | Enjoyment: Sport Satisfaction Instrument (Baena-Extremera et al., 2012; Duda & Nicholls, 1992)                                                                                                                                                  | significantly more enjoyment in EG over time and compared to CG                                                                                                                                           |
| 10  | Sotos-Martinez et al., 2022<br>Spain   | Analyse the impact of a gamified PE intervention on students' behavioral regulation and BPN satisfaction.              | quasi-experimental design; EG/CG; pre- and post-test              | $n = 275$ (female 127, male 148); age: 12-16; secondary education               | 5 weeks; 8 sessions (à 55 Min); different topics; EG: classcraft; CG: usual PE                                                                                                       | BPN satisfaction: Basic Psychological Needs in Exercise Scale (Moreno Murcia et al., 2008; Vlachopoulos & Michailidou, 2006)<br><br>Behavioral regulation: Sport motivation Scale (Granero-Gallegos et al.,                                     | significantly higher BPN satisfaction, increased intrinsic motivation and decreased amotivation in EG over time                                                                                           |

| No. | study information                               | study aims                                                                                                                           | study design                                                       | sample characteristics                                        | intervention characteristics                                                                                                          | variables and instruments                                                              | main findings                                                                                                                                                         |
|-----|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |                                                 |                                                                                                                                      |                                                                    |                                                               |                                                                                                                                       | 2018; Pelletier et al., 1995)                                                          | compared to CG                                                                                                                                                        |
| 11  | Sun, 2012<br>USA                                | Determine students' situational interest in an exergaming unit in comparison to traditional PE.                                      | quasi-experimental design; wait-control design; pre- and post-test | $n = 74$ (40 female, 34 male); age 9-12; primary education    | 4 weeks; 2 sessions per week (à 30 Min); cardiovascular fitness; EG: 8 exergaming stations (e.g. DanceDance-Revolution); CG: usual PE | Situational interest: Situational Interest Scale (Chen et al., 1999; Sun et al., 2008) | significantly higher situational interest in EG than in CG; significant decrease in situational interest over time in EG and CG                                       |
| 12  | Sun, 2013<br>USA<br><br>(follow-up to Sun 2012) | Attempt changes in students' situational interest in an exergames over time and the role of children's gender played in the changes. | quasi-experimental design; wait-control design; pre- and post-test | $n = 70$ (40 female, 30 male); age 9-12; primary education;   | 4 weeks; 2 sessions per week (à 30 Min); cardiovascular fitness; EG: 8 exergames (e.g. DanceDance-Revolution); CG: usual PE           | Situational interest: Situational Interest Scale (Chen et al., 1999; Sun et al., 2008) | follow-up to Sun, 2012: significant decrease in challenge, exploration and novelty in EG compared to Sun, 2012; significant higher enjoyment in EG boys than in girls |
| 13  | Vega-Ramírez et al., 202<br>Spain               | Assess the degree of students' motivational satisfaction with a smartphone app in PE.                                                | cross-sectional design; no CG                                      | $n = 40$ (24 female, 16 male); age 15-18; secondary education | 5 sessions; physical condition and health; smartphones with Polar beat                                                                | Satisfaction: satisfaction questionnaire (self-developed)                              | students reported DM use in PE as motivating, innovative and effective                                                                                                |
| 14  | Zhu & Dragon, 2016<br>USA                       | Investigate students' situational interest in technology-integrated PE.                                                              | quasi-experimental design; EG/CG; repeated measures                | $n = 53$ (38 female, 15 male); age 10-12; primary education   | 2 weeks; 5 sessions (à 50 minutes); Fitness; EG: iPads to scan QR-codes; Edmodo; CG: usual PE                                         | Situational interest: Situational Interest Scale (Chen et al., 1999)                   | significantly lower situational interest in EG than in CG                                                                                                             |

app = Application; BPN = basic psychological needs; CG = control group; EG = experimental group; e.g. = for example; ICT = internet communication technology;  $n$  = sample size; PE = physical education; USA = United States of America.

