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Impact of COVID-19 lockdown on physical activity and performance in K-12 physical education: A systematic review

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Abstract

This study explores how the transition to online learning during the COVID-19 lockdown specifically affected the physical performance and activity levels of kindergarten to 12th grade (K-12) students in physical education (PE) classes. This article examines the challenges PE teachers face in maintaining physical activity (PA) engagement remotely and the most effective strategies focusing on a systematic review of the literature published between 2019 and 2023. The study integrates findings from diverse contexts highlighting differences in resources, infrastructure and teacher preparedness. The review highlights specific interventions that successfully mitigated a decline in PA and promoted the physical and mental well-being of students during the pandemic. Among these, structured virtual programs that incorporated innovative technological tools and emphasized family engagement were particularly effective in addressing the decline in physical and mental health indicators. Findings indicate that family participation, easily accessible digital materials, and organized online physical education sessions can be crucial in maintaining students' PA levels. These results underline the importance of tailored strategies to address the unique challenges of online PE and provide evidence for adapting curricula to future crises. This review provides key insights for future applications of online learning in PE with implications for improving student outcomes in physical health during remote learning.

Keywords: COVID-19, Digital tools, Family involvement, Online learning, Physical education, Remote learning, Student physical activity, Teacher preparedness.

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Contents

Contribution of this paper to the literature
This study provides the first systematic review focused on how online physical education during the COVID-19 lockdown impacted K-12 students' physical performance and activity levels. It uniquely explores the effectiveness of specific strategies, such as structured virtual programs and family engagement while analyzing contextual differences in teacher preparedness, resources and infrastructure.

1. Introduction

The global pandemic of COVID-19 drastically disrupted education systems worldwide as schools closed and classes were moved online (UNESCO, 2023). This shift represented a significant challenge for teachers but Physical Education (PE), traditionally grounded in active participation and classroom interaction, faced unique obstacles. A primary concern was whether online classes would be effective at maintaining physical activity (PA) levels compared to face-to-face instruction.

This study addresses the question: How has the transition to online learning impacted the PA levels and physical performance of students from kindergarten to 12th grade (K-12) during the COVID-19 lockdown? This research evaluates the effectiveness of strategies used in online PE to sustain physical activity and mitigate lockdown's negative effects such as increased sedentary behavior and mental health issues by narrowing the scope of this inquiry.

Educational systems worldwide underwent drastic changes during the COVID-19 pandemic particularly the shift to online education. Adapting PE, an inherently active subject, to a remote format presented a significant challenge. Studies have shown that PE is crucial during infectious disease outbreaks as it supports key health factors, including psychological and mental well-being (González-Calvo, Barba-Martín, Bores-García, & Hortigüela-Alcalá, 2022). This systematic review includes a comparative analysis of the transition to online PE during lockdown and its effects on student PA and performance. PA maintenance has been demonstrated to be beneficial for cardiovascular disease management coping with psychological disorders, and preventing the deleterious effects of inactivity (Cunningham, O'Sullivan, Caserotti, & Tully, 2020; Goodwin, 2003). However, there is limited documentation on the effectiveness of online PE in achieving these outcomes. This review examines gaps in studies conducted between 2019 and 2023 to recommend measures for the effective remote implementation of PE classes. The role of PE during the lockdown became even more significant due to its established benefits to both physical and psychological health. Numerous studies have underscored the importance of maintaining PA for preventing declines in cardiovascular health, mitigating mental health risks and sustaining overall well-being. However, the effectiveness of PE in maintaining these benefits during remote learning remains underexplored regarding its impact on students' physical performance. This paper conducts a systematic review of studies published from 2019 to 2023 to identify and analyze the interventions that successfully adapted PE to the online format. This research aims to provide insights that can guide future PE practices during remote learning by focusing on student outcomes related to PA levels and physical performance.

1.1. Significance and Research Questions

The significance of this study lies in its potential to inform future applications of online PE particularly in crisis situations requiring remote learning. The research aims to preserve reasonable levels of PA by identifying effective approaches towards this issue which Hahn and Truman (2015) consider to be both educational and public health matters.

1.2. Research Questions

1. What were the PA levels of K-12 students during the COVID-19 lockdown, particularly concerning the shift to online learning?
2. What were the most efficient measures that PE teachers applied to engage students in PA remotely?
3. How did family engagement and access to digital devices impact the teaching effectiveness of adapted online PE classes?

2. Materials and Methods

2.1. Search Strategy

A systematic review was conducted following the methodology outlined by Kitchenham (2004) with searches performed across several academic databases including Google Scholar, Web of Science, Scopus, ERIC, and MEDLINE/PubMed. The search was conducted in October 2023 and the search terms for this literature review were derived from prior searches conducted by Gordon et al. (2020); Mujiono and Gazali (2021); Stojan et al. (2022) and Crawford and Cifuentes-Faura (2022) with modifications tailored to the scope of this review (see Table 1).

Table 1. Systematic review sources: Search databases, strings, and number of results.

Data base	Search string	Results
Google scholar	Physical education, COVID-19 or corcoronavirus , lockdown or quarantine or stay-at-home or closure or home confinement.	18400
Web of science	Physical education, COVID-19 or corcoronavirus, lockdown or quarantine or stay-at-home or closure or home confinement.	1123
Scopus	Physical education, COVID-19 or corcoronavirus, lockdown or quarantine or stay-at-home or closure or home confinement.	3663
ERIC	Physical education, COVID-19 or coronavirus , quarantine or lockdown or stay-at-homeor closure or home confinement.	22
MEDLINE/PubMed	Physical education [Title/ Abstract] and COVID-19[Title/ Abstract] or coronavirus [Title/ Abstract] and lockdown [title/ abstract]) or quarantine [Title/ Abstract] or stay-at-home [Title/Abstract] or closure [Title/ Abstract]) or (Home confinement [Title/ Abstract].	36
Total		23244

2.2. Study Selection

Selected papers had to meet the following criteria for inclusion in this review:

- Publication in academic journals or conference proceedings from December 2019 onwards.
- Written in English.
- Addressing the topic of the COVID-19 pandemic.
- Focusing on the subject of PE.
- Contextualizing research within the framework of remote/online learning during the lockdown period.
- Inclusion of primary and secondary education students or teachers in the sample of participants.

