

Physical Activity Time and Intensity in Physical Education During the COVID-19 Pandemic

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Joana Lourenço¹ , Catarina Rodrigues¹, Fábio Flôres¹, and Denise Soares²

Abstract

With the COVID-19 outbreak, schools have experienced difficulty providing moderate-to-vigorous physical activity (MVPA) to their students, which should normally account for at least 50% of children's physical education (PE) class time. We aimed to determine the intensity of physical activity (PA) within PE classes at various grade levels to compare children's in-class PA with the World Health Organization's (WHO) recommended guidelines. Thus, 301 students (1st to 12th grade) participated in the investigation. Children were evaluated during the PE classes with different typologies and durations. We assessed PA intensity using accelerometry and grouped data into either sedentary-to-light PA (SEDLI) or MVPA. Each child was assessed using both the time spent in PA (hours:minutes:seconds) and the percentage of time spent in PA versus other class activities. We found that, in the second-grade level group (fifth and sixth grades), girls spent more time in MVPA intensity than boys. Additionally, two-hour PE classes doubled the SEDLI for students in the third-grade group, and polythematic classes (those with more than one sport) promoted more MVPA level time than monothematic classes (only one sport). Concerning PA intensity during PE classes, 31–43% of the PE class total time was spent in MVPA but presented short duration and did not usually persist for 10 consecutive minutes (59% of the time). Children spent a

¹KinesioLab, Research unit in human movement, Piaget Institute, Portugal

²Liberal arts Department, American University of the Middle East, Kuwait

Corresponding Author:

Joana Lourenço, KinesioLab, Research Unit in Human Movement, Piaget Institute, Avenida Jorge Peixinho, n.º30, Lisboa 4410-269, Portugal.

Email: joana.fds116@gmail.com

large amount of time at the SEDLI intensity, considered insufficient for PA health benefits. Finally, to meet WHO guidelines for PA intensity, PE classes will need to increase MVPA time and reduce non-active periods between activities.

Keywords

intensity, health, exercise, school, accelerometry

Introduction

Physical activity (PA) is a key means of promoting children's health (Lourenço et al., 2021). Past research has also shown that children with low levels of PA have an increased risk of obesity (Mattioli et al., 2020), cardiovascular problems (Bowden Davies et al., 2018), diabetes (Sigal et al., 2018), and cancer (Feuerstein & Nekhlyudov, 2018). Most recently, the COVID-19 outbreak, through its impact on school closures, drastically reduced in-class physical education (PE) opportunities for PA for both boys and girls. Before the COVID-19 pandemic, young people averaged nine hours per day in sedentary habits, and only 36% of children and adolescents aged 15–21-years-old were considered sufficiently physically active (Lopes et al., 2015). Moreover, even before the COVID-19 outbreak, only one-third of the time spent in PE classes was devoted to vigorous activity (Fairclough & Stratton, 2005; Viciano et al., 2015). Thus, historically, PE classes have provided children too few movement opportunities and have not substantially raised children's generally low PA levels.

During much of the COVID-19 pandemic, Portuguese children were confined to their homes, exacerbating problems with children's insufficient movement through closures of schools and public playgrounds, and through lost opportunities for outdoor activities (Pombo et al., 2021). This confinement likely worsened children's eating patterns, led to decreased sleep duration, and was associated with increased levels of physical inactivity, already at precariously low levels. Indeed, studies have revealed a weekly decrease of 2.3 hours in children's PA in recent years, and during the lockdown, time spent in PA was decreased to 1.29 hours per week (Pietrobelli et al., 2020). During the first lockdown period in March-April 2020, Portuguese children under the age of 12 were reported to have spent 80% of their time confined to sedentary activity (Pombo et al., 2020), with most of that time in front of a computer screen, due to online classes.