### Study aims

The study aims related to motivational aspects can be divided into three categories based on the theoretical foundation of the SDT. The first category covers aims regarding the effects of DM on students' intrinsic motivation (Gao et al., 2013; Higginson et al., 2019; Lee & Gao, 2020; Papastergiou et al., 2021; Quintas & Bustamante, 2021; Sun, 2012, 2013; Zhu & Dragon, 2016). The second category of aims focuses on the DM impact in PE on students' behavioral regulation in PE (Legrain et al., 2015; Maněnová et al., 2022; Nation-Grainger, 2017; Papastergiou et al., 2021; Quintas et al., 2020; Quintas & Bustamante, 2021; Sotos-Martínez et al., 2022; Vega-Ramírez et al., 2020). The third category covers aims regarding the impact of DM on BPN satisfaction (Legrain et al., 2015; Quintas et al., 2020; Sotos-Martínez et al., 2022). The aims of Vega-Ramírez et al. (2020) could not be classified using the three categories because this study dealt with motivational effects of DM in PE in general.

### Study designs

All included studies used quantitative research methods. The majority of studies were based on quasi-experimental study designs with minimum pre- and post-tests ( $n = 12$ ) (Gao et al., 2013; Higginson et al., 2019; Lee & Gao, 2020; Legrain et al., 2015; Maněnová et al., 2022; Nation-Grainger, 2017; Quintas et al., 2020; Quintas & Bustamante, 2021; Sotos-Martínez et al., 2022; Sun, 2012, 2013; Zhu & Dragon, 2016). Nine of these studies used a design with both an experimental group (EG) and a control group (CG). Gao et al. (2023) and Sun (2012, 2013) used the method of waiting CG. In addition, some studies used pre- and post-test cross-sectional designs with CG (Papastergiou et al., 2021) and without CG (Vega-Ramírez et al., 2020).

### Study characteristics

The 14 included studies represent 12 populations. In two cases, two studies dealt with the same population: Quintas et al. (2020) and Quintas and Bustamante (2021) and Sun (2013, 2012). The 12 study populations differed in terms of educational level, age group, size, and gender distribution. Regarding educational level, eight publications referred to the field of primary education (Gao et al., 2013; Lee & Gao, 2020; Papastergiou et al., 2021; Quintas et al., 2020; Quintas & Bustamante, 2021; Sun, 2012, 2013; Zhu & Dragon, 2016), four to secondary education (Higginson et al., 2019; Nation-Grainger, 2017; Sotos-Martínez et

al., 2022; Vega-Ramírez et al., 2020), and one to primary and secondary education (Maněnová et al., 2022). Participant age ranged from nine to 18 years. Most studies covered an age range of approximately two years. The largest age range (11–16 years) was covered by Maněnová et al. (2022). Thirteen studies included boys and girls (Gao et al., 2013; Higginson et al., 2019; Lee & Gao, 2020; Legrain et al., 2015; Maněnová et al., 2022; Papastergiou et al., 2021; Quintas et al., 2020; Quintas & Bustamante, 2021; Sotos-Martínez et al., 2022; Sun, 2012, 2013; Vega-Ramírez et al., 2020; Zhu & Dragon, 2016), and one study focused on boys (Nation-Grainger, 2017). The sample sizes were between 10 (Nation-Grainger, 2017) and 417 participants (Quintas et al., 2020; Quintas & Bustamante, 2021).

#### *Intervention characteristics*

The interventions differed in terms of intervention timeframes, topics, and the uses of DM to support teaching and learning. The timeframes ranged from single interventions (Papastergiou et al., 2021) to nine months (Gao et al., 2013). During these periods, the number of sessions per week varied from one (Maněnová et al., 2022; Nation-Grainger, 2017) to five (Lee & Gao, 2020). The sessions lasted between 15 (Gao et al., 2013) and 90 minutes (Legrain et al., 2015; Maněnová et al., 2022). Regarding the topics, 11 studies referred to individual sports (Gao et al., 2013; Higginson et al., 2019; Legrain et al., 2015; Nation-Grainger, 2017; Papastergiou et al., 2021; Quintas et al., 2020; Quintas & Bustamante, 2021; Sun, 2012, 2013; Vega-Ramírez et al., 2020; Zhu & Dragon, 2016) and three to individual sports and team sports (Lee & Gao, 2020; Maněnová et al., 2022; Sotos-Martínez et al., 2022). Regarding the uses of DM to support teaching and learning, the included studies provided information in their methods sections about how DM were used in PE. More specifically, information was provided about DM content (e.g. which app was used), the form of the interactions between DM and students, and the goal pursued by the authors in using DM. Based on this information, we classified the studies into five categories in terms of DM use in PE (Table 2).

