REVIEW ARTICLE

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Physical Education Classes and Health Outcomes among Children and Adolescents: A Systematic Review of Observational Studies

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Abstract: Background: The aim of the current study was to examine the association between physical education classes (PE) and health outcomes. Materials and Methods: A systematic review was carried out with studies identified in seven databases. The eligibility criteria included an observational design, objective or self-reported measure of PE exposure (i.e., participation or frequency in classes) and any health outcome. The synthesis of data was performed by clustering studies according to the direction of association between PE classes and each outcome, classified as beneficial, no effect, inconclusive, or harmful. Results: A total of 6,102 studies were screened, of which 99 were included, with 2,717,508 participants and 22 groups of outcomes. The results revealed a beneficial effect of PE on physical activity (74%), mental health (69%), physical fitness (80%), sports practice (80%), self-rated health (75%) and smoking (60% of studies). No effect was found for the association between PE and alcohol consumption. Inconclusive results emerged from studies that analyzed body fat indicators, sedentary behavior, academic achievement, and the other 12 outcomes. Conclusions: PE as offered in schools, provides health benefits regarding physical activity, mental health, physical fitness, sports practice, self-rated health, and smoking, in addition to the pedagogical aims of the discipline.

Keywords: Health behavior, Lesson, School, Students

1. Introduction

School is a relevant environment to promote health behavior and, consequently, improve well-being and adequate development among children and adolescents. In the school context, Physical Education (PE) is a discipline that is part of the mandatory curriculum and has many objectives for the integral development of students through human movement, including health promotion. Although there is some discussion regarding the strategy used to promote health through PE, whether by providing a direct increase in physical activity and other behaviors during classes or by promoting health education (Quennerstedt, 2019), the potential of PE to promote health is supported by literature (Bandeira *et al.,* 2022).

The effects of PE on student health have been investigated and the results of experimental studies demonstrated improvements in cardiorespiratory fitness, flexibility, muscular strength and endurance, handgrip strength, speed, agility, body mass index, and waist circumference (Rocha *et al.,* 2025; Reis *et al.,* 2024). Minor modifications to typical PE provision also positively impact adolescent mental health and wellbeing (Rocliffe *et al.*, 2024). Interventions in PE consistently increase physical activity during PE classes, however experimental evidence do not support the improvement on physical activity outside schools (Reis *et al.,* 2024). Experimental designs enable causal inferences to be made and can be used to assess new strategies for incorporation into PE. However, interventions deliberately modify the context of classes by increasing volume, intensity, curriculum,

teaching practices, and content. As a consequence, the results are related to a format of PE that is probably not conventionally applied in schools worldwide.

In order to assess the benefits of the real scenario of PE on student´s health, some researchers have conducted observational studies. Many studies investigated the association between PE and a variety of outcomes, such as health related behaviors (Barbosa et al., 2012; El-ammari *et al.,* 2017; Martins *et al.*, 2022; Uddin *et al.,* 2020; Zhan *et al.,* 2021), body fat (Ekblom-Bak *et al.,* 2018; Khan *et al.,* 2019; Sabia et al., 2017), mental health (Knaus et al., 2020; Southerland *et al.,* 2016; Werneck *et al.,* 2020), physical fitness (Coledam *et al.,* 2018; Peralta *et al.,* 2020; Santos *et al.*, 2020), academic achievement (Knaus *et al.,* 2020; Shen, 2017) and other health indicators (Ekblom-Bak *et al.,* 2018; Jodkowska *et al.*, 2019; Barros *et al.,* 2013; Bergmann *et al.,* 2020; Araujo *et al.*, 2024). The high number of studies analyzing different health parameters and heterogeneity of the results make it difficult to understand how PE as offered in schools is associated with health among children and adolescents. A systematic review could summarize the available literature and provide information that contributes to future curricular reformulation, teaching practice, and public policies regarding PE, as well as describing the gaps in this field of knowledge.

Therefore, the aim of the current study was to examine the association between PE classes and health outcomes through a systematic review of observational studies.

2. Materials and Methods

This is a systematic review conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement (Page *et al.,* 2020), checklist, presented in Appendix 1, and was registered with PROSPERO (CRD42021251188).

2.1 Eligibility criteria

The following inclusion criteria were adopted in this review: a) Sample of children or adolescents (or adults when longitudinal design was adopted and tracking was performed since childhood/adolescence); b) Self-reported or objective measure of any physical education classes measure; c) Observational design; d) Any self-reported or objectively measured health outcome; e) Description of the association between physical education classes (exposure) and health (outcome) adjusted for confounders; f) Published in English, Spanish, or Portuguese languages.

Exclusion criteria were: a) The PE variable was an outcome; b) Variables were not mutually exclusive; c) Studies analyzing the contribution of PE for daily physical activity or sedentary behavior; d) The outcome was only during PE or school routine; e) Implementation of public policies; f) PE classes expressed as grade, performance, enjoyment, satisfaction, or fun; f) Outcome was injury during PE; g) Statistical analysis with no adjustment (only bivariate).