The following exclusion criteria were applied:

- Papers classified as viewpoints, opinions, demands for change, analyses of requirements or any other type of study that does not involve the application of tangible advancements.
- Studies describing responses to COVID-19 that did not pertain to online or remote learning.
- Investigations situated in the higher education context.
- Works written in languages other than English.
- Research analyzing the post-lockdown scenario.

2.3. Data Extraction

A data extraction form was developed based on previous investigations. Data extracted included:

- Article identifiers: authors, year, title, journal, and length (# pages).
- Context: type and number of participants, educational stages, and country.
- Summary of development or intervention.
- Results and conclusions as reported by the authors.
- Risk of bias in study reporting.

2.4. Quality Assessment

In evaluating the quality of the included studies, the focus was on assessing the risk of reporting bias. Established quality assessment tools were employed to adhere to customary reporting standards for systematic reviews. However, it is important to note that the interpretation of results should be contextualized within the backdrop of the COVID-19 lockdown to avoid imposing undue expectations on authors due to the challenges of conducting research during a pandemic.

A visual RAG (red, amber, green) ranking system was utilized as previously employed by Gordon et al. (2020) and Stojan et al. (2022) to gauge the risk of reporting bias. The assessed areas included foundational theories, available resources, educational settings, pedagogical methods, and subject matter (see Table 2). Items were categorized as exhibiting a low risk of bias (green), a moderate risk of bias (amber), or a high risk of bias (red).

Table 2. Quality assessment and risk of bias of the interventions presented.

Bias source	High quality	Unclear quality	Low quality
Underpinning bias (U)	Clear and relevant description of theoretical models or conceptual frameworks that underpin the development.	A limited discussion of underpinning, with minimal interpretation in the context of the study.	No mention of underpinning.
Resource bias (R)	A clear description of the cost/ time / resources needed for the development	Some limited description of resources	No mention of resources
Setting bias (S)	Clear details of the educational context and learner characteristics of the study	Some description but not significant as to support dissemination	No details of learner characteristics or setting
Educational bias (E)	A clear description of relevant educational methods employed to support delivery	Some educational methods were mentioned but there was limited detail as to how they were applied.	No details of educational methods
Content bias (C)	Provision of detailed materials (Or details of access)	Some elements of materials presented or summary information.	No educational content presented

Source: Stojan et al. (2022).

3. Results

The detailed search strategy and manuscript selection process are presented in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group*, 2009) as shown in Figure 1. The search process yielded several records. However, many contained vague references to the pandemic without providing sufficient contextualization. Initially, 23,244 records were obtained from the database search. After the duplicates were deleted, 20,106 records remained. These records underwent an initial, less thorough review based on the title and abstract of the articles leading to the retention of 67 studies.

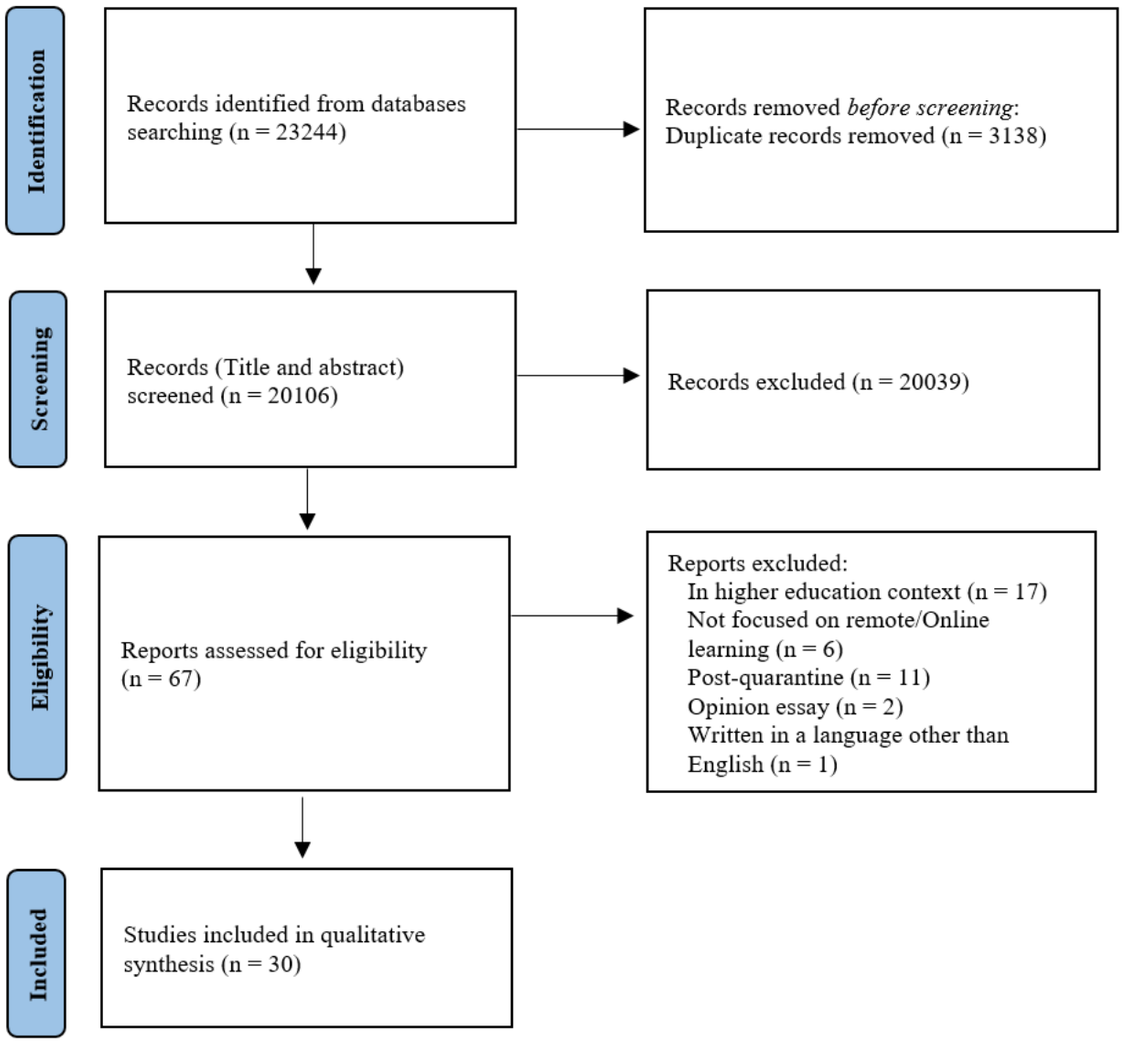

Figure 1. PRISMA flow diagram for included studies.