**Table 2** Information on digital media uses.

| No. | Digital media use                                                                       | Publications                                                                                                                                                                                     |
|-----|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | DM is used to instruct students before and during exercise.                             | Gao et al., 2013; Lee & Gao, 2020; Legrain et al., 2015; Maněnová et al., 2022; Papastergiou et al., 2021; Quintas et al., 2020; Quintas & Bustamante, 2021; Sun, 2012, 2013; Zhu & Dragon, 2016 |
| 2   | DM is used to provide feedback (bio and video).                                         | Lee & Gao, 2020; Legrain et al., 2015; Nation-Grainger, 2017                                                                                                                                     |
| 3   | DM is used to monitor (1) behavior or (2) exercise related data (e.g. heart frequency). | (1) Quintas et al., 2020; Quintas & Bustamante, 2021; Sotos-Martínez et al., 2022<br>(2) Nation-Grainger, 2017; Vega-Ramírez et al., 2020; Zhu & Dragon, 2016                                    |
| 4   | DM is used to provide knowledge and information.                                        | Lee & Gao, 2020; Legrain et al., 2015; Vega-Ramírez et al., 2020                                                                                                                                 |
| 5   | DM is used to entertain during exercise.                                                | Higginson et al., 2019; Lee & Gao, 2020                                                                                                                                                          |

#### *Variables and instruments*

All studies used questionnaires to measure motivational variables. Similar to the study aims, the variables and instruments could also be divided into the three categories of intrinsic motivation, behavioral regulation, and BPN satisfaction.

First, eight studies measured constructs related to intrinsic motivation. Papastergiou et al. (2021) used the intrinsic motivation inventory developed by Ryan (1982). Sun (2012, 2013) and Zhu and Dragon (2016) employed the situational interest scale of Chen et al. (1999). Gao et al. (2013) and Lee and Gao (2020) measured enjoyment based on adapted versions of the enjoyment-competence scale by Ommundsen et al. (2008). Quintas and Bustamante (2021) used the sport satisfaction instrument developed by Duda and Nicholls (1992). Higginson et al. (2019) measured enjoyment using a self-developed questionnaire.

Second, behavioral regulation was measured in five studies. Legrain et al. (2015) used the physical education motivation scale developed by Tessier et al. (2010). The situation motivational scale of Guay et al. (2000) was used by Maněnová et al. (2022). Nation-Grainger (2017) made use of the behavioral regulation in exercise questionnaire (Markland & Tobin, 2004). Quintas et al. (2020) used the perceived locus of causality scale (Goudas et al., 1994). Sotos-Martínez et al. (2022) employed the sport motivation scale (Pelletier et al., 1995). Third, three studies measured BPN satisfaction. Quintas et al. (2020) and Sotos-Martínez et al. (2022) used the basic psychological needs in exercise scale by Vlachopoulos and Michailidou (2006). The basic psychological needs in sport scale by Gillet et al. (2008) was employed in Legrain et al. (2015). Vega-Ramírez et al. (2020) developed their own questionnaire with 10 items to measure overall motivation and attitudes toward DM in PE.

*Main findings*

Eight studies reported results in the category of intrinsic motivation. Papastergiou et al. (2021) found significant differences between EG and CG in relation to the dimension of enjoyment and interest. Gao et al. (2013) and Quintas and Bustamante (2021) showed that EG participants enjoyed PE significantly more than CG participants. Sun (2012, 2013) reported higher scores in all situational interest dimensions in PE with exergames. Over time, in EG and CG, all dimensions decreased significantly (except attention), but in EG, the dimensions remained at a higher level (Sun, 2012). A follow-up survey by Sun (2013) showed that challenge, exploration, and novelty decreased further compared to Sun (2012), whereas attention and enjoyment remained at the same level as in the first survey. The remaining three studies found no (Higginson et al., 2019; Lee & Gao, 2020) or negative (Zhu & Dragon, 2016) effects in the category of intrinsic motivation.

Five studies reported results in the category of behavioral regulation. Maněnová et al. (2022) found decreased amotivation and increased identified regulation in EG over time. Sotos-Martínez et al. (2022) reported decreased amotivation and increased intrinsic regulation in EG compared to CG. Quintas et al. (2020) reported lower external regulation and higher intrinsic motivation in EG over time compared to CG, but the differences were not significant. Nation-Grainger (2017) found increased identified regulation in EG. Legrain et al. (2015) showed that self-determined motivation was higher when BPNs were satisfied.

