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Indoor physical education measured by heart rate monitor

A case study in Portugal

G. Y. WANG [1, 2], B. PEREIRA [1], J. MOTA [3]

Aim. **Reports indicated that children are spending too much time being physically inactive during physical education classes and many school physical education programs are not meeting the recommendation. The purpose of this study was to investigate the physical activity levels in Portuguese indoor physical education classes.**

Methods. **The physical activity levels of 28 Portuguese 7th grade children were assessed by heart rate monitor during their indoor physical education classes.**

Results. **The study showed that much physical education class time had been wasted, and less than 70% of physical education class time had actually been used in classes. On average, 14.4 minutes of 45-min physical education classes and 27.9 minutes of 90-min physical education classes had been spent in MVPA with children's heart rates above 139 bpm; 6.7 minutes of 45-min physical education classes and 15.7 minutes of 90-min physical education classes had been spent in VPA with children's heart rates above 159 bpm. Children engaged in more MVPA, VPA, and continuous bouts of physical activity in 90-min physical education classes than those of 45-min physical education classes. There were no significant differences in activity levels between genders in co-educational indoor physical education classes.**

Conclusion. **This indoor PE class study supports the results that children are less active during school physical education classes. Both the quantity and the quality of school physical education needs to improve to encourage children to engage in a substantial amount of physical activity both inside and outside school.**

KEY WORDS: Heart rate - Exercise - Child.

School physical education is recognized as the most widely available for promoting physical activity among children and adolescents.[1] Quality physical education can make important contributions to public health.[1] Children are the most active segment, but many of them do not participate in recommended levels of physical activity.[2] Reports indicated that children in physical education classes are spending too much time being physically inactive and many school physical education programs are not meeting the recommendation.[3] U.S. Healthy People 2010's report on school-based children in grades 9 through 12 in 1999 indicated that only 29% of American students participated in daily school physical education; 27% of students had engaged in moderate physical activity (MPA) for at least 30 minutes on 5 or more of the previous 7 days, 65% of them in vigorous physical activity 3 or more days per week for 20 or more minutes per occasion, 38% of students were physically active in physical education class more than 20 minutes 3 to 5 days per week.[3] In Portugal, most school children only have physical education classes twice a week, one of 90 minutes and another of 45 minutes. But there were not so many studies on Portuguese children's activity levels during physical education. Also only few reports

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of quantity and quality of PE in middle school have been published.[4]

To assess children's physical activity levels, a heart rate monitor (HRM) is probably the most common objective method, due to its validity and reliability,[5] relatively low cost and ability to record value over time.[6] The HRM is also a good tool for assessing moderate to vigorous physical activity (MVPA).[7] Mota [8] used heart rate telemetry measured at 30-s intervals and found that Portuguese boys and girls spent 60.2% and 46.5% of PE class time respectively with their heart rates higher than 140 beats min^{-1} (bpm). Kulinna [9] found that the heart rate pattern in physical education varied according to gender, grade and activity by using a heart rate monitor to record the heart every 15 seconds. The HRM has been used in physical education for nearly 40 years.[10] Recently, there has been a significant improvement in the technology available to measure children's heart rates. Children's heart rates have been measured at 5-s or beat to beat intervals using a lightweight, portable, short wave, radio telemetry system to capture a reliable, detailed heart rate.[11]

The aim of this study was to use a new HRM to investigate Portuguese 7th grade students' physical activity levels during the different indoor physical education classes. As we found that most school physical education classes were taking place in the school gym because of weather conditions in northern Portugal, we especially wanted to know whether Portuguese children are physically active during their indoor physical education classes.

Materials and methods

The subjects of the study consisted of 14 boys (mean age 12.5 years) and 14 girls (mean age 12.1 years), selected randomly from a sample of 264 children. Nearly 45.7% of these 264 children reported not participating in recommended levels of physical activity which also included their physical education, 20% of them did not participate in any leisure physical activity after school physical education.[12] The physical characteristics of the sample were measured. The children's heart rates were measured during 14 indoor PE classes (7 classes in 45-min PE and 7 classes in 90-min PE). The PE contents included football, basketball, handball, volleyball, gymnastics, and skill evaluation. The professional physical educators were aged from 25 to 45 y. The total area of the school indoor gym is 900 m^2, which can be divided into 3 equal parts (how big the playground the students have depends on how many classes there are at the same time). Actual PE class time was calculated on the basis of the heart rate monitor. The Polar S810 Heart Rate Monitor, which we selected, consists of a chest strap with wireless electrodes and a watch receiver-microcomputer. The HRMs were preset to record and store heart rate data every 5-s for the duration of a class period. Each time, 1 boy and 1 girl were selected randomly from the co-educational PE class, the subjects were asked to wear a HRM and were made to lie perfectly still on a bench for approximately 3 min to record their resting heart rate before the PE class. Teachers were instructed to maintain their normal methods of teaching. Subjects were informed to do everything as normal. The researcher reminded children to start and stop the HRMs when their PE teachers began and finished their classes. The children's heart rate data in the HRM memory were transferred to the PC through a POLAR infrared interface. The Polar Precision Performance 3.0 software was used to check and correct the errors in HR files. Excel and SPSS11.0 were used to calculate and analyze the data; the t-test was used to test heart rate difference between different genders in different indoor PE. Statistical significance was set at $p<0.05$.