All articles were then read, and their eligibility was ascertained. At this stage, a total of 37 studies were excluded for not meeting the set parameters, such as focusing on remote or online learning being published in languages other than English, including participants from higher education or addressing the post-confinement situation. In total, 30 studies were included in this examination, all of which were published by December 2019, coinciding with the onset of the COVID-19 pandemic. For ease of understanding, each of the selected studies is accompanied by a summary in Appendix A.

3.1. Study Characteristics

The distribution of publication years is shown in Table 3 and Appendix A, specifically in the 'year' column. The first articles in this review were published online in July 2020 (An, 2020) while the latest contribution by Coulter et al. (2023) was published in August 2023. The breakdown of articles per year is as follows: 5 articles were published in 2020, the number rose to 16 in 2021, 7 articles were added in 2022 and finally, 2 articles were included in 2023.

Table 3. Characteristics of included studies.

Characteristics	Samples N
Year	
2020	5
2021	16
2022	7
2023	2
Type of participants	
Students	16
Students' parents	4
Teachers	10
Educational stage	
Kindergarten	1
Primary and secondary education	10
Primary education	12
Secondary education	7

The participants were divided into three main groups: students (n = 16), teachers (n = 10), and parents of students (n = 4). Regarding the educational levels covered, the sample articles were distributed as follows: one article focused on early childhood education, ten on primary and secondary education, twelve specifically on primary education and seven on secondary education.

The number of students involved in each study varied widely ranging from as few as eight participants to as many as 15,631 as depicted in Figure 2. Specifically, eight studies had fewer than 100 participants, fifteen studies

had between 100 and 999, and seven studies included more than 1,000 participants. The study conducted in 2020 had the largest sample with 15,631 students.

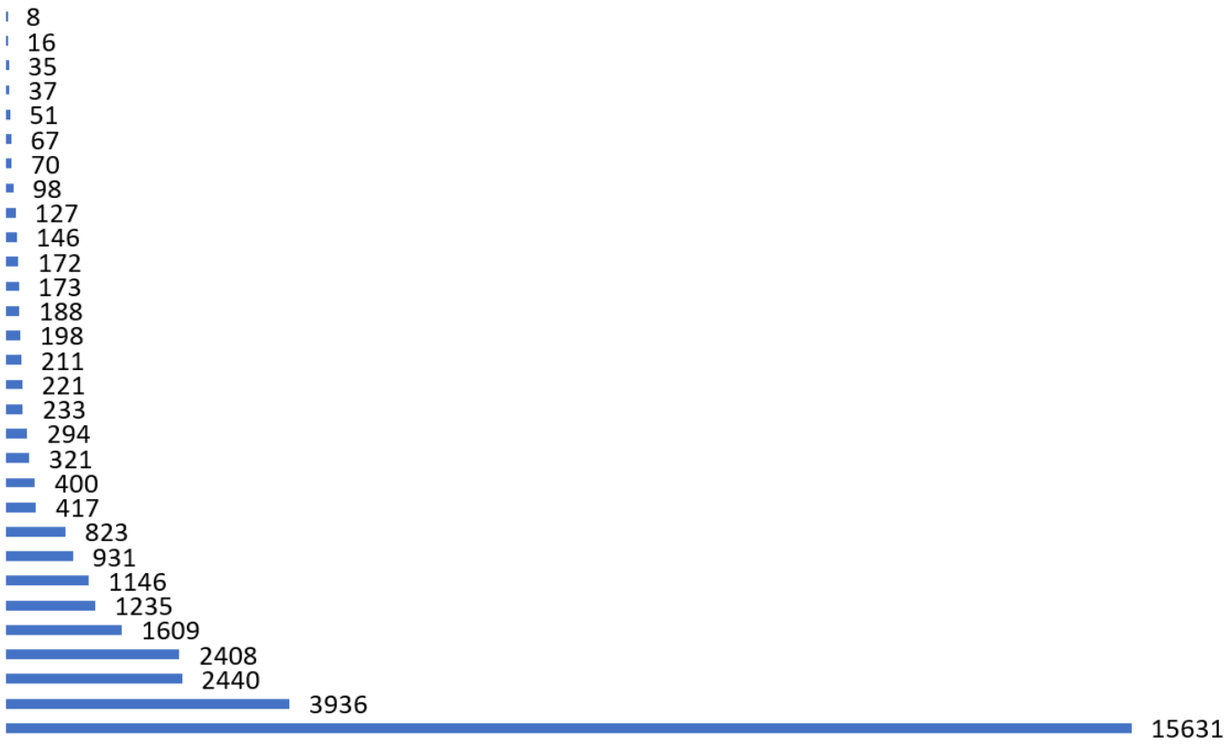

Figure 2. Number of participants in each article.

The geographical distribution of the studies is shown by their countries of origin as outlined in Appendix A under the column "country" . The breakdown of articles by country is as follows: The United States contributed five articles while Slovenia and Turkiye each contributed three. Brazil, France and Italy each had two published articles. Additionally, several countries had one article each, including Australia, Austria, China, Colombia, Croatia, the Czech Republic, Finland, Ireland, Greece, Hong Kong, Mexico, the Netherlands, Poland, South Africa, Switzerland, and Tunisia.

The risk of bias in these studies is visually presented in Figure 3 (risk of bias in reporting) and detailed in Appendix A ('risk of bias study reporting). Generally, the quality of the studies was rated from moderate to high, due to the length of the articles and the impact factors of the journals in which they were published.