2.2 Information sources

The databases Web of Science, MEDLINE via PubMed, Scopus, Sport Discus via EBSCO, EMBASE, LILACS, and SciELO were searched until October 10, 2022, with no restriction of time.

2.3 Search strategy

A specific search strategy was designed for each database and the strategies are fully described in Appendix 2. Keywords were inserted in three groups: a) PE variable: "compliance" OR "participation" OR "enrollment" OR "engagement" OR "achievement" OR "attendance" OR "requirement" OR "Frequency") AND "physical education" AND "Class*' OR "lesson"; b) Outcomes (a list of any health variable, including a general key-word "health"); c) population: "child*" OR "adolesc*" OR "teen*" OR "youth" OR "student").

2.4 Selection process

The selection was performed using the software Rayyan (http://rayyan.qcri.org). Duplicate records were excluded and potential studies were screened in order of titles, abstracts, and full texts, independently, according to the eligibility criteria, by two authors (DHC Coledam and GA Arruda). Disagreements were resolved through consensus.

2.5 Data collection process

Data were manually extracted from the included studies using a standardized spreadsheet, by the main author (DHC Coledam), and checked for consistency by the research group. The following data items were extracted: Author, year of publication, country, sample size, design, exposure variable, health outcomes, main results, and covariates.

2.6 Methodological Quality Assessment

Methodological Quality Assessment was assessed using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies, developed by the National Heart, Lung, and Blood Institute [26]. Two independent authors (DHC Coledam and G Santos) assessed each study and discrepancies were solved through consensus. The score is expressed as the percentage achieved of the total number of questions of the instrument and classified as poor (≤24%), fair (25–49%), good (50–74%), or excellent (≥75%) quality, independently of study design.

2.7 Synthesis methods and effect measures

Results were synthesized based on the association between PE classes and outcomes. Any effect measure of associations was considered (odds ratio, prevalence ratio, incident ratio, or β coefficients). Although only observational studies were included in this review, we classified the presence and direction of associations as effects. Each study was classified into four categories: I) Positive effect: The results indicated that PE was associated with a better profile of the outcome; II) Partial effect (positive or negative): PE was associated with a better health profile, but the association occurred: a) only for specific subgroup of sample (i.e., sex, age, region, ethnicity); b) when the study analyzed more than one outcome for the same health category and results were not the same, but not contrary (i.e., PE associated with moderate physical activity but not associated with total physical activity); III) None: When the association between PE and health was not significant; IV) Negative effect: When the association indicated that PE was associated with a poor profile of the outcome.

The conclusion of synthesis of the results is based on the following criteria: Beneficial: 60 to 100% of studies showed a positive or partially positive effect of PE on outcome; Inconclusive: 34 to 59% of studies showed a positive or partially positive effect, or included <3 studies; No effect: 0 to 33% of studies showed a positive or partially positive effect of PE; Harmful: 60 to 100% of studies showed a negative or partially negative effect of PE on outcome.

Sensitivity analysis was conducted by comparing the synthesis of results excluding studies that presented poor or fair methodological quality.

3. Results and Discussion

3.1 Study selection

A total of 6,102 records were screened, of which 3279 were duplicated and 163 were assessed for eligibility. After full text reading, 64 were excluded, mainly due to non-adjusted analysis (n=15), no PE variable in the study (n=11), and lack of an association analysis (n=8). A total of 99 studies and 2,717,508 participants were included in this review. The flow diagram of the systematic review is described in Figure 1.

3.2 Study characteristics

The majority of the studies included in this review analyzed samples from Brazil n=40 and the USA n=21, with only seven assessing samples from different countries. The distribution of studies according to year of publication was: up to 2010 (n=20), 2011-2015 (n=28), and 2016-2022 (n=51). Furthermore, a high number of studies assessed adolescents n=60 and adopted a cross-sectional design n=88. With regard to exposure variables, a measure of participation, attendance, or enrollment was used in 19 studies, a combination of volume of PE and participation, attendance, or enrollment was adopted in 24 studies, while an indicator of PE volume was used in 26 studies. Studies were classified into 22 groups of outcomes, the most frequent of which were physical activity (n=47), anthropometric or body fat indicators (n=24), mental health (n=16), sedentary behavior (n=16), physical fitness or motor performance (n=10), academic achievement (n=7), diet (n=6), sports practice (n=5), alcohol and smoking (n=5).

3.3 Methodological Quality Assessment

The distribution of the included studies according to methodological quality was: poor n=1 (1.0%), fair n=11 (11,1%), good n=82 (82,8%), and excellent n=5 (5.1%), Appendix 3.

3.4 Results of individual studies

The results of the individual studies are described in Appendix 4.