Results

Descriptive statistics of the participants' characteristics, duration, and all heart rate measurements of 90-min and 45-min indoor PE classes are shown in Table I. Figure 1 shows the curves of 1 boy's and 1 girl's heart rate in their 90-min co-educational PE class (basketball). The percentage of subjects in sustained periods with heart rate above 139 bpm, 159 bpm are present in Figures 2, 3.

In 90-min indoor PE classes, we found that the scheduled class time was reduced to 61.2 min of actual class time, and 31% of class time had been wasted in changing clothes and taking a bath, etc. The children's average heart rate during their actual class time was 138.1 bpm. On average, the children spent 27.9 min in MVPA with their heart rate above 139 bpm. The maximal time that the children spent in MVPA was 73.9 min, the minimal time was 4.5 min, and the difference was 69.4 min. Moreover, 50% of the

TABLE I.—*Descriptive statistics of the subjects characteristics and heart rate related measures in different indoor PE classes.*

	90-min indoor PE				45-min indoor PE			
	All (n=14)		Boy (n=7) Mean (SD)	Girl (n=7) (Mean SD)	All (n=14)		Boy Mean (SD)	Girl Mean (SD)
	Mean (SD)	Min-Max			Mean (SD)	Min-Max		
Age (years)	12.1 (0.4)	12.0-13.0	12.3 (0.5)	12.0 (0.0)	12.4 (0.8)	11.0-13.0	12.7 (0.5)	12.1 (0.9)
Height (m)	1.63 (0.1)	1.53-1.76	1.67 (0.1)	1.59 (0.1)	1.58 (0.1)	1.51-69	1.61 (0.1)	1.55 (0.04)
Weight (kg)	55.5 (10.7)	40.0-82.0	59.4 (12.6)	51.6 (7.3)	60.0 (11.6)	43.0-75.0	59.4 (10.3)	60.6 (13.6)
BMI (kg/m^2)	20.8 (2.4)	17.1-27.4	21.1 (3.2)	20.4 (1.5)	23.9 (3.7)	19.2-28.9	22.9 (2.9)	24.9 (4.3)
HR Resting (bpm)	20.8 (2.4)	70-84	75.0 (4.1)	81.1 (2.0)*	78.1 (4.3)	70-82	75.1 (4.3)	81.1 (1.1)*
Average HR in PE (bpm)	138.1 (21.4)	119-179	138.5 (22.5)	137.7 (22.0)	140.5 (9.3)	21.4-32.8	28.1 (4.5)	30.8 (2.0)
Percentage of PE Actual Time (%)	68.0 (10.6)	54.4-91.1	70.6 (11.6)	65.3 (9.6)	64.4 (8.0)	47.6-73.0	62.5 (9.9)	68.4 (4.5)
Total PE time ≥140 bpm (min)	27.9 (23.9)	4.5-73.9	29.7 (23.7)	26.1 (25.8)	14.4 (4.4)	7.8-20.7	14.2 (5.0)	14.6 (4.2)
Total PE time ≥160 bpm (min)	15.7 (20.4)	1.0-66.0	18.2 (23.1)	13.3 (18.8)	6.7 (4.0)	2.3-14.1	8.3 (4.6)	5.0 (2.6)
Total PE time ≥60% MHRR (min)	18.4 (22.0)	1.5-70.7	21.2 (24.5)	15.5 (20.6)	7.9 (4.5)	3.1-16.9	10.1 (5.1)	5.7 (2.6)
Total PE time ≥75% MHRR (min)	10.1 (17.3)	0-57.8	12.9 (20.9)	7.2 (13.9)	2.6 (2.1)	0.3-8.2	3.4 (2.8)	1.9 (0.8)

*) $p<0.001$; PHRR=Maximal Heart Rate Reserve; bpm: beats per minute.