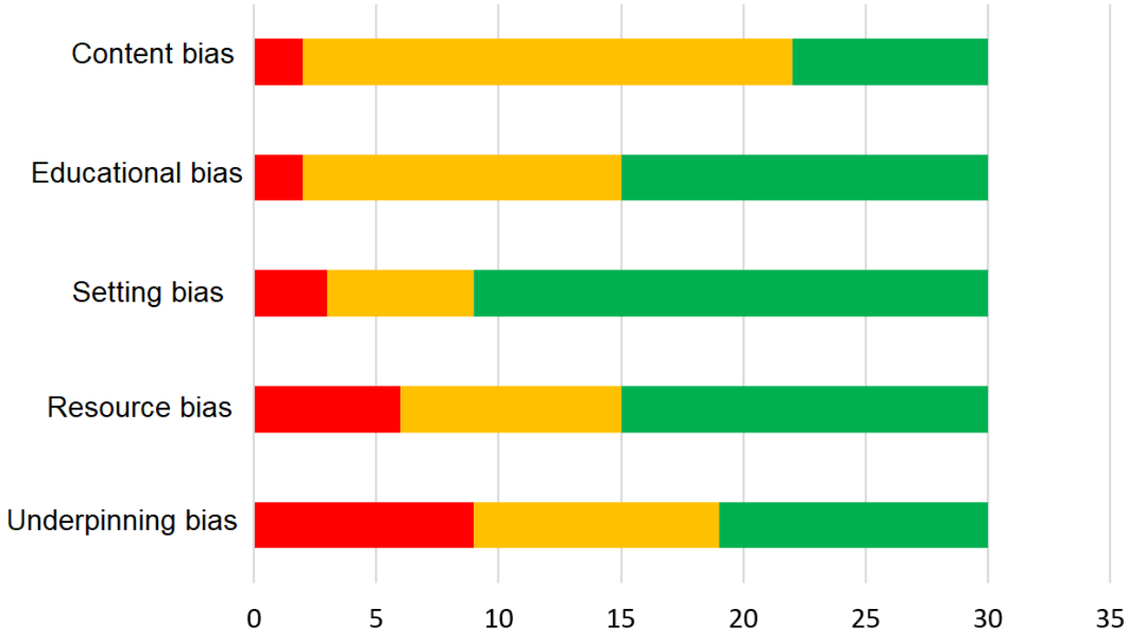

Figure 3. Risk of bias in study reporting.

4. Discussion

4.1. How PE Has Been Taught

The results indicate that a significant proportion of teachers have predominantly adopted online teaching approaches with a primary emphasis on fitness and health content while content related to body expression, games, sports, and motor skills often took a secondary role (Petrusic & Stemberger, 2021).

Several reviews have articulated that the online learning model can be effectively implemented in PE with the assistance of supporting platforms and applications (Souissi et al., 2021). Notable measures taken to facilitate this transition include the introduction of online learning platforms such as Blackboard, Zoom, TronClass, Classin, and

Wechat group platforms as well as the provision of online training and the comprehensive collection of course-related information (Li & Cheong, 2022). For instance, Schoology, a learning management system designed for educational institutions incorporates a video application that proves invaluable in demonstrating psychomotor domain movements (Peçanha, Goessler, Roschel, & Gualano, 2020; Petrusic & Stemberger, 2021). This platform serves as an avenue to conduct PE activities that closely mirror in-class learning, offering extensive communication opportunities that facilitate discussions and collaborative teamwork (Purnomo et al., 2022). Additionally, Schoology is equipped with diverse multimedia resources, such as audio, video, and images which enhance the learning experience in PE especially through the video application's demonstration of psychomotor movements (Pajek, 2022). Students also receive valuable feedback in the form of activity comments enabling them to gain insights directly from teachers.

Another approach to delivering PE is through video vlogs, enabling students to access numerous vlog videos on physical activities available on video provider platforms (Audor González, Lerma Castaño, & Roldán González, 2022). Teachers can further engage students by assigning practical tasks such as creating vlog videos demonstrating physical activities in line with their interests and course materials which can then be submitted for review (Gobbi et al., 2020). A distance learning model coupled with collaborative involvement from students' parents is facilitated through a monitoring sheet that tracks student learning activities (Audor González et al., 2022).

While there is a heightened intention to promote PA during closures, it does not invariably translate into increased PA-promoting behaviors. Some teachers may face challenges in actualizing their intentions due to resource limitations or other impediments (Maltagliati et al., 2021).

The current findings underscore that remote PE interventions effectively maintain or even enhance students' self-perceived physical fitness. Consequently, this study advocates for remote PE classes that incorporate physical exercises, body movement practices, sports engagement, dance, games and PA within the home environment while also encouraging active participation from families. This approach emerges as a pertinent strategy for enhancing self-perceived physical fitness in schoolchildren (Audor González et al., 2022).

4.2. Teachers' Problems with Information and Communication Technology

Online teaching and learning have become established modes of delivery in developed countries and to a certain extent in some developing nations. Nevertheless, the transition from traditional face-to-face instruction to online learning poses substantial challenges for teachers, students, families and even governments in many countries due to constraints such as financial limitations, inadequate skillsets, limited information and communication technology (ICT) infrastructure, restricted internet access and insufficient educational resources (Basilaia & Kvavadze, 2020; Şahin, 2021).

In the field of PE, teachers have displayed positive attitudes toward ICT, recognizing their potential as tools for pedagogical innovation and enhanced learning experiences (Şahin, 2021). Paradoxically, many PE teachers, despite acknowledging the value of technology, do not feel adequately prepared to effectively integrate it into their teaching practices. Some may even fail to fully appreciate the significance of technological integration in PE, possibly because previous technology applications in this field were primarily designed for in-person classroom use. Thus, the transition to online instruction poses a unique challenge for PE teachers as the sudden shift necessitates the immediate and mandatory integration of ICT, a process complicated by the predominantly physical nature of PE content. Moreover, the importance of developing students' technological skills highlighted by Ordonhes, Hercules, and Cavichiolli (2021) becomes particularly salient during lockdown periods.

In this exceptional educational context, Jakobsson, Malm, Furberg, Ekelund, and Svensson (2020) contend that technology represents the sole viable means to maintain both physical well-being and mental health during lockdowns. Furthermore, ICT plays a critical role at the communicative and managerial levels for PE teachers (Ordonhes et al., 2021). This includes communication with other educational stakeholders such as fellow teachers and administrative personnel (Coulter et al., 2023). Consequently, during lockdowns, ICT is indispensable for enhancing PA levels and facilitating communication, management, and teaching interventions. It is important to note that family dynamics and individual teacher circumstances can influence the availability and effectiveness of virtual teaching for PE educators (Papastergiou, Kanaros, Papamichou, & Vernadakis, 2021).