3.5 Results of synthesis

The results synthesized according to outcome are presented in Table 1.

Data synthesis was presented in order of the number of included studies for each outcome. The total number of studies considering each outcome is higher than 99 because some studies assessed more than one outcome or PE exposure. In these cases, the study was referenced only once in the text, but considered according to the number of outcomes and exposure that was analyzed. The stratification of analysis according to design was not feasible due to the low number of longitudinal studies (n=11).

The association between PE classes and physical activity was analyzed in 47 studies, and 35 (74,5%) showed a positive or partially positive effect of PE (El-ammari *et al.*, 2017; Martins *et al.* 2022; Uddin et al., 2020; Zhan *et al.*, 2021; Ekblom-Bak *et al.*, 2018; Knaus *et al.*, 2020) (Bezerra *et al.*, 2016; Cheah *et al.*, 2018; Farias Júnior *et al.*, 2012; Gordon-Larsen *et al.*, 2000; Hobin *et al.*, 2010; Jesus *et al.*, 2022; Lowry *et al.*, 2013; Peltzer & Pengpid, 2015; Perry *et al.*, 2011; Sharma *et al.*, 2018; Silva *et al.*, 2018; Silva *et al.*, 2019; Tassitano *et al.*, 2010; Vancampfort *et al.*, 2019; Bergmann *et al.*, 2013; Ceschini *et al.*, 2009; Ryu *et al.*, 2020; Tenorio *et al.*, 2010; Cawley *et al.*, 2007; Cawley *et al.*, 2013; Gomes *et al.*, 2014; Naiman *et al.*, 2015; Perez, 2003; Silva *et al.*, 2014; Coledam *et al.*, 2014; Loucaides *et al.*, 2013; Myers *et al.*, 1996; Nakamura *et al.*, 2013), 10 presented no effect (Barbosa *et al.*, 2012; Nakamura *et al.*, 2013; Lima & Silva, 2018; Murphy *et al.*, 2017; Silva *et al.*, 2009; Wang *et al.*, 2017; Bacil *et al.*, 2013; Rezende *et al.*, 2014; Tavares *et al.*, 2020) and two presented a negative effect (Gomes *et al.*, 2014; Palakshappa *et al.*, 2015). Summary: The results indicate a beneficial effect of PE on physical activity.