PE classes have been viewed as an optimal context for helping children develop motor competence, motor learning, and general motor development (Flôres et al., 2019). According to the World Health Organization (WHO, 2020) children who engaged in moderate-to-vigorous physical activity (MVPA) intensity showed associated improvements in cardiorespiratory fitness, muscular fitness, cardiometabolic and bone health, and they experienced positive effects on cognitive functioning, academic outcomes, and mental health. The Association for Physical Education (2015) has recommended that at least 50% of total PE class time should be spent in MVPA. Thus,

WHO guidelines (WHO, 2020) urge schools and PE teachers to increase opportunities for students to participate in PA, and strive to make children physically fit, by providing them tools for engaging in a healthy lifestyle (Lin et al., 2019; Pate et al., 2006).

In the last few years, public schools in Portugal organized PE classes with attention to both time in class and type of class. PE classes are generally performed twice per week for 90 and/or 45 minutes duration. In some private schools, schools have some autonomy in choosing 1-hour and/or 2-hour class periods per week (Ministério da Educação, 2012). PE class typology normally consists of either monothematic classes in which one sport is used during all the class (e.g., a class about volleyball) or polythematic classes in which students have direct contact with different sports and exercises (e.g., circuit training with four stations at basketball, physical conditioning, tennis, and indoor soccer (Bom et al., 2001)).

Children have been found to be more active on PE days than on non-PE days (Mayorga-Vega et al., 2018; Viciano et al., 2017), showing that PE may improve time spent in MVPA and supporting the long-held view that PE classes provide optimal opportunities for children to increase their PA levels and improve their health (Department of Health and Human Services, 2008; Sierra-díaz et al., 2019). Many studies have shown that children's PA can be evaluated with different kinds of instruments (Cardon & Bourdeaudhuij, 2007; Kirkham-King et al., 2017; McClain et al., 2008). Among these have been the accelerometer which provides objective data regarding the time children spend being active in daily activities (Duncan et al., 2019; Jones et al., 2020). Accelerometers have an easy application to all age groups (Fabre et al., 2020; Trost, 2013), and they have been used to measure PA in a variety of contexts (Cain et al., 2013; Corder et al., 2008; Troiano, 2005). Past research has shown that accelerometers have evaluative utility in PE classes (Kirkham-King et al., 2017; Mayorga-Vega et al., 2018; Viciano et al., 2015, 2017). Generally, these studies have demonstrated that the accelerometer is a reliable and useful instrument that does not interfere with the participant's daily routine. Accelerometers can provide meaningful information regarding PA and PE intensity levels (Mayorga-Vega et al., 2018; Viciano et al., 2017). Pre-pandemic accelerometer studies revealed that PA lessons comprise 33% of the total PE class time (Fairclough & Stratton, 2005). Since there are no post-pandemic accelerometer studies of children's routines, new updated information of this type is needed.

As far as we know, no study has assessed PA levels within PE classes after the first COVID-19 induced school lockdowns. It is important to understand the impact of these lockdowns on children's PE classes specifically. Additionally, it is important to know whether children can achieve the Association for Physical Education recommended PA intensity levels during PE classes. Accordingly, we aimed to evaluate the intensity of PE classes in different student age/grade groups and to verify whether children can achieve these recommended levels. We hypothesized that, in general, children would not achieve the PA intensity recommended, and that polythematic PE classes would provide higher PA levels than monothematic PE classes, with boys outperforming girls

concerning the amount of MVPA. Finally, we expected that a 2-hour PE class would provide children with lower levels of PA than a 1-hour class.

Method

Participants

Our participant sample consisted of 301 students from the first through 12th grades of schools in central Portugal, selected by convenience sampling, after the first COVID-19 induced lockdown regarding on-site classes. Regarding participant ethnicity, 91.5% of these children were Caucasian, 3.7% were African, and 4.8% were Asian. The first grade-based group included four school years (first to fourth grades), the second grade-based group included two school years (fifth and sixth grades), the third grade-based group included three school years (seventh to ninth grades), and the high school grade group included three years (10th to 12th grades). Participants’ characteristics are presented in Table 1.