Three studies reported results in the category of BPN satisfaction. All studies revealed higher BPN satisfaction in EG than in CG (Legrain et al., 2015; Quintas et al., 2020; Sotos-Martínez et al., 2022). Quintas et al. (2020) found that BPN satisfaction in EG with exergames increased over time (but not significantly), whereas BPN satisfaction in traditional PE decreased significantly in CG over time.

The study of Vega-Ramírez et al. (2020), a pilot study without CG, showed that students rated PE with DM as motivating, innovative, and effective.

**Discussion**

The purpose of this scoping review was to provide an overview of the research on the motivational effects of DM in PE and to discuss these effects against the backdrop of SDT. This scoping review included peer-reviewed empirical studies on the use of DM in PE that were published in English and that reported motivational effects measured using quantitative methods. In total, 14 studies were examined. These 14 studies represent 12 populations of students from primary and secondary education between nine and 18 years of age. The sample sizes varied between 10 and 417 students and consisted mostly of boys and girls.

This scoping review includes studies that reported on the motivational effects of DM use in PE using the categories of intrinsic motivation, behavioral regulation, and BPN satisfaction. In the included studies, the interventions mostly involved individual sports. Eleven studies reported positive effects on intrinsic motivation, behavioral regulation, and BPN satisfaction, two found no effects, and one study showed negative effects. Motivational changes were produced with the following categories of DM uses: instruction, feedback, monitoring, knowledge transfer, and entertainment. Overall, this scoping review demonstrates that the use of DM in PE has the potential to increase self-determined forms of behavioral regulation, decrease controlled forms of behavioral regulation, and enhance BPN satisfaction.

The aims of the included studies could be assigned to the following three theoretical categories: intrinsic motivation ( $n = 8$ ), behavioral regulation ( $n = 5$ ), and BPN satisfaction ( $n = 3$ ). This result demonstrates the predominance of studies on intrinsic motivation and behavioral regulation. At the same time, this predominance is not highly meaningful because the categories cannot be fully separated, as attested by the fact that intrinsic motivation is also part of the OIT (Deci & Ryan, 2000). Nevertheless, these three categories show that authors assume that the use of DM can impact motivation in all areas of SDT. The three categories also reveal that different motivational processes are implied to theoretically explain the effects of DM in PE. Therefore, it is reasonable to assume that various motivational processes reflected in OIT and BPNT are triggered by DM use in PE. These findings should be considered in further research and in practice.

Most of the included studies used DM in individual sports ( $n = 11$ ). In these studies, fitness ( $n = 5$ ) and dancing ( $n = 3$ ) were the most common individual sports. One explanation for these results could be that these activities are highly present in the context of the digitalization of PA and sports, as reflected by the multiplicity of fitness apps (e.g. sworkit and GoogleFit), YouTube videos for home workouts, and sports games for consoles (e.g., DanceDanceRevolution and WiiFit). Such apps, videos, and games were considered in the included studies (e.g. sworkit, GoogleFit, tutorials on YouTube, and exergames, such as DanceDanceRevolution or JustDance). This indicates that most authors used existing products because of their availability and attempted to adapt them to PE instead of developing new ones. The preference for individual sports may have been influenced by the organizational circumstances. In individual sports, a person usually acts alone, whereas team sports involve interactions in teams and with opposing teams. These organizational arrangements may be a barrier to DM use in team sports, as evidenced by the fact that no study in this review used DM in team sports only. However, some studies ( $n = 3$ ) used DM for both individual and team sports, but DM use in team sports was mainly related to the organization of PA and not to PA itself. For example, DM was used to randomly assign teams (teamshake) or monitor the game score (score board).