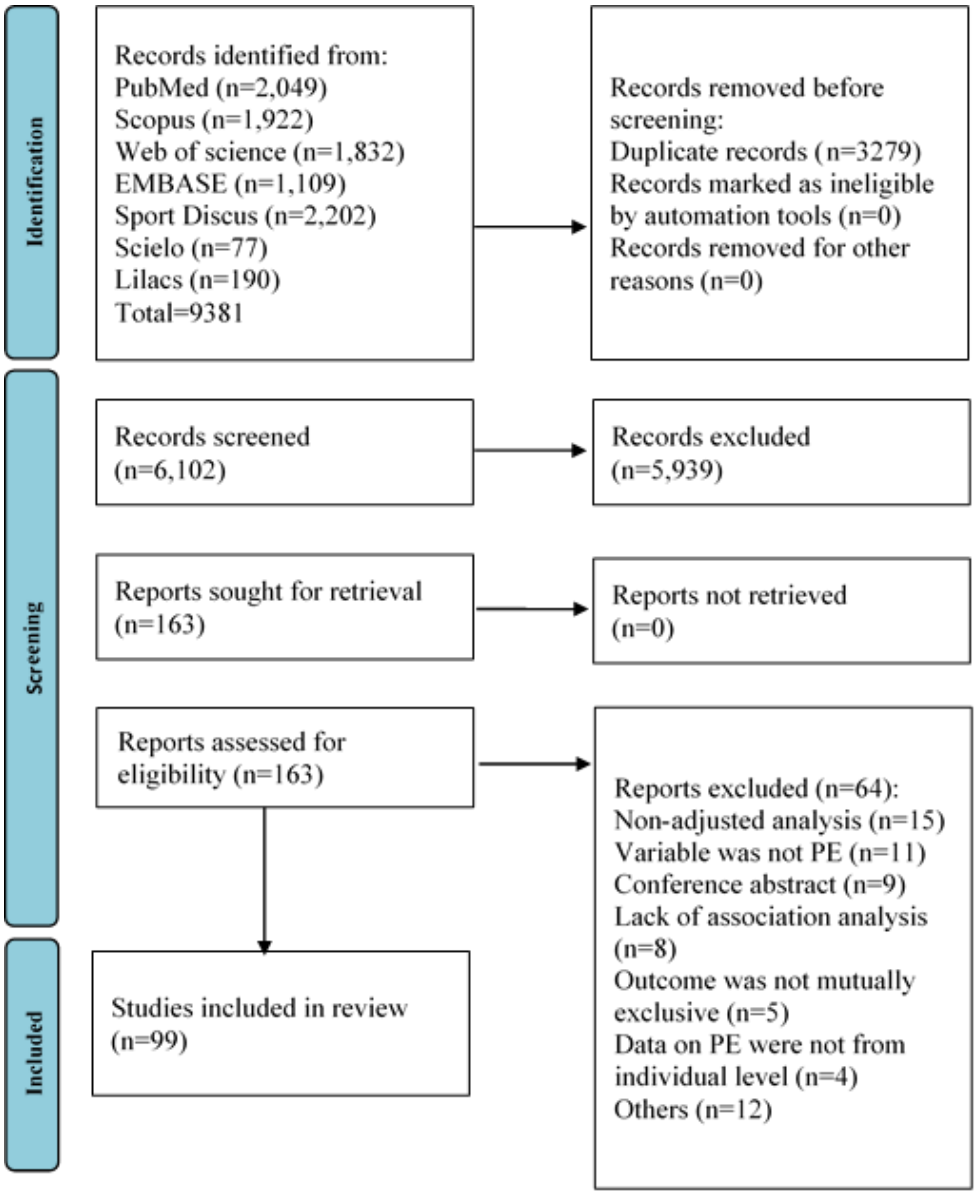

Figure 1. Flow diagram of the systematic review

Table 1. Summary of associations between PE and health outcomes (all included studies)

Outcome	Exposure	Positive effect (n)	Partially positive (n)	None (n)	Partially negative (n)	Negative effect (n)	Conclusion
Physical activity	Volume	Bezerra *et al.* 2016, Cheah *et al.* 2018, Farias Júnior 2012 Gordon-Larsen *et al.* 2000, Hobin *et al.* 2010, Jesus *et al.* 2022, Lowry et al. 2013 Martins *et al.* 2022, Peltzer and Pengpid 2016, Perry *et al.* 2011, Sharma *et al.* 2018, Silva *et al.* 2018, Silva *et al.* 2019, Tassitano *et al.* 2010, Uddin *et al.* 2020, Vancampfort *et al.* 2019, Zhan *et al.* 2021	Cawley *et al.* 2007 Cawley *et al.* 2013 Gomes *et al.* 2014 Knaus *et al.* 2020* Naiman *et al.* 2015 Perez 2003 Silva *et al.* 2014	Barbosa filho *et al.* 2012, Lima and Silva 2018, Murphy et al. 2017, Nakamura *et al.* 2013, Silva *et al.* 2009, Wang *et al.* 2017	Gomes *et al.* 2014	Palakshappa *et al.* 2015	
	Participation	Bergmann *et al.* 2013, Ceschini *et al.* 2009* Ryu *et al.* 2020 Tenório *et al.* 2010	Coledam *et al.* 2014, Ekblom-Bak *et al.* 2018*, El-ammari *et al.* 2017, Loucaides *et al.* 2007* Myers *et al.* 1996* Nakamura *et al.* 2013 Silva et al. 2014	Bacil *et al.* 2013 Rezende *et al.* 2014 Tavares *et al.* 2020 Barbosa Filho *et al.* 2012			

Total (n=47)		21	14	10	1	1	Beneficial
Sensitivity (n=41)		19	10	10	1	1	Beneficial
Overweight, obesity, body fat, body mass index or other anthropometric indicator.	Frequency	Ekblom-Bak *et al.* 2018* Kim *et al.* 2012, Santos *et al.* 2019, Veugelers and Fitzgerald 2005	Cawley *et al.* 2013 So *et al.* 2011 Wardle *et al.* 2007	Bednar and Rouse 2020, Cawley *et al* 2007, Martins *et al.* 2017, Prazeres Filho *et al.* 2019, Knaus *et al.* 2020*		Santos *et al.* 2019	
	Participation	Khan *et al.* 2019, Novaes *et al.* 2009*, Puia *et al.* 2017*,	Tassitano *et al.* 2009	Bacil *et al.* 2016 Coledam; Ferraiol 2017, Coledam *et al.* 2018, Henrique *et al.* 2018*, Pérez *et al.* 2006, Puia *et al.* 2017*, Sabia *et al.* 2017			
Total (n=24)		7	4	12	0	1	Inconclusive
Sensitivity (n=18)		4	4	9	0	1	Inconclusive
Mental health	Frequency	Ferreira *et al.* 2020, Santos *et al.* 2021, Wang *et al.* 2021, Werneck *et al.* 2020	Brosnahan *et al.* 2004 Knaus *et al.* 2020* Song 2021	Bednar and Rouse 2020, Kremer *et al.* 2014 Southerland *et al.* 2016†	Knaus *et al.* 2020*, Song 2021		
	Participation	Ferreira *et al.* 2020, Kremer *et al.* 2014, Pinto *et al.* 2021,	Santos *et al.* 2015				
Total (n=16)		7	4	3	2	0	Beneficial
Sensitivity (n=14)		7	3	3	1	0	Beneficial
Sedentary behavior	Frequency	Jesus *et al.* 2022 Kwak *et al.* 2022* Martins *et al.* 2022	Herman et al. 2015*, Tassitano et al. 2010, Tenório et al. 2010	Barbosa Filho *et al.* 2012, Lowry *et al.* 2013, Prazeres Filho *et al.* 2019 Silva *et al.* 2009	Cawley *et al.* 2013, Silva *et al.* 2018, Silva *et al.* 2019	Peltzer and Pengpid 2016	
	Participation			Barbosa Filho *et al.* 2012,			