We obtained oral assent from all child participants, and we obtained written consent from their parents/guardians before beginning the experiment. Additionally, the school board signed a document authorizing the study within the school. No participants had any developmental difficulties or medical restrictions for performing the physical activities. We obtained ethical approval for the investigation from the University Ethics Committee (Protocol: CEIP/3/2020), and the study protocol followed all guidelines laid down by the Declaration of Helsinki.

Procedures

Participants’ PA levels were evaluated during their PE classes at school after the first COVID-19 lockdown. For this investigation, children wore accelerometers during the class so that we might collect data regarding the time they spent in sedentary and light-intensity PA (SEDLI) and moderate-to-vigorous PA (MVPA). Two PE teachers were

Table 1. Characteristics of the Participant Sample according to Age, Gender, Height, and Body Mass.

| Grade Groups | Gender (n) | Age range (in years) | M Height (SD) in cm | M Body mass (SD) in kg |
|--------------|-------------|----------------------|---------------------|------------------------|
| 1 | Males (56) | 6 to 9 | 1.33 (0.10) | 30.68 (7.60) |
| | Female (62) | | 1.29 (0.10) | 27.48 (5.08) |
| 2 | Male (17) | 10 to 12 | 1.43 (0.67) | 37.28 (7.19) |
| | Female (12) | | 1.48 (0.09) | 39.18 (8.16) |
| 3 | Male (12) | 13 to 15 | 1.65 (0.09) | 54.16 (8.66) |
| | Female (17) | | 1.59 (0.05) | 49.32 (6.61) |
| High School | Male (11) | 16 to 18 | 1.77 (0.06) | 63.91 (10.43) |
| | Female (9) | | 1.71 (0.04) | 54.76 (4.79) |

trained to collect data according to the specifications of the assessment protocols and, at least one of the authors of this study personally supervised every data collection session. All of these supervising investigators followed the same protocol, conducted within the school gymnasiums, during PE classes. All data gathering occurred in March 2021.

To ensure that the PE class's functioning and duration were not affected by the research procedure, the investigators placed the accelerometers on the students before the start of the class. During class, the investigators observed the activities and collected data regarding the class type and its duration. After finishing the PE class, the investigators collected the equipment necessary to process the data.

Children and their accelerometers were identified in pairs (e.g., as participant 1 - accelerometer 1). Class duration was divided into either a 1-hour or a 2-hour class, depending on the student's grade level. Regarding class duration, 100% of the first and second graders had a 1-hour class. Students in the third grade had 70% of their time in a 2-hour class, and 100% of the high school students attended a 1-hour class. The PE class was divided by class type (work by stations/circuits with multiple activities—polythematic or monothematic sport). During polythematic classes, the main activities were running, catching, throwing, and juggling. The order and the purpose of each class varied, due to teacher planning. Regarding the monothematic classes, teachers organized their activities, using games or sports (e.g., handball, basketball, volleyball, rugby). Despite these PE content differences, both types of PE shared a similar structure, such that classes began with an active warm-up and then spent the main part of the class in a polythematic or monothematic approach, finishing with stretches in the end. Teachers then provided feedback, but no data were collected regarding feedback.

Instruments

We used the Bioimpedance Equipment Inbody 270 (InBody USA, Cerritos, CA, USA) to measure the participant's body composition by transmitting an electrical impulse through the body. The Seca stadiometer was used to measure the participant's height (GmbH & Co, Hamburg, Germany). We measured the intensity of PE classes with the triaxial accelerometer ActiGraph wGT3X + BT (Pensacola, FL, USA) sensitive to movements performed up to 8g of magnitude ($1g = 9.81 \text{ m/s}^2$) used during all classes. All students wore the accelerometer on their non-dominant wrists. The protocol used in data collection and treatment was the same as had been applied in another publication of validation of accelerometry data collection for children at this specific age; and it is the most accurate value for predicting children's PA intensity with an R^2 for vector magnitude (VM) of 0.736 (Chandler et al., 2015). Accelerometers were set to a frequency of 60 Hz during all weeks, counting movements during the classes daily; and, for post hoc analysis, we used a time filter to define a PE class time for each class. Further analysis was performed using the VM, calculated using values of the three principal axes (sagittal, transverse, and longitudinal). The VM value was created by weighing each of the three axes equally, giving no plane of movement priority over

another, which may be more suitable for the wrist placement of the accelerometer in which there is no dominant plane of movement, especially in children (Chandler et al., 2015).