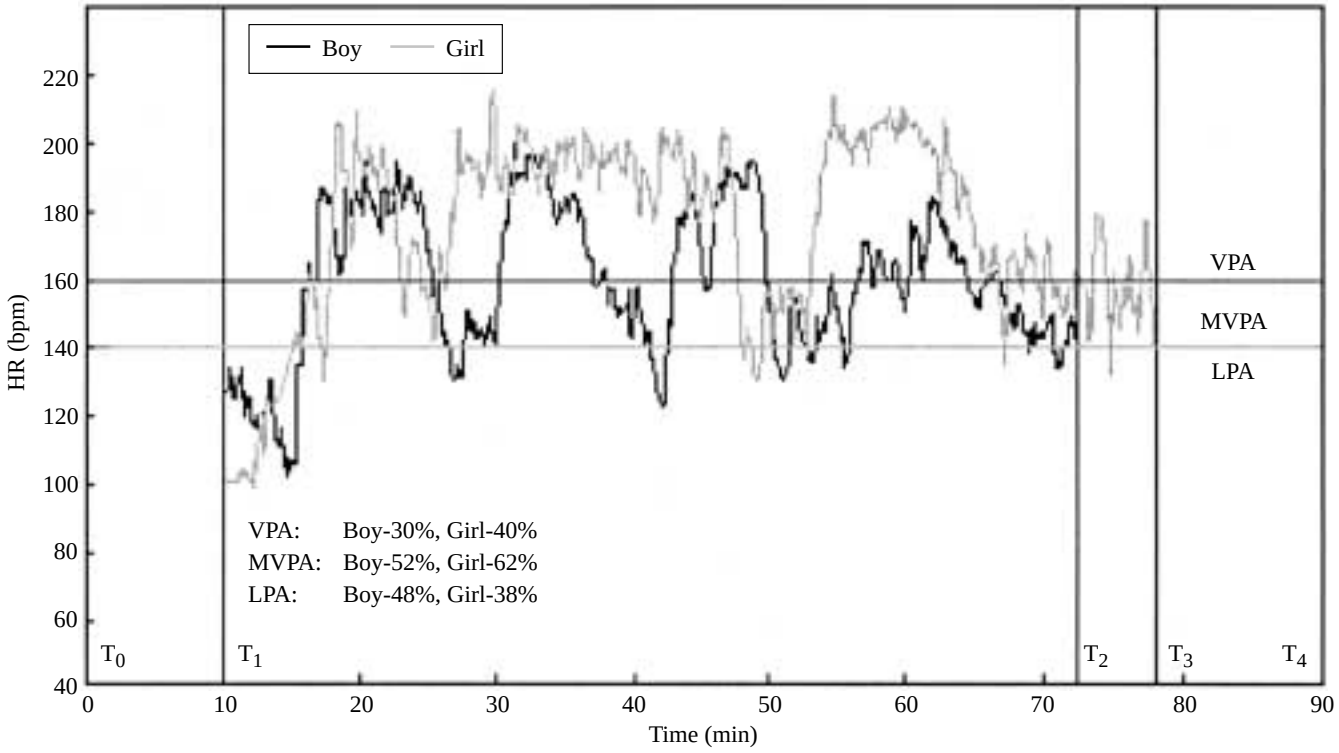

Figure 1.—The curves of students' heart rates in 90-min co-educational PE class (basketball). T_0-T_1: time used in changing clothes; T_1-T_2: time that boy spent in PE class; T_2-T_3: time that girl spent in PE class; T_1-T_3: time that girl spent in PE class; T_2-T_4: time that boy spent in taking bath, etc.; T_3-T_4: time that girl spent in taking bath, etc.

children (boys: 57.1%, girls: 42.9%), achieved at least one 5-min period of continuous MVPA, but only 35.7% of them (boys: 42.9%, girls: 28.6%) experienced a 10-min periods of continuous MVPA; 14.3% of them (boys:14.3%, girls:14.3%) experienced a single 20-min period of continuous MVPA. The children spent 15.7 min in vigorous physical activity (VPA) with their heart rate above 159 bpm; 35.7% of them (boys:

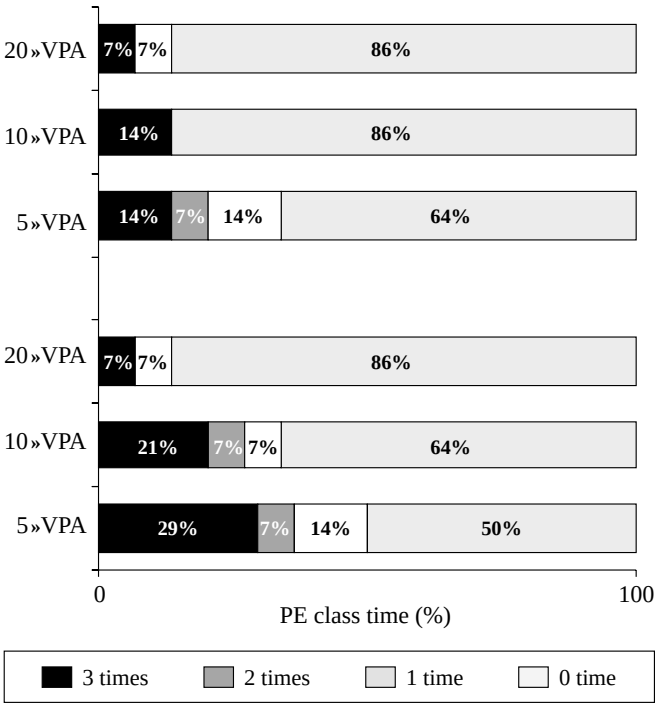

Figure 2.—Children's sustained periods of MVPA and VPA in 90-min PE classes.

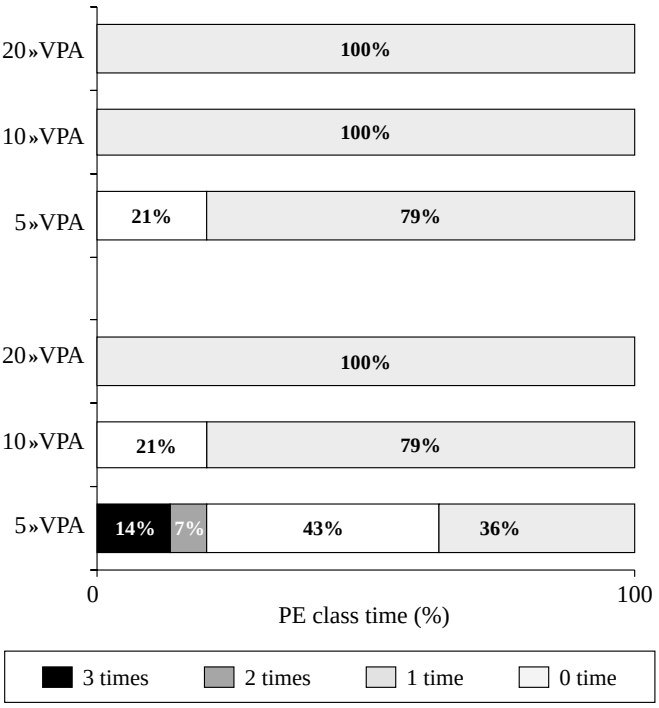

Figure 3.—Children's sustained periods of MVPA and VPA during 45-min PE classes.

42.8%; girls: 28.6) achieved at least 1 5-min period of continuous VPA; 14.3% of them (boys: 14.3%; girls: 14.3%) even experienced 2 or 3 20-min periods of continuous VPA.

In 45-min indoor PE classes (Table I), we found that the scheduled class time was also reduced to 29.5 min of actual class time, 35.6% of class time had been used in changing clothes, taking a bath, etc. The children's average heart rate during their actual class time was 140.5 bpm. On average, the children spent 14.4 min in MVPA with their heart rate above 139 bpm. The maximal time children spent in MVPA was 20.7 minutes, the minimal time was 7.8 minutes, and the difference was 12.9 minutes; 64.3% of the children (boys: 71.4%, girls: 57.1%) achieved at least 1 5-min period of continuous MVPA; but only 21.4% of them (boys: 42.9%, girls: 0%) experienced a 10-min periods of continuous MVPA; no one experienced a single 20-min period of continuous MVPA. Children spent 6.7 min in VPA with their heart rate above 159 bpm; 21.4% of them (boys: 42.9%, girls: 0%) achieved at least 1 5-min period of continuous VPA; but no one experienced 2 or 3 20-min periods of continuous VPA.