				El-ammari *et al.* 2017			
Total (n=16)		3	3	6	3	1	Inconclusive
Sensitivity (n=14)		2	2	6	3	1	Inconclusive
Physical fitness and motor performance	Frequency	Ruedl *et al.* 2016* Santos *et al.* 2020	Knaus *et al* 2020*			Santos *et al.* (2020)	
	Participation		Coledam *et al.* 2016, Coledam *et al.* 2018, Coledam and Ferraiol 2017, Ekblom-Bak *et al.* 2018*, Peralta *et al.* 2020	Coledam et al. 2018			
Total (n=10)		2	6	1	0	1	Beneficial
Sensitivity (n=7)		1	4	1	0	1	Beneficial
Academic achievement	Frequency	Kim and So 2012, Knaus *et al.* 2020*	Carlson *et al.* 2008	Dills *et al.* 2011, Bednar and Rouse 2020			
	Participation		Shen 2017	Esteban-Cornejo *et al.* 2017			
Total (n=7)		2	2	3	0	0	Inconclusive
Sensitivity (n=6)		1	2	3	0	0	Inconclusive
Sports practice	Frequency		Lima and Silva 2019, Knaus *et al.* 2020*		Cawley *et al.* 2013		
	Participation	Coledam *et al.* 2014, Sousa *et al.* 2016					
Total (n=5)		2	2	0	1	0	Beneficial
Sensitivity (n=4)		2	1	0	1	0	Beneficial
Diet	Frequency	Martins *et al.* 2022	Tassitano *et al.* 2010	Barbosa Filho *et al.* 2012	Chen and Wang 2013		
	Participation		Martins *et al.* 2022	Barbosa Filho *et al.* 2012			
Total (n=6)		1	2	2	1		Inconclusive

Sensitivity (n=4)		1	2	2	1		Inconclusive
Alcohol	Frequency		Dunn 2014, Martins *et al.* 2022	Barbosa Filho *et al.* 2012, Tassitano *et al.* 2010			
	Participation			Barbosa Filho *et al.* 2012			
Total (n=5)		0	2	3	0	0	None
Sensitivity (n=5)		0	2	3	0	0	None
Smoke	Frequency		Dunn 2014, Tassitano *et al.* 2010, Martins *et al.* 2022	Barbosa Filho *et al.* 2012			
	Participation			Barbosa Filho *et al.* 2012			
Total (n=5)		0	3	2	0	0	Beneficial
Sensitivity (n=5)		0	3	2	0	0	Beneficial
Self-rated health	Frequency	Prazeres Filho *et al.* 2019		Knaus *et al.* 2020*			
	Participation	Jodkowska *et al.* 2019* Ekblom-Bak *et al.* 2018*					
Total (n=4)		3	0	1	0	0	Beneficial
Sensitivity (n=1)		1	0	0	0	0	Beneficial
Simultaneous behavioral risk	Frequency	Martins *et al.* 2022		Barbosa Filho *et al.* 2012			
	Participation	Tassitano *et al.* 2014		Barbosa Filho *et al.* 2012			
Total (n=4)		2	0	2	0	0	Inconclusive
Sensitivity (n=4)		2	0	2	0	0	Inconclusive
Cardiovascular indicators	Frequency			Silva *et al.* 2022			
	Participation		Ekblom-Bak *et al.* 2018*	Coledam *et al.* 2018			
Total (n=3)			1	2			Inconclusive
Sensitivity (n=2)			0	2			Inconclusive
Active commuting	Frequency	Martins *et al.* 2022					
	Participation	Bacil *et al.* 2013			Rezende *et al.* 2014		