Data Processing

We downloaded data in 5-second epoch lengths to be applied later, following these cut-off values for PA intensity of VM (units in counts/min): Sedentary <305, Light 306–817, Moderate 818–1968, Vigorous >1969 (Chandler et al., 2015). We followed a common approach for collecting accelerometry data in PE classes by computing the total time spent in MVPA intensity relative to total time in PE to determine levels of activity or inactivity (Aibar & Chanal, 2015). We calculated the time, in minutes, at each intensity using the Program Actilife (version 6.13.4), in which a time filter was also applied between the start and end time of each class, according to the information filled out on the class form.

Statistical Analysis

We used descriptive analysis with means and standard deviations to characterize participants' data. The normality of the data distribution was confirmed by the Kolmogorov-Smirnov test (all p values >.05). We used a two-tailed t -test for independent samples to compare the time spent in each intensity between genders, students in 1-hour and 2-hour classes, and PE class typologies; and we used the Cohen's d as the index of effect size (considering d 's of 0.20 small, 0.50 medium, and 0.80 large) (Cohen, 1988). We used a one-way ANOVA test to compare the intensity of the classes among the grade years. For follow-up analysis, we used Tukey's post-hoc test. We set the level of statistical significance at $p < .05$. We performed all data analysis with the Statistical Package for the Social Sciences (SPSS, v. 27.0; IBM Corporation, New York).

Results

Gender Comparisons

Most children spent their PA time engaged in SEDLI (60.22%) rather than MPVA (39.78%). Regarding sex, boys spent 59.82% in SEDLI and 40.18% in MPVA, while girls spent 60.62% during SEDLI and 39.38% in MPVA. Table 2 presents these data, including data for different Grade Groups.

PE Class Types

As shown in Figure 1a, Grade Group 1 children spent more time engaged in SEDLI PA when they had monothematic classes than when they had polythematic

Table 2. Comparisons Between Genders in % of PE Time Spent at Two PA Intensity Levels for Four Grade Groups.

| Intensity Level | Grade Group | Gender | M % Total time (SD) | df | t value | p-value | Cohen's d |
|-----------------|--------------------|--------|---------------------|-----|---------|---------------|-----------|
| SEDLI | 1 | Boys | 55.92 (14.11) | 219 | -1.105 | 0.270 | 0.15 |
| | | Girls | 58.04 (14.45) | | | | |
| | 2 | Boys | 73.23 (7.84) | 28 | 2.194 | 0.037* | 0.81 |
| | | Girls | 66.96 (7.64) | | | | |
| | 3 | Boys | 61.46 (2.76) | 28 | 0.232 | 0.824 | 0.01 |
| | | Girls | 60.37 (10.98) | | | | |
| | High School | Boys | 67.67 (5.40) | 18 | -1.167 | 0.258 | 0.53 |
| | | Girls | 70.85 (6.77) | | | | |
| MVPA | 1 | Boys | 44.01 (14.11) | 219 | 1.105 | 0.270 | 0.15 |
| | | Girls | 41.96 (14.45) | | | | |
| | 2 | Boys | 26.77 (7.84) | 28 | -2.194 | 0.037* | 0.81 |
| | | Girls | 33.04 (7.64) | | | | |
| | 3 | Boys | 38.54 (2.76) | 28 | -0.232 | 0.824 | 0.01 |
| | | Girls | 39.63 (10.98) | | | | |
| | High School | Boys | 55.92 (14.11) | 18 | -1.105 | 0.270 | 0.53 |
| | | Girls | 58.04 (14.45) | | | | |

(stations/circuits) classes. In Grade Group 3 some students were in 1-hour, and some were in 2-hour classes. As shown in Figure 1b, those in 2-hour classes spent more time engaged in SEDLI than did those in 1-hour classes.