Various communication channels have been employed to engage with students and parents with virtual platforms serving as the primary mode of interaction and email serving as a secondary communication channel throughout the lockdown (Coulter et al., 2023). Some teachers have also acknowledged the use of mobile instant messaging for communication purposes. Interestingly, social media platforms have been widely used by the majority of teachers, although a portion remains somewhat hesitant to embrace them (Dunton, Do, & Wang, 2020; Papastergiou et al., 2021).

In this context, teachers must continuously evolve in terms of their mindset and creativity to devise innovative approaches for PE that align with the specific learning objectives of the subject (Dunton et al., 2020).

4.3. Lack of PA

There was a substantial and noteworthy decline in the PA MET-minutes per week among PE teachers during the school closures necessitated by the COVID-19 pandemic. This decline in their PA levels during the pandemic is concerning given the valuable contributions PE teachers make to public health by mitigating sedentary lifestyles (Bronikowska, Krzysztoszek, Łopatka, Ludwiczak, & Pluta, 2021; Hall-López, 2020; López-Valenciano, Suárez-Iglesias, Sanchez-Lastra, & Ayán, 2021).

Concurrently, there was an observable increase in students' body mass during this period with approximately 27% of participants experiencing a moderate to significant increase in body weight (Pavlovic et al., 2021). Consequently, there was a notable shift in the nutritional status of students marked by a 5.2% increase in the proportion of students classified as overweight or obese (Nolan & Zbaracki, 2022). It is worth noting that students who reduced their training frequency due to lockdown were three times more likely to experience an increase in body mass compared to those who maintained their PA levels (Planinšec, Matejek, Pišot, Pišot, & Šimunič, 2022; Zenic et al., 2020). Sustaining PA is paramount for health prevention particularly given the increased health risks

associated with elevated body mass and the manifold benefits of PA for cardiovascular, pulmonary, and muscular health (Greier et al., 2021; Ng et al., 2021).

4.4. Teachers' Problems with Student Evaluation

The evaluation process during the lockdown was marked by significant uncertainty with some teachers choosing not to implement it. Only half of the surveyed teachers confirmed their intention to carry out an evaluation and just a third of them had already planned and organized the process. Methodological restructuring during the lockdown has presented teachers with numerous challenges with assessment being one of the most significant (Burgess & Sievertsen, 2020).

The establishment of a continuous evaluation process has introduced complexities into the realms of assessment and grading. Regarding PE content, various regional decrees broadly structure it around elements such as health, motor skills, bodily expression, and the practice of games and sports. However, the exceptional circumstances of the lockdown have created uncertainties regarding the feasibility of delivering specific content (Cece, Guillet-Descas, & Lentillon-Kaestner, 2022). The virtual nature of teaching may render some activities impractical, prompting teachers to prioritize content that effectively enhances students' psychological and physical well-being (Chan et al., 2021). The inability to conduct in-person assessments and institute a continuous evaluation process exacerbates the challenge of evaluation and grading during lockdown, a predicament that is compounded by the inherently physical nature of PE content (Aydoğmuş, Yüksel, & Revan, 2022).

Beyond the grading aspect, the primary purpose of assessment is to provide insights into student progress for both parents and other educators. Lapses in this information-sharing process could hinder the early identification of learning difficulties, potentially leading to long-term adverse consequences for students (Cece et al., 2022). While some authors have suggested using predicted scores if the assessment process is discontinued. Research by Aydoğmuş et al. (2022) indicates that such predictions are often inaccurate and can exacerbate the performance gap between high-achieving students and those from disadvantaged backgrounds.

In cases where direct evaluation is not feasible or practical, questionnaires can serve as a viable alternative. In this regard, a self-perceived physical fitness questionnaire has been identified as a valid and reliable tool for assessing children's self-perceptions of their physical fitness within the age range of 6 to 13 (Lemes et al., 2022).

4.5. Impact of the Lockdown on the Students

Students have expressed that online learning for PE during the COVID-19 pandemic has not been fully effective. Some students have faced challenges such as poor home internet connections or a lack of access to computers for classwork and homework which have compounded the issues with online learning (Basilaia & Kvavadze, 2020).

Additionally, there has been a significant reduction in the PA levels of students specializing in PE, particularly in terms of PA duration (Stverakova et al., 2021). The most significant decline has been observed in intense PA, which decreased by as much as 46.69%. Furthermore, there was a noticeable increase in the level of sedentary behavior. These findings should not be underestimated, as a substantial decrease in PA can have adverse effects on blood glucose levels and body composition, increase the risk of depression and anxiety disorders, reduce the overall quality of life, and compromise the immune system (Koen, Neethling, & Taylor, 2021).

The lockdown period has also taken a toll on students' mental health leading to various psychological symptoms (Mouloud & Krine, 2020). An increase in psychiatric issues such as depression, anxiety, and panic disorders has been reported. The prevalence of depressive symptoms among students has risen during the lockdown, with contributing factors such as isolation, social distancing, and separation from peers and friends. Changes in lifestyle, such as prolonged periods of staying at home, a lack of exercise in gyms or sports facilities, and extended screen time have led to issues like insomnia, reduced appetite, and diminished concentration (Eyler et al., 2021; Ten Velde et al., 2021). Students' emotional well-being has been notably unstable in the context of PE learning. Therefore, it is imperative for PE teachers to establish a supportive environment that fosters emotional stability among students, especially when the atypical learning circumstances are a source of stress (Perez, Thalken, Ughelu, Knight, & Massey, 2021). Teachers should strive to reassure students and prevent them from feeling overwhelmed during these challenging times.

4.6. Comparison with Previous Studies on Online PE

The results of this review align with other studies such as Direito, Jiang, Whittaker, and Maddison (2015) which emphasized the vital role of technology in maintaining PA. According to Garcia-Hermoso et al. (2020) this study also found that online platforms combined with structured physical exercise and family involvement were crucial for students to maintain fitness levels.

According to Taher et al. (2022) challenges were confirmed especially in resource-limited settings where students have limited access to digital resources and opportunities for PA.

5. Conclusion

This systematic review highlights the complexities and challenges of delivering PE online during the COVID-19 pandemic while also emphasizing the potential for maintaining student PA through carefully designed interventions. Strategies that focused on structured physical exercises, active family involvement, and the use of accessible digital platforms proved effective in maintaining PA levels and promoting physical health during the lockdown.