Total (n=3)		2	0	0	1	0	Beneficial
Sensitivity (n=3)		2	0	0	1	0	Beneficial

Positive effect: The association indicated that PE is associated with a better profile regarding the outcome; Partial effect (positive or negative): When PE was associated with health, but the association occurred: a) only for a specific subgroup of the sample (i.e., sex, age, region, ethnicity); b) When the study analyzed more than one outcome for the same health category and results were not the same, but not contrary (i.e., PE associated with MVPA but not associated with TPA); None: When the association between PE and health was not significant; Negative effect: The association indicated that PE was associated with a poor profile regarding the outcome; When the study analyzed two PE exposures (participation and volume), the study was included in more than one box; Conclusion: Beneficial: 60 to 100% of studies showed a positive or partially positive effect of PE on outcome. Inconclusive: 34 to 59% of studies showed a positive or partially positive effect, or included <3 studies. No effect: 0 to 33% of studies showed a positive or partially positive effect of PE. Harmful: 60 to 100% of studies showed a negative or partially negative effect of PE on outcome. Total: Sum of studies included in each classification according to the outcome; Sensitivity: Sum of studies included in each classification according to the outcome after exclusion of those with poor methodological quality; †The author used effect size cutoffs for the odds ratio (OR<0.694) to confirm an association. For this reason the study was inserted as no effect. *Study classified as poor methodological quality, included when analysis considered all studies and excluded for sensitivity analysis.

For anthropometric and body fat indicators, 11 (45.8%) studies showed a positive or partially positive effect of PE (Ekblom-Bak *et al.*, 2018; Khan *et al.*, 2019; Cawley *et al.*, 2013; Kim *et al.*, 2012; Santos *et al.*, 2019; Veugelers & Fitzgerald, 2005; Novaes *et al.*, 2009; Puia & Leucuta, 2017; So *et al.*, 2011; Wardle *et al.*, 2007; Tassitano *et al.*, 2009), 12 presented no association (Sabia *et al.*, 2017; Knaus *et al.*, 2020; Coledam *et al.*, 2018; Cawley *et al.*, 2007; Puia & Leucuta, 2017; Bednar & Rouse, 2020; Martins *et al.*, 2017; Prazeres Filho *et al.*, 2019; Bacil *et al.*, 2016; Coledam *et al.*, 2017; Henrique *et al.*, 2018); Pérez et al., 2006; Hardman *et al.*, 2013) and 1 demonstrated a negative effect (Santos *et al.*, 2019). Summary: The effect of PE on anthropometric and body fat indicators is inconclusive.

The association between PE classes and mental health was assessed in 16 studies. In 11 of them (68,7%) there was evidence of a positive or partially positive effect of PE (Knaus *et al.*, 2020; Werneck *et al.*, 2020; Ferreira *et al.*, 2020; Santos *et al.*, 2021; Wang *et al.*, 2021; Kremer *et al.*, 2014; Pinto *et al.*, 2021; Brosnahan *et al.*, 2004; Santos *et al.*, 2015; Song *et al.*, 2021), 3 presented no effect (Bednar & Rouse, 2020; Kremer *et al.*, 2014; Southerland *et al.*, 2016) and 2 showed a partially negative effect (Knaus *et al.*, 2020; Song *et al.*, 2021). Summary: A beneficial effect of PE on mental health

For sedentary behavior, six studies (37.5%) had a positive or partially positive effect, (Martins *et al.*, 2022; Jesus *et al.*, 2022; Tassitano *et al.*, 2010; Tenorio et *al.*, 2010; Kwak *et al.*, 2022; Herman *et al.*, 2015), six demonstrated none effect (Barbosa Filho *et al.*, 2012; El-ammari *et al.*, 2017; Lowry *et al.*, 2013; Silva *et al.*, 2009; Prazeres Filho *et al.*, 2019), four presented a negative effect of PE (Peltzer & Pengpid, 2015; Silva *et al.*, 2018; Silva *et al.*, 2019; Cawley *et al.*, 2013). Summary: The association between PE and sedentary behavior is inconclusive.

The association between PE and physical fitness and motor performance was analyzed in ten studies, eight of them (80%) indicated a positive or partially positive effect (Ekblom-Bak *et al.*, 2018; Knaus *et al.*, 2020; Coledam *et al.*, 2018; Peralta *et al.*, 2020; Santos *et al.*, 2020; Coledam *et al.*, 2017; Ruedl *et al.*, 2016; Coledam *et al.*, 2016), one presented no effect (Coledam et al., 2018), and one presented a negative effect (Santos *et al.*, 2020). Summary: Beneficial effect of PE on physical fitness or motor performance.

Seven studies assessed the association between PE classes and academic achievement. Four of them (57.1%) presented a positive or partially positive effect of PE (Knaus *et al.*, 2020; Shen, 2017; Kim & So, 2012; Carlson e*t al.*, 2008), while three indicated no effect of PE on academic achievement (Dills *et al.*, 2011; Esteban-Cornejo *et al.*, 2017; Bednar & Rouse, 2020). Summary: The effect of PE on academic achievement is inconclusive.

The association between PE and sports practice was assessed in five studies. Four of them (80%) presented a positive or partially positive effect of PE on sports practice (Knaus *et al.,* 2020; Coledam *et al.,* 2014; Sousa *et al.,* 2016; Lima & Silva, 2019) and one presented a partially negative effect (Cawley *et al.,* 2013). Summary: The effect of PE on sports practice was beneficial.