In total, we found only 28.6% of 90-min PE classes, in which children achieved the objective of at least 50% of lesson time (45 min) in MVPA with their heart rate above 139 bpm. But no one achieved that in all 45-min PE classes. Figure 1 shows the curves of the students' heart rate in their co-educational 90-min PE class (basketball). We can see more than 20 minutes had been wasted in changing clothes at the beginning of the class and taking a bath at the end. Fortunately the boys and girls were more active in this class.

Discussion

This is a cross-sectional study assigned to assess children's physical activity behavior during PE classes using heart rate telemetry. Allor [13] indicated that using traditional 140 bpm and 160 bpm heart rate cut-points may be easy to handle in large-scale epidemiological research but may not adequately describe vigorous exercise. Stratton suggested that, in children around puberty, heart rates above 139 bpm have been used as a threshold for moderate physical activity, and

above 159 bpm for vigorous physical activity.[11] Stratton also suggested that the percentage of maximal heart rate reserve (%MHRR) may be the most appropriate way to represent relative intensities. MVPA intensity of at least 60% MHRR is considered as appropriate for physical education curriculum goals for promoting physical activity, vigorous physical activity intensity above 75% MHRR may stimulate increased cardiorespiratory activity.[11] Morrow and Freeson [14] suggested that adolescents should perform physical activity for 30 minutes per bout, 3 days per week, at 75% of MHRR to achieve cardiorespiratory benefits, and U.S. Healthy People 2010 not only proposed the proportion of adolescents who engage in MVPA and VPA to promote health and cardiorespiratory, but also suggested, 50% of the physical education lesson time must involve MVPA to elicit cardiovascular fitness gain.[3]

A comparable study earlier showed that 5th grade Portuguese 10-year-old boys and girls spent 60.2% and 46.5% of lesson time respectively in MVPA with heart rates above 139 bpm.[8] Our study shows that 7th grade Portuguese boys and girls spent 51.6% and 48% of lesson time in 45-min indoor PE in MVPA with heart rates above 139 bpm, respectively. On average students spent 49.8% of actual class time in MVPA with their heart rate above 139 bpm. This result is close to a recent study in the United States,[9] which showed students in grades 3 through 12 spent 51% of physical education class time in their heart rate zones, but it is higher than the resent study from Hong Kong,[15] which showed primary school children, spent 32.4% of actual PE class in MVPA with children's heart rate above 139 bpm. We also found that many studies use the actual PE class time to express the percentage of PE class time being physically active. For example a recent study in Hong Kong showed that 35-min PE lesson was reduced to only 22 min of actual class time, children actually spent 32.4% of actual (or 19.7% of scheduled) time at the recommended level.[15] We notice that the percentage is higher when we use the actual class time. But the actual PE class time is also changeable and incomparable; it does not count all the time being wasted in PE classes (such as the time spent in changing clothes, taking a bath, etc.). If we use the scheduled class time, we find that only 32% of the scheduled class time (or 49.8% of the actual class time) in 45-min indoor PE classes and 31% of the scheduled class time (or 42.6% of the actual class time) in 90-min indoor PE classes is spent at recommended levels (MVPA). So we can see the intensity objective of 50% class time is still far from being met. So we also suggest using the scheduled class time in future studies.

The current international recommendations for health enhancing physical activity, which stresses at least 30 minutes of MPA, on most, or preferably all, days of the week can have significant positive health effects and that the activities can be accumulated by shorter bouts each lasting for around 10 minutes,[16] Corbin et al. proposed "a lifetime physical activity" guideline of a minimum of 30 min per day and an optimum of 60 min per day of MVPA for children and adolescents.[17] U.S. Healthy People 2010 also listed its physical activity objectives a) to increase the proportion of adolescents who engage in VPA 3 or more days per week for 20 min or more per occasion, and b) to increase the proportion of adolescents who engage in regular, preferably daily, MPA at least 30 min per occasion.[3]

School physical education is in a uniquely favorable position to increase physical activity and fitness for children. For many children, school physical education classes are also the only outlet for them to exercise and to gain the benefits of physical activity. The subjects of this study were selected from the sample of 264 middle school children. According to physical activity levels revealed by the questionnaire, 20% of them did not participate in any leisure physical activity after school physical education and 45.7% of them did not participate in recommended levels of physical activity which also included their physical education.[12]