Grade Group Comparisons

The relation between time spent at each activity intensity level by grade group is shown in Figure 2. Grade Group 1 spent an average of 25 minutes (43%) of their 1-hour total

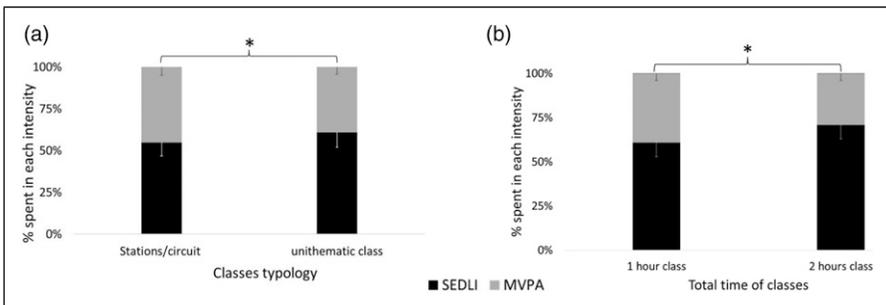


Figure 1. Grade Groups Activity Level Comparisons. (a) Grade Group 1 Comparisons of Activity Intensity Levels Between PE Class Types. * $p < .05$ (b) Grade Group 3 Comparisons of Activity Intensity Levels Between 1-hour and 2-hour Classes. * $p < .05$.

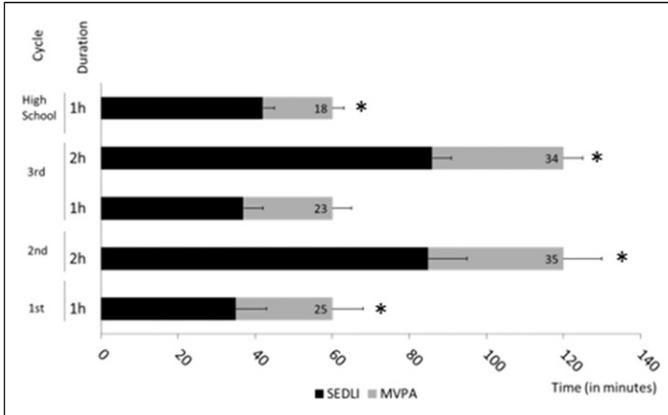


Figure 2. Time Spent in Each PA Intensity According to Grade Group.
 Note: In Grade Group 3, some students were in 1-hour and some were in 2-hour classes.* shows significant differences ($p < .05$).

time at MVPA intensity. Grade Group 2 spent an average of 35 min (29%) of their 2-hour total time at MVPA intensity. Grade Group 3 spent an average of 23 min (39%) of their 1-hour total time in MVPA and an average of 34 min (29%) in their 2-hour total time at MVPA. The high school Grade Group spent an average of 18 min (31%) at MVPA. While students in 2-hour classes spent significantly more time at MVPA than did those in 1-hour classes, the percentage of the PE class spent in MVPA was not higher in 2-hour than in 1-hour classes. There were significant differences between Grade Group 1 relative to Grade Group 2 in time spent at MVPA ($p < .001$), and there were significant differences between Grade Group 1 and Grade Group 3 in time spent at MVPA ($p < .001$). Among students in 1-hour classes, there were significant differences between Grade Group 1 and the High School Grade Group in time spent at MVPA ($p = .001$).

For describing continuous time spent by children and adolescents in MVPA intensity, Figure 3 shows the percentage of children who reached 0-3 bouts of time spent in MVPA, where one bout represented 10 minutes of consecutive activity at MVPA intensity with a spike tolerance of two minutes. We found that 59% of children in this study never reached 10 minutes of consecutive activity in MVPA intensity.