Maintaining PA through remote learning is not only feasible but also crucial for supporting students's physical and mental well-being, particularly during times of crisis. These insights provide a foundation for further research and the development of online PE practices that could benefit both educational outcomes and public health.

This article demonstrates online PE, when supported by structured interventions, can mitigate the negative impact of school closures on students' PA. The interventions that yielded the best results included a combination of structured exercise, accessible digital tools and student family involvement. These findings highlight the need for further development of distance education curricula especially for students with limited resources and teachers facing the digital divide.

5.1. Implications and Suggestions

The findings of this review emphasize the importance of incorporating technology and family engagement into online PE classes. Schools should invest in teacher training on digital tools and ensure that all students have access to the necessary resources to fully participate in online PE.

Future studies should explore the long-term effects of remote PE on students' physical and mental health and examine ways in which schools can better support teachers in resource-limited environments.

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Appendix

Appendix A. Suggested heading: Detailed overview of included studies.

Autor	Year	Title	Journal name	Length	Type of participants	# Participants	Educational stages	Country	Summary of development or intervention	Results and conclusions	Risk of bias in study reporting				
											U	R	S	E	C
An (2020)	2020	Projecting the impact of the coronavirus disease-2019 pandemic on childhood obesity in the United States: A microsimulation model.	Journal of sport and health science	11	Students	15631	Kindergarten	United States	A microsimulation model simulated the trajectory of a nationally representative kindergarten cohort's body mass index z-scores and childhood obesity prevalence from April 2020 to March 2020.	Public health interventions are urgently called to promote an active lifestyle and engagement in physical activity among children to mitigate the adverse impact of COVID-19 on unhealthy weight gains and childhood obesity.					
Audor González et al. (2022)	2022	Effects of physical exercise on the body composition and conditional physical capacities of school children during confinement by covid-19.	Global pediatric health	7	Students	70	Primary education	Colombia	The objective of the present study was to determine the effects of physical exercise on body composition in a sample of school-age children during confinement by COVID-19. A quantitative approach study and quasi-experimental design with pre-test and post-test.	A structured physical exercise program through virtuality for schoolchildren can be a strategy to control overweight and obesity in children during confinement and improve their conditional physical capacities (Speed, jumping).					
Aydoğmuş et al. (2022)	2022	Analysis of physical activity levels of physical education teachers during the COVID-19 pandemic.	Education quarterly reviews	10	Teachers	417	Primary / Secondary education	Turkiye	The aim of this study is to examine physical education teachers' physical activity levels during the COVID-19 pandemic period	While there was a negative and significant correlation between total PA and years of service and age, a positive and significant correlation was found between experience and BMI and age. As a result, it can be concluded that physical education teachers continue their active lives despite the					

										restrictions during the COVID19 pandemic period.					
Bronikowska et al. (2021)	2021	Comparison of physical activity levels in youths before and during a pandemic lockdown.	International journal of environmental research and public health	13	Students	127	Secondary education	Poland	This study aimed to compare physical activity (PA) levels before and during a pandemic lockdown among adolescent polish youths. An online survey tool that included validated measures of adolescents' MVPA and socio-environmental, potential confounders was administered to youths.	The results suggest a negative impact of the pandemic on PA undertaken by youths. Based on these results we see the need for increased action by both physical education (PE) teachers and parents to motivate and support youngsters in taking up systematic PA consciously.					
Cece et al. (2022)	2022	Teacher well-being and perceived school climate during COVID-19 school closure: The case of physical education in Switzerland.	The teacher educator	17	Teachers	188	Primary / Secondary education	Switzerland	The study aim was to contribute to the understanding of the teachers' wellbeing experiences (Burnout and engagement) and school climate perceptions during the lockdown for PE teachers in comparison with those of teachers of other subjects.	School closure was related to higher collaboration, vigor scores and lower levels of physical fatigue for PE teachers. These positive effects for the PE teachers suggest using some profits of the COVID-19 period in normal teaching conditions.					
Chan et al. (2021)	2021	Effectiveness of online teaching in physical education during COVID-19 school closures: a survey study of frontline physical education teachers in Hong Kong.	Journal of physical education & sport	8	Teachers	294	Primary / Secondary education	Hong Kong	This survey study aims to examine the effectiveness of online teaching in physical education (PE) and support needed from the teachers' perspective.	In summary, the effectiveness of online teaching in PE during COVID-19 school closures was generally perceived to be low and difficult by the frontline PE teachers. Schools and governments should provide sufficient support, such as online teaching kits and concrete teaching guidelines, for PE					

										teachers to develop creative and interactive online lessons, which will in turn benefit students in motor skill acquisition and physical activity level.					
Coulter et al. (2023)	2023	PE at home: keeping the 'E'in PE while home-schooling during a pandemic.	Physical education and sport pedagogy	12	Students' parents	173	Primary education	Ireland	This study examined parents'experiences of using the PE at Homeresource and contributes to documenting the PE home-learning experience and can inform how the education system mightrespond and incorporate remote teaching into the future.	The PE at home lessons address the teaching and learning of PE in multiple contexts, particularly in an online environment, and they can be used in multiple ways to promote learning.					
Dunton et al. (2020)	2020	Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the US.	BMC public health	13	Students' parents	211	Primary education	United States	This study examined the effects of the COVID-19 pandemic on PA and sedentary behavior (SB) in U.S. children. Parents and legal guardians of U.S. children (Ages 5–13) were recruited through convenience sampling and completed an online survey between April 25–May 16, 2020. Measures included an assessment of their child's previous day PA and SB by indicating time spent in 11 common types of PA and 12 common types of SB for children.	Parents of older children (Ages 9–13) vs. younger children (Ages 5–8) perceived greater decreases in PA and greater increases in SB from the pre- to early-COVID-19 periods. Children were more likely to perform PA at home indoors or on neighborhood streets during the early- vs. pre-COVID-19 periods. About a third of children used remote/Streaming services for activity classes and lessons during the early-COVID-19 period.					