In terms of effects of DM on intrinsic motivation, behavioral regulation, and BPN satisfaction in PE, this review found mostly positive results in at least one variable (11 of 14 studies). First, five studies found positive effects of DM on intrinsic motivation. These positive effects were mainly caused by DM uses that children consume frequently during their leisure time and that thus probably have a high emotional value (e.g. exergames such as JustDance). Therefore, it can be deduced that playful DM activities support positive feelings, such as pleasure, enjoyment, and interest, which characterize intrinsic motivation (Deci & Ryan, 2008). Second, five studies found positive effects of DM use on behavioral regulation. These effects occurred in all stages of behavioral regulation, which shows that DM can reduce amotivation and controlled forms of behavioral regulation as well as enhance self-determined forms. For example, Sotos-Martínez et al. (2022) reported reduced amotivation and Nation-Grainger (2017) increased identified regulation due to DM use in PE. These findings are important because they show that DM in PE can have positive effects on every form of behavioral regulation, which demonstrates that DM is involved in various motivational processes. Third, three studies showed positive effects of DM use on BPN satisfaction. These effects were related to all three BPN (autonomy, competence, and relatedness) and were not centered on one specific need. Therefore, DM use in PE can improve students' BPN satisfaction, something for which individuals strive naturally (Deci & Ryan, 2008). Furthermore, BPN satisfaction supports the process of internalization, which helps reach autonomous behavioral regulation (Deci & Ryan, 2008). This theoretical connection between BPNT and OIT was reflected in the study of Legrain et al. (2015: 392), which revealed a "positive relationship between posttest need satisfaction and self-determined motivation." In contrast to these results on the positive relationships between DM use and motivation, three studies reported no positive effects of DM use in PE on SDT variables. These three studies aimed to detect the effects of DM use on intrinsic motivation (enjoyment and situational interest). Zhu and Dragon (2016), who found less interest among students in EG than in CG, explained the negative motivational effects in EG by referring to the fact that DM use for the monitoring and documentation of heart rates was related too tenuously to the execution of PA. This could be a relevant point in the study of Lee and Gao (2020), in which DM was mainly used by teachers and not by students. Higginson et al. (2019), who showed students videos on screens during PA (e.g. Shrek and High School Musical), did not find any differences in enjoyment between EG and CG. It can be assumed that there was a lack of connection between the videos and PA, which made it impossible to reach motivational effects on PA. Based on these three studies, it can be deduced that DM use in PE for the purpose of increasing intrinsic motivation should at best be closely linked to the PE activity itself.

The different purposes for which DM were used in the included studies could be divided into the following five categories: instruction ( $n = 10$ ), feedback ( $n = 3$ ), monitoring ( $n = 6$ ), knowledge transfer ( $n = 3$ ), and entertainment ( $n = 2$ ). There are similarities between these five categories that lead to three conclusions regarding DM use in PE. First, the categories of exercise instruction and feedback reveal that DM can help students in exercise execution and improvement. In particular, DM can show students models or point out important aspects of movements or techniques. In addition, DM can support PE teachers in lesson planning and in the implementation of PE lessons. One example is the study of Papastergiou et al. (2021), in which exercise instructions in CG were provided by a teacher and in EG by a tablet; in the latter case, the teacher had time for exercise corrections. Second, the categories of monitoring and knowledge transfer showed that DM can help students become aware of the relevance and consequences of PA. Therefore, DM use can enable students to better understand and reflect on their behaviors during PA, including what is happening in their bodies. One example is the study of Lee and Gao (2020: 575), which involved "anatomical pictures showing which parts of the body are being strengthened as a result of doing certain exercises." Third, the category of entertainment reveals that DM are associated with better student moods and can help establish a pleasant atmosphere in PE classes, which, in turn, supports students in enjoying PE. One example is the study of Higginson et al. (2019), in which students listened to music and watched films while cycling.

These three conclusions regarding the different DM uses in PE help to understand how DM can affect students' motivation. For example, self-directed exercise instruction via smartphones can be expected to promote autonomy satisfaction, while video feedback can promote competence satisfaction in exercise execution. In addition, DM use in PE can facilitate greater internalization of motivation. For example, it is likely that knowledge transfer and information related to the background of exercises can promote identified behavioral regulation. Finally, a better mood in PE through entertainment can promote intrinsic motivation. Although these assumptions provide theoretical explanations for changes in students' motivation, most of the included studies did not provide sufficient information to explain such motivational effects or referred only to the very general fact that children have more fun when using DM (e.g. Gao et al., 2013; Quintas et al., 2020). Moreover, the given five categories could not be seen as the final answer on how DM can be used in PE, as they only show an insight based on the included 14 studies. It remains to be researched which motivational processes were triggered by the different DM uses in PE in detail and how these motivational processes can be explained using SDT.

### *Limitations*

Limitations of this review are related to the methodology and the included studies. Regarding the methodology of this scoping review, first, the literature search was restricted to peer-reviewed empirical articles in English. Other study types (e.g. conference abstracts and handbook chapters) and languages

were excluded. Second, no qualitative studies could be included. Third, there is a risk of publication bias because studies reporting no or negative effects on students' motivation are less likely to be published.