Discussion

This study aimed (a) to evaluate the intensity of PA within PE classes for various grade groupings of school-aged children and adolescents and (b) to relate these PA intensity levels to PE intensity recommendations for this population. To this end, we also evaluated PA levels in different typologies and durations of Portuguese PE classes across grade groups.

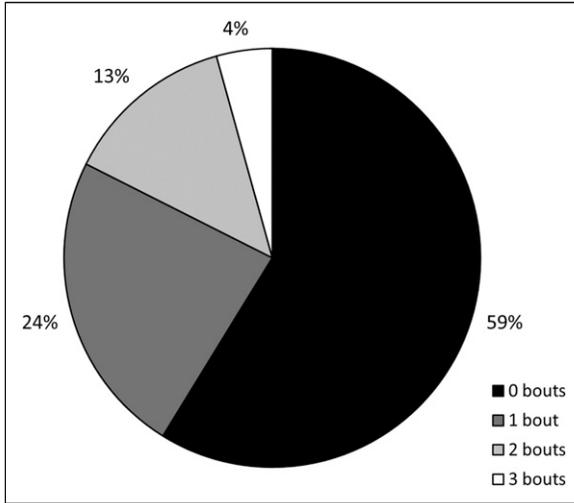


Figure 3. Percentage of Children Reaching Periods of 10 Consecutive Minutes in MVPA (1 bout).

Contrary to what we expected, in our Grade Group 2, there were significant sex differences in the percentage of time spent in each intensity, with girls spending more time in MVPA intensity than boys ($p = .037$). This important finding may highlight the particular importance of PE as PA opportunities for girls, since most prior studies have shown that boys are more active than girls (Howells & Coppinger, 2021; Rooney & McKee, 2018; Silva et al., 2015). In fact, Maihan et al. (2006) noted that girls reported boys to be influential barriers to their attitudes toward PA.

On the other hand, some prior findings were in accordance with our results. Analyzing single-gender and mixed-gender classes (the same class type as in this investigation), Wallace et al., (2020) found that girls spent more time at MVPA during single-gender versus mixed-gender classes. Other investigators also found that girls presented better activity results than boys in different exercises and activities (Duncan et al., 2013; Flôres et al., 2021). Thus, while girls' lower levels of PA generally are a widespread concern (Verloigne et al., 2012), PA within PE classes, especially single-gender classes, and perhaps especially in Portugal, may be a setting in which sex differences in MVPA reverse such that girls show greater amounts of more intensive PA. Explanations for our findings may include that the schools used for data collection provide a wide range of extracurricular activities that afford girls opportunities to engage in many afterschool sports programs (Kuritz et al., 2020) and girls at these particular schools might be uniquely predisposed toward higher PA levels perhaps even due to their maturational levels (Gallahue et al., 2021).

Not surprisingly, our comparisons of students in 1-hour and 2-hour PE classes in Grade Group 3 revealed significant differences in the percentage of time spent in each

intensity, with children spending 39% of 1-hour class times in MVPA compared to 29% of 2-hour class times ($p = .003$), corroborating our a priori hypothesis. While the [Association for Physical Education \(2015\)](#) has recommended that students spend 50–80% of their PE class time in moderate-to-vigorous intensity, we found that an extra hour in PE class increased students' percentages of SEDLI rather than MVPA time. As most of the time spent during PE classes was for exercise transitions and content explanations, rather than MVPA, there is a need for PE teachers to use different strategies to maximize practice time and improve movement efficiency ([Grube et al., 2018](#)).