Eyler et al. (2021)	2021	Children's physical activity and screen time during COVID-19 pandemic: A qualitative exploration of parent perceptions.	Health behavior and policy review	10	Students' parents	16	Primary education	United States	In this study, we explore parent perception of children's physical activity and screen time during COVID-19 stay-at-home orders. We interviewed 16 parents of children ages 5-12 years in the St. Louis, Missouri region using snowball sampling.	Parents perceived the amount of physical activity as the same or increased but reported an increase in screen time.						
Gobbi et al. (2020)	2020	Promoting physical activity during school closures imposed by the first wave of the COVID-19 pandemic: Physical education teachers' behaviors in France, Italy and Turkey.	International journal of environmental research and public health	15	Teachers	1146	Primary / Secondary education	France, Italy, and Turkey	We aimed to investigate the effects of lockdown on PE teachers' behaviors promoting their students' out-of-school PA and differences between three European countries.	A significant multivariate main effect time × country × gender ($p < 0.001$) was reported for the behaviors promoting students' PA, with French and Italian teachers increasing some behaviors, while Turkish teachers showing opposite trends.						
Greier et al. (2021)	2021	Physical activity and sitting time prior to and during COVID-19 lockdown in Austrian high-school students.	AIMS public health	10	Students	221	Secondary education	Austria	The present study examined PA and sitting time in 14 to18-year-old Austrian high school students prior to and during the second COVID-19 lockdown in Austria. Data was collected via an online questionnaire during fall/Winter 2020/21. Questions were based on the international physical activity questionnaire, which examined frequency and duration of PA and sitting time.	The frequency of walking (Days/Week) also decreased during COVID-19 lockdown, which also contributed to a significant decline in total walking time ($p < 0.01$). Further, the decline in PA was more pronounced in boys, while girls reported a greater decline in walking. These differences were due to higher PA and walking in boys and girls, respectively, prior to the lockdown. During the lockdown sex						

										differences in PA and sitting time were limited. Taken together, these results highlight the impact of COVID-19 policies on PA in adolescents and emphasize the importance to promote an active lifestyle even in times of home confinement.					
Hall-López (2020)	2020	Physical activity levels in physical education teachers before and during school suspension brought by the COVID-19 quarantine.	Facta universitatis. series: Physical education and sport	6	Teachers	37	Primary / Secondary education	Mexico	The aim of this paper was to compare the physical activity (PA) levels in physical education (PE) teachers before and during school suspension brought by the COVID-19 quarantine.	PE teachers are considered professionals who help public health by reducing sedentary lifestyle in society. In that context, decrement in PA level, i.e., their inactivity determined during the COVID-19 pandemic is unacceptable.					
Koen et al. (2021)	2021	The impact of COVID-19 on the holistic development of young South African at-risk children in three early childhood care and education centres in a rural area.	Perspectives in education	18	Teachers	8	Primary / Secondary education	South Africa	A qualitative approach was taken, following a participatory action-learning and action-research (PALAR) design where all participants collaborate as equal partners and construct their own meaning from experiences within the action-learning set (ALS) to advocate for change.	The findings highlight that, even during a lockdown, it vital that collaborative ways are found to harness the precious early years with a view not only to meeting these children's needs but also to laying the foundation for a sustainable future. It is argued that if teachers were to apply the Ubuntu philosophy, they would learn how to make lifelong use of the acquired skills to improve the holistic well-being of young children on an ongoing basis.					

Lemes et al. (2022)	2022	Changes in children's self-perceived physical fitness: results from a physical education internet-based intervention in COVID-19 school lockdown.	Sport sciences for health	9	Students	67	Primary education	Brazil	To establish the changes in children's self-perceived physical fitness (SPPF) during pandemic COVID-19 social distancing in a school lockdown	A remote physical education intervention effectively maintained or even increased individual results of children's SPPF.					
Li and Cheong (2022)	2022	The impact of the COVID-19 pandemic on the physical fitness of primary school students in china based on the bronfenbrenner ecological theory.	Frontiers in psychology	9	Students	1235	Primary education	China	This research sought to determine the impact of the pandemic on the physical fitness of primary school students. Using the Chinese national student physical fitness standard as a guide, the students were subjected to BMI, vital capacity, 50 m sprint, sit and reach, timed rope-skipping, timed sit-ups, and 50m × 8 shuttle run measurements.	The results showed that the overall physical fitness of the participants was better after the lockdown. Specifically, vital capacity, sit and reach, timed rope-skipping and timed sit-ups had improved after the lockdown. Meanwhile, 50m × 8 shuttle run dropped slightly but not significantly whereas 50 m sprint dropped sharply after the lockdown.					
Maltagliati et al. (2021)	2021	Predicting changes in physical education teachers' behaviors promoting physical activity during the COVID-19 pandemic using an integrated motivational model.	Journal of teaching in physical education	10	Teachers	931	Primary / Secondary education	France and Italy	This study identifies motivational determinants in changes in PE teachers' behaviors promoting PA.	Results showed that, from before to during lockdown, an increase in autonomous motivation (Especially among French teachers) and motivation were associated with an increase in the intention to promote PA					
Ng et al. (2021)	2021	Finnish late adolescents' physical activity during COVID-19 spring 2020 lockdown.	BMC public health	11	Students	2408	Secondary education	Finland	We aimed to examine physical activity levels of late adolescents, the contexts to be physical active and its changes during the spring 2020 lockdown. A national representative	Overall, most late adolescents reported their PA levels decreased during lockdown. Findings from this study continue to demonstrate factors associated with					

									sample of late adolescents completed self-report online surveys on PA behaviours between March and June 2020.	PA in the context of the COVID-19 lockdown.					
Nolan and Zbaracki (2022)	2022	The impact of pandemic lockdowns and remote learning on student fitness: an investigation of changes to high school student fitness levels.	Journal of teaching in physical education	8	Students	146	Secondary education	Australia	The purpose of this study was to investigate the impact on health-related fitness resulting from COVID-19 lockdowns on male high school students in Melbourne, Australia.	The impact on students' fitness levels was noteworthy, and the long-term impacts of this decrease are yet to be seen. This research brings focus to what can be done to maintain adolescent fitness when their usual exercise opportunities are not available.					
Ordonhes et al. (2021)	2021	Using distance learning as a strategy for maintaining income of physical education professionals during the COVID-19 pandemic.	Education and information technologies	12	Teachers	400	Primary / Secondary education	Brazil	The study aimed to understand how was the performance of Brazilian physical education professionals during this period.	Most professionals performed their activities at home (71%) and used different digital platforms as work tools, noting that distance learning was a strategy used and well regarded by professionals.					
Pajek (2022)	2022	Impact of the COVID-19 pandemic on the motor development of schoolchildren in rural and urban environments.	BioMed research international	7	Students	1609	Primary education	Slovenia	We aimed to examine the impact of the pandemic and society closure on motor development of school children and to find differences between rural and urban environments.	The greatest effects of pandemic closure were found in the 600-meter run, in polygon course backwards test, in the number of sit-ups in 60 seconds, and in the 60-meter sprint. Children from rural areas showed worse decrement in physical fitness index compared to urban areas, except for 600-meter run. We conclude that the pandemic closure has had a significant inhibitory					