In terms of limitations related to the included studies, first, only three studies mentioned the extent to which a given theoretical background was incorporated into the intervention design. Thus, in the majority of the included studies, it was unclear whether the intervention design was theory driven. This is a limitation because a clear theoretical explanation of which intervention content was used for which purpose would facilitate a more accurate interpretation of the findings. Second, the studies provided different amounts of information on the intervention content. Some studies explained very precisely which kinds of DM were used, how, and for what purpose (e.g. Lee & Gao, 2020), while some only provided very limited information on what was done in the intervention (e.g. Sotos-Martínez et al., 2022). To summarize, these missing or varying amounts of information made it difficult to compare the included studies and interpret the findings in general. In addition, missing information may lead to misinterpretations by readers and complicate the planning of replication studies, which means that the research has only limited value for both researchers and practitioners.

### *Implications*

This scoping review offers important implications for further research on the motivational effects of DM use in PE. First, in addition to the prevalent quasi-experimental designs with measurement points in short succession, more controlled longitudinal research with repeated measures is needed, preferably with follow-ups. Only then can statements about the short-term, medium-term, and long-term motivational effects of DM in PE be made. Second, qualitative research with standardized and theory-driven interview guidelines could supplement the results regarding the changes in behavioral regulation and BPN satisfaction reached by quantitative research. Third, future research should address intervention differences in terms of devices and applications (e.g. smartphones, exergames, and smartwatches) and DM uses (i.e. for instruction, feedback, monitoring, knowledge transfer, or entertainment). In this respect, research should focus on whether there are forms of DM use that are particularly conducive to change motivation and whether there are differences between subgroups (e.g. boys vs. girls). Fourth, it is necessary to embed interventions into psychological theories. Regarding the theoretical background, this scoping review provides initial insights into the motivational processes triggered by the use of DM in PE that could be attributed to SDT. To explain motivational processes, in the future, motivational theories should be used from the beginning of intervention planning.

### **Conclusions**

This scoping review included 14 studies, of which different forms of DM use in PE and different positive motivational effects of DM use in PE can be derived. These results lead to several conclusions for both research and practice. In terms of research, theoretical and empirical implications are of interest. Regarding theory, the five forms of DM use (i.e. instruction, feedback, monitoring, knowledge transfer, and entertainment) lead to motivational effects that can be embedded into the context of self-determination theory. Specifically, these five forms of DM use in PE lead to increased self-determined forms of behavioral regulation, decreased controlled forms of behavioral regulation, and enhanced BPN satisfaction. These effects underline the empirical and practical relevance of the SDT-subtheories organismic integration theory (OIT) and basic psychological needs theory (BPNT) with regard to DM use in PE. OIT and BPNT explain how different forms of DM use can make a positive contribution in that students are more motivated in a self-determined manner in PE. These theoretical considerations should be seen in practice as a way to make PE more motivating for students and to help them develop a self-determined motivation towards physical activity in PE.

In addition to these theoretical considerations, our scoping review also reveals empirical flaws in current research. Most included studies do not provide sufficient study designs (e.g. longitudinal or experimental designs). Therefore, neither the change process itself nor moderator processes can be explained to shed light on why and how students' motivation changes. For this reason, further research is needed to investigate the exact processes behind the motivational effects related to the use of DM in PE. Self-determination theory or other theories (e.g. social cognitive theory, Bandura, 1999) can be used as a framework for developing such study designs. Accordingly, future research should also investigate whether there are different motivational effects with different forms of DM use and how sustainable the motivational effects are.

Finally, in terms of practice, our findings already offer some conclusion for PE teachers. First, PE teachers should think about which form of DM use is suitable for their PE lessons. The different forms of DM use are likely to be useful for different goals. Second, PE teachers should think about the combined use of DM. It was found that although the use of DM for exercise instruction was probably the most common due to its simplicity, it was often complemented by other forms of DM use such as video feedback. Third, PE teacher should consider for which sports the use of DM is most appropriate. As shown in this review, DM may be easier to integrate in individual sports because there is less interaction between students than in team sports. Nevertheless, the targeted use of DM is also conceivable in team sports (e.g. instruction of tactics) and should be considered by PE teachers. However, much remains unclear about the use of DM in PE and the motivational effects. This refers especially to the usability and suitability of the forms of DM use in different age groups of students as well as possible effects on PA motivation in everyday life.

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