Regarding PE class typology for Grade Group 1, as expected, there were significant differences in SEDLI and MVPA intensity that favored polythematic class types for greater intensity ($p = .001$). Previously, students were found to be more motivated when there was a greater variety of PA activity provided in polythematic lessons ([Metzler, 2011](#)). In addition, children in this class typology spent less time in a single sport, promoting their contact with other sports in the same class ([Vieira, 2015](#)). This finding suggests particular benefits to teacher utilization of polythematic classes as a means of increasing children's PA intensity levels. According to the amount of time spent in each intensity level by grade group, MVPA intensity was at 43% of total class time in Grade Group 1, 29% for Grade Groups 2 and 3 (with Grade Group 3 students in a 2-hour class), and 39% for Grade Group 3 students in a 1-hour class. The high school Grade Group spent only 31% of overall time in MVPA intensity. Thus, younger children spent more time in MVPA intensity than older children as has been shown in prior research in which children decreased their PA levels and/or PA intensity with increased age ([Pulido Sánchez & Iglesias Gallego, 2021](#); [Trost et al., 2002](#)). This behavioral shift could be cultural or developmental, since older children appear to prefer to spend time in sedentary social activities, such as dating, talking, and spending less physically active time with friends.

Separately analyzing the total time spent in MVPA intensity and consecutive 10-minute bouts of continuous MVPA ([Mayorga-Vega et al., 2018](#)), we found that, even though children spent nearly the recommended percentage of time in MVPA of at least 50% of total class time at MVPA intensity, they only engaged in sustained, 10-minute bouts of consecutive MVPA for 41% of the time. Other investigations of 12-year-old students in Spain showed that when using games from all around the world children reached a 64% threshold of class time spent at the MVPA level ([Puente-Maxera et al., 2021](#)). However, these investigators used no analysis of the length of the exercise bout. Our results, showing that even MVPA intensities ranging from 31–43% MVPA were not typically continuous, highlights the importance of gathering accelerometry-based bout analysis data to avoid data misinterpretation.

Regarding the impact of the COVID-19 pandemic adaptations, our research showed that children were spending less than the recommended time in MVPA within their PE classes. Since improving children's PA time and intensity is a goal for every school, new strategies for encouraging higher-level PA intensity are needed. Teachers should attend to organizing class time to maximize time spent in PA versus standing in line or

engaging in activities that do not foster whole-body movement. Additionally, teachers must help students develop necessary skills through exercise activities to provide them access to sports and activities that further encourage a wide range of movements (Fairclough & Stratton, 2005). Finally, as noted earlier, teachers should provide more polythematic (vs. monothematic) PE classes to improve student PA levels.

Limitations and Directions for Further Research

Among the limitations of this study, we only analyzed children's in-class PA levels and cannot address how the COVID-19 pandemic may have impacted children's extra-curricular PA levels. Second, we relied on a convenience sample from central Portugal. A larger and more diverse sample, and extra-curricular data, would permit further and more comprehensive analysis of the factors influencing PA intensity. Future investigators might also analyze the association between children's motor competence post-COVID-19 to better understand whether the associations we found between higher and lower PA activity and intensity persist beyond this pandemic experience (Stodden et al., 2008) and to study any differences between children's in-school and out-of-school PA levels.

Conclusions

Data obtained through this study revealed that a large group of Portuguese children spent most of their PE time in SEDLI, rather than MVPA, failing to meet PA levels recommended by the Association of Physical Education for protecting them from future health problems and inactivity in adulthood. We uncovered important PE variables that can increase children's MVPA time during PE lessons while decreasing the non-active time between activities. Two-hour classes may merely double SEDLI time rather than MVPA time. In this study, girls were more active than boys at some grade levels, highlighting the importance of PE for girls. We replicated consistent earlier findings that younger children were more active than older children, and we found that polythematic lessons encouraged a higher frequency of MVPA. Of importance to data interpretation and future research, we also showed that analyzing whether or not children are engaged in continuous PA (i.e., 10-minutes bouts of MVPA) can be important to determinations of whether MVPA intensity is sufficient for PA-associated health benefits.

Declaration of conflicting interests

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ORCID iD

Joana Lourenço  <https://orcid.org/0000-0003-2002-7238>

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