Six studies investigated the association between PE classes and diet. Three studies (50%) indicated a positive or partially positive effect (Martins *et al.,* 2022; Tassitano *et al*, 2010), two indicated no effect (Barbosa *et al.,* 2017) and one showed a partially negative effect (Chen and Wang, 2013). Summary The association between PE classes and diet is inconclusive.

Five studies were included for alcohol consumption and smoking. Two (40%) indicated a partially positive effect (Martins *et al.,* 2022; Dunn, 2014), while three showed no effect of PE on alcohol consumption (Barbosa *et al.,* 2012; Tenorio *et al.,* 2010). With regard to the effect of PE on smoking, three studies (60%) demonstrated a partially positive effect (Martins *et al.*, 2022; Tenorio *et al.,* 2010; Dunn, 2014), while two indicated no effect (Barbosa *et al.,* 2012). Summary: No effect of PE was shown on alcohol consumption and positive effect for on smoking.

Four studies investigated the association between PE classes and self-rated health. Three studies (75%) indicated a positive effect (Ekblom-Bak *et al,* 2018; Jodkowska *et al.,* 2019; Prazeres Filho *et al.,* 2019) and one presented no effect (Knaus *et al.,* 2020). Summary: Beneficial Effect of PE on self-rated health.

The association between PE classes and simultaneous behavioral risk was investigated in four studies. Two studies (50%) demonstrated a positive effect (Martins *et al.,* 2022; Tassitano *et al.,* 2014) and two showed no effect (Barbosa *et al.*, 2012). Summary: There was an inconclusive effect of PE on simultaneous behavioral risk.

Three studies analyzed the association between PE classes and active commuting or cardiovascular indicators. Two studies (66.6%) demonstrated a positive effect (Martins *et al.,* 2022; Bacil *et al.,* 2013) and one negative effect of PE on active commuting (Rezende *et al.,* 2014). Summary: Beneficial effect of PE on active commuting. One study (33.3%) revealed positive effect (Ekblom-Bak *et al.,* 2018) of PE on cardiovascular indicators and two indicated no effect (Coledam *et al.,* 2018; Silva *et al.,* 2022). Summary: Inconclusive effect of PE on cardiovascular indicators.

For injury (Lowry *et al.,* 2007; Peltzer & Pengpid, 2015) and a positive attitude for physical activity (Prazeres *et al.,* 2019; Hardman *et al.,* 2013), only two studies were included, while for substance abuse (Dunn, 2014), bone health (Slemenda *et al.,* 1991), testicular cancer risk (Littman *et al.,* 2009), violence (Barros *et al.,* 2013), musculoskeletal symptoms (Bergmann *et al.,* 2020), sexual risk behavior (Pimentel *et al.,* 2013), and respiratory disease (Silva *et al.,* 2022) only one study was available (data not shown in Table 1). Summary: Considering the insufficient evidence, the effect was inconclusive for all mentioned outcomes.

3.6 Sensitivity Analysis

Sensitivity analysis was conducted to assess a possible effect of studies with a poor methodological (those that attain lower than 50% of quality assessment score) quality on the result synthesis. Twelve studies (12.1%) were classified with a poor methodological quality and were excluded from the sensitivity analysis (Table 1). Sensitivity analysis did not change the synthesis conclusions.

The main results found were that PE provided worldwide in schools was associated with a better profile of physical activity, mental health, physical fitness, sports practice, self-rated health, and smoking, but not with other outcomes.

To our knowledge, this was the second systematic review to analyze the association between PE and health, and the present results regarding physical activity and sedentary behavior were similar to the previous study (Silva *et al.* 2022). Silva et al. 2022 found that higher frequency of PE was associated to physical activity in 56 of 68 (82%) and in 14 of 24 results (58%) for sedentary behavior. In fact, the proportion of significant results are higher than those found in the present review and can be attributed to differences in inclusion and exclusion criteria, for example considering outcomes that were not mutually exclusive, such as the contribution of PE on physical activity during school time or in days with PE. However, despite the differences in proportion of significant results, considering the same cut-off adopted in the present review (>60%), the results were the same indicating beneficial effect of PE on

physical activity and inconclusive results for sedentary behavior.

Strategies with PE to promote physical activity practice beyond the class have been widely implemented (Bandeira *et al.*, 2022). Some aspects developed during classes can explain the association of PE with physical activity and sports practice (Prazeres *et al.*, 2019; Hardman *et al.*, 2013), such as acquisition and improvement of motor skills, positive attitudes for physical activity, perceived competence, emotional competence, and knowledge related to health and body practices, which can result in an increase in physical activity outside school. Physical activity is multifactorial and attributing this behavior of students to PE is an over simplistic approach. This can be evidenced by the high amount of strategies adopted worldwide to promote active and healthy lifestyles through physical education classes and the need of action plans that integrate different actors of the school context (Bandeira *et al.*, 2022). However, the present results indicated that in addition to other determinants of physical activity, ensuring the provision of PE in the school curriculum and encouraging PE participation could be one of the ways to promote leisure time PA and sports practice among children and adolescents.