										effect on the motor development of schoolchildren and has reduced their overall physical fitness with worse decline in rural areas.					
Papastergiou et al. (2021)	2021	Effects of a project based on mobile applications, exergames and a web 2.0 social learning platform on students' physical activity and nutritional criteria in the era of COVID 19.	Educational media international	19	Students	51	Secondary education	Greece	The aim of this study was the investigation of the impact of a year-long, student-centered physical education (PE) project, in which mobile applications for physical activity (PA) and nutrition monitoring, exergames and an online social learning platform were utilized, on students' PA, sedentary behavior and food selection criteria.	The analysis of the data, which were collected through questionnaires, showed an increase in the experimental group students' use of mobile devices for PA and nutrition monitoring as well as a greater improvement of their perceived helpfulness of PA applications and food selection criteria, in relation to the control group. The quarantine did not significantly affect their levels of PA and sedentary behavior, although, in the control group, PA decreased significantly and sedentary time increased significantly.					
Pavlovic et al. (2021)	2021	Keeping children healthy during and after COVID-19 pandemic: Meeting youth physical activity needs.	BMC public health	7	Teachers	2440	Primary / Secondary education	United States	The purpose of this study was to: 1) examine the maintenance of physical education and physical activity during the distance learning time, 2) determine the resources educators are utilizing to deliver PE curricula, and 3) understand the challenges experienced	79% of respondents reported that students were either "significantly less" or "somewhat less" physically active during the closure. Challenges experienced by teachers were identified.					

									by educators during distance learning.						
Perez et al. (2021)	2021	Nowhere to go: Parents' descriptions of children's physical activity during a global pandemic.	Frontiers in public health	8	Students' parents	321	Primary education	United States	To understand, from the perspective of parents, how the COVID-19 shelter-in-place mandates affected children's physical activity, while also considering families' socioeconomic status.	Analyses indicated that shelter-in-place mandates restricted children's opportunities for physical activity. However, if families had access to outdoor spaces or equipment, they could encourage and support more physical activity opportunities than those without.					
Petrusic and Stemberger (2021)	2021	Effective physical education distance learning models during the Covid-19 epidemic.	CEPS journal	18	Students	198	Secondary education	Slovenia	Our research aimed to determine which PE distance learning models proved to be the most effective during the epidemic, resulting in a high level of pupils' activity despite participation from home.	The results showed that the most effective model was the flipped learning teaching model, where pupils were given an overview in advance of the different forms of teacher video recordings. Then they also actively participated with their ideas in the performance of the online lesson.					
Planinšec et al. (2022)	2022	Consequences of COVID-19 lockdown restrictions on children physical activity-a slovenian study.	Frontiers in public health	10	Students	3936	Primary education	Slovenia	The aim of the study was to examine how these restrictions were reflected in the amount of different forms of physical activity.	We found that during lockdown there has been an alarming decrease in the frequency and duration of organized PA at school and at sports clubs.					

Şahin (2021)	2021	Self-evaluated teacher effectiveness in physical education and sports during schools closedown and emergency distance learning: Teacher effectiveness in physical education.	International journal of curriculum and instruction	15	Teachers	172	Primary / Secondary education	Turkey	This quantitative study scrutinizedthe self-assessment of physical education and Sport teachers about theironline physical education classes.	The findings of the study showedthat certain variables such as technological competencies, technical support provided by the school, and application/software support were influential in the participant physical education teachers' self-assessment. In addition, it was found outthat SETEQ-PE variables such as technological competencies, technical support provided by the school, and application/software support affected to PE and sports teachers' self-assessment responses.					
Souissi et al. (2021)	2021	Distance motor learning during the COVID-19 induced confinement: Video feedback with a pedagogical activity improves the snatch technique in young athletes.	International journal of environmental research and public health	13	Students	35	Primary education	Tunisia	The purpose of the present study was to investigate which of two strategies, Video Feedback with pedagogical activity (VF-PA) or video feedback (VF), would be more beneficial for the remote error correction of the snatch weightlifting technique during the confinement period.	The present findings suggest combining video feedback with pedagogical activity during the pandemic induced online coaching or physical education to improve movement learning in school aged children.					
Stverakova et al. (2021)	2021	The impact of COVID-19 on physical activity of Czech children.	PLoS one	14	Students	98	Primary education	Czech Republic	The purpose of this study was to evaluate the level of physical activity (PA) of Czech children during COVID-19 in autumn 2020.	Total PAQ-C score was 0.38 lower during COVID compared to Pre-COVID. COVID lockdown resulted in significant reduction of PA in Czech children.					

Ten Velde et al. (2021)	2021	Physical activity behaviour and screen time in Dutch children during the COVID-19 pandemic: Pre-, during-and post-school closures.	Pediatric obesity	7	Students	233	Primary education	Netherlands	To investigate the effect of COVID-19 measures on screen time and PA in Dutch children pre-, during- and post-school closures.	Children were less physically active, and screen time was higher during and after the school closures due to the COVID-19 lockdown. This is alarming as an active lifestyle in children is crucial in preventing chronic diseases such as obesity.					
Zenic et al. (2020)	2020	Levels and changes of physical activity in adolescents during the COVID-19 pandemic: contextualizing urban vs. rural living environment.	Applied sciences	14	Students	823	Secondary education	Croatia	The purpose of this investigation was to evaluate the changes in PAL and factors associated with PALs among Croatian adolescents while considering the impact of community (Urban vs. rural living environment).	The results showed a significant influence of the living environment on the decrease of PAL, with a larger decrease in urban adolescents. The differences between urban and rural adolescents with regard to the established changes in PALs and relationships between the predictors and PALs are explained by the characteristics of the living communities (Lack of organized sports in rural areas), and the level of social distancing in the studied period and region/country.					