Four other outcomes associated with PE were physical fitness and motor performance, mental health, self-rated health and smoking. The psychosocial and biological mechanisms underlying the association between physical activity and mental health have been described (Werneck *et al.*, 2020). It is probable the same mechanisms are present in the association between PE and better mental health. Physical activity is inherent to PE, during classes students are exposed to interactions and social network, have support of the teacher and peers, and present improvements in positive attitudes, social skills, self-competence and self-perceptions (Araujo *et al.*, 2024), aspects that can contribute to better mental health. Considering physical fitness and motor performance, PE aims to provide a high motor repertoire and skill development through childhood and adolescence. Furthermore, PE induces effort during the classes (Peralta *et al.*, 2020), and sports game and fitness activities are common elements of the discipline content, which can result in cardiorespiratory and musculoskeletal adaptations that improve physical fitness. With regard to self-rated health, PE can probably affect self-rated health in two ways: Directly, students perceived their health as better due to their participation in PE; Indirectly, PE can promote health education (Quennerstedt, 2019) or by the provision of practical health content such as PA and fitness activities (Rocha *et al.*, 2025), and improvements in health as a consequence of PE can result in better self-rated health.

Despite the associations found, the present systematic review did not demonstrate an association between PE with the other outcomes. With regard to academic achievement, the results can be interpreted as positive, since curriculum reforms commonly substitute PE time for other disciplines such as language, sciences, and math. The present results indicate that even with inconclusive results, none of the seven studies included demonstrated a negative effect (Knaus *et al.*, 2020; Shen, 2017; Bednar & Rouse, 2020; Kim & So, 2012; Carlson *et al.*, 2008; Dills *et al.*, 2011; Esteban-Cornejo *et al.*, 2017), while four shown a positive effect of PE on academic achievement. Considering the benefits to other outcomes, as described in this review, PE should be ensured in the school mandatory curriculum.

Regarding the other health variables that were not associated with PE or presented inconclusive results, it is relevant to reinforce that health promotion is not the only objective of PE, which implies that most PE curriculums are not designed specifically for health promotion and the conventional PE setting may not be sufficient to promote health behaviors. Likewise, it cannot be disregarded that health outcomes have a multifactorial etiology, as do overweight and other adiposity indicators, which implies that other variables could have a determinant effect, or even that although PE has great potential to promote health, some barriers prevent the achievement of these goals (Bednar & Rouse, 2020; Esteban-Cornejo *et al.*, 2017). Furthermore, health is a complex construct and a health-promoting school requires global action which includes government and school policies, community partnerships, school curriculum, environment, and health services (Sawer *et al.*, 2021).

The present systematic review provides some directions for future studies and practical implications. There is a clear need for longitudinal studies, standardization of PE measures, and improved investigation of some outcomes, since the many of variables of this review have less than five studies and the main focus is centered on physical activity and adiposity indicators. Different from previous information based on from experimental designs, we conducted a systematic review of observational studies, that represent PE in a real context. The results

indicated that despite the difficulties and barriers faced by the discipline routine, as well as not having health promotion as the only purpose, PE is associated with benefits related to leisure time physical activity and sports practice, mental health, physical fitness, and self-rated health, with no impairment in academic achievement. Considering the high prevalence of physical inactivity (Silva *et al.,* 2018), mental disorders (Ferreira *et al.,* 2020), low physical fitness (Coledam *et al.,* 2018), and non-sports practice (Lima and Silva, 2019), ensuring PE classes in the mandatory curriculum is one of the ways to promote health, mainly in students who are prevented from adopting health behaviors outside school (Coledam & Ferraiol, 2017).

The results of the present study should be interpreted considering some limitations. First, only observational studies were included and the majority are cross-sectional. For this reason, the main limitation is that reverse causality cannot be disregarded for any outcome. Second, it was not possible to assess the curriculum and content of PE adopted in each study and due to worldwide cultural and educational differences, PE is probably different across studies. Finally, the heterogeneity of studies prevented conduction of a meta-analysis, which could provide an accurate estimate of pooled weighted effect sizes for each outcome.

4. Conclusion

This systematic review of observational studies revealed that among 22 outcomes analyzed, PE was associated with a better profile of students' leisure time physical activity, mental health, physical fitness, sports practice, self-rated health, and smoking, with no evidence of a harmful effect. Educational systems should ensure the provision of Physical Education classes which, in addition to pedagogical purposes, can promote health among children and adolescents.

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Author Contribution Statement

DHCC, GAA, GS and AHNR participated in study design, data collection, data analysis and interpretation, manuscript writing, manuscript revision, and final approval of the manuscript. All the authors read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there was no conflict of interest.

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