McKenzie *et al.*[4] indicated that even in those schools with daily PE, students were not receiving adequate amounts of physical activity. This situation is likely to be worse in many other schools, where PE is not offered daily. Unlike many American schools that offer physical education daily, most Portuguese school children only have physical education classes twice a week. In this study, during the 90-min PE, 27.9 min had been spent in MVPA with heart rate above 139 bpm and 15.7 min had been spent in VPA with heart rate above 159 bpm; during the 45-min PE, 14.4 min of class time had been spent in MVPA and 6.7 min had been spent in VPA. In total, during an uninterrupted week we found that on average students accumulated a total 43.3 min of MVPA and 23.4 min of VPA in all their school physical education classes per week. Considering the intensity objective of 50% PE class time, their total time spent in MVPA and VPA during school

physical education, and their physical activity levels during the school PE and recess recorded by the questionnaire, we found that many children in this study had not met existing physical activity recommendations for health. So, it is necessary to motivate these children to be more physically active both inside and outside the school. The school physical educators need to maximize PE class time spent in MVPA and VPA. Students also need to be encouraged to participate in extracurricular physical activity regularly.

Armstrong [18] monitored the heart rate of 839 young people aged 5-16 years from South West England over 3 schooldays and found that boys spent a significantly greater percentage of time in MVPA than the corresponding girls. During school PE, Mota [8] monitored 10 boys and 10 girls of mean age 10.2 years, showing that boys spent significantly more time than girls with their heart rate above 139 beats min^{-1}, during the monitored period. McKenzie *et al.*[4], using the System for Observing Fitness Instruction Time instrument (SOFIT), found that boys were more active than girls overall and during skill drills, game play, and free play. According to this case study on children's heart rate in co-educational indoor PE classes, we actually noticed that most of the time girls had a higher heart rate during the fixed amount of exercise, but the boys' heart rates were lower and recovered more quickly in the same exercise. These situations cannot be easily found by the observation (SOFIT). But during the time of free play and ball games, boys were more active than girls. Stratton [11] stated that few studies have investigated the gender differences in activity levels during PE class and that such studies should include MHRR data owing to gender differences in resting and activity heart rates. In this study, we found that girls' resting heart rate is significantly higher than boys', but in all we did not find significant gender difference in their physical activity levels during their co-educational indoor PE classes by way of %MHRR. This is maybe because the children in co-educational PE are provided with similar opportunities for boys and girls to participate in physical activity.

Recent recommendations on physical activity for children and adolescents did not include a component of sustained exercise.[3, 19, 20] Researchers found that young people's physical activity patterns are characterized by short, rather than sustained, bouts of activity.[21] Some researchers began to study and use it. Simons-Morton *et al.*[22] used the 10-min criterion in a self-report study. Debusk *et al.*[23] found that 10-min continuous bouts that accumulated to 30 min were effective in improving aerobic capacity. Blair *et al.*[24] also recommended for people 10-min continuous bouts of exercise. The study of daily physical activity of school children in Singapore, showed that only 18% of boys and 6.3% of girls experienced daily 10-min periods of continuous MVPA with children's heart rates above 139 bpm.[25] Armstrong *et al.*[26] showed that 36% of boys and 48% of girls, aged 11-16 years did not experience a single 10 min period MVPA with their heart rate above 139 bpm during 3 days of monitoring, only 3.9% of boys and 0.6% of girls experienced daily 20-min periods of continuous activity at an arbitrary criterion of 70% of the age-predicted maximum heart rate. There were not too many reports on the continuous bouts of MVPA and VPA in school PE. In this study, we found that children in 90-min indoor PE classes had more chance of achieving 10-min and 20-min continuous periods of MVPA with heart rates above 139 bpm than in their 45-min indoor PE classes. But still more than 30% of children did not achieve at least 5-min continuous period of MVPA in both 90-min and 45-min indoor PE classes. We found that children in 90-min indoor PE classes even had the chance to achieve 20-min continuous periods of VPA with heart rate above 159 bpm, but in 45-min indoor PE classes, they seldom had the chance to achieve 5-min continuous periods of VPA to improve their aerobic capacity.

Many factors influence physical activity levels during PE classes; McKenzie *et al.*[4] found that 31% of 45-min PE scheduled time had been wasted in clothes changing, etc., and only 69% of scheduled time (M=34 min, SD=5.1) had been used for PE. In this study, we found that more than 30% PE scheduled time had been wasted mainly in clothes changing, bath taking, etc. So we wonder why these times should be included in school physical education classes? McKenzie *et al.*[27] also reported that activity levels varied according to the content of PE classes. According to children's heart rates in this study, we found that lesson contents, class size, playground size, facilities, discipline, and management can all play an important role on the levels of indoor PE. We found that students engaged in more MVPA ($r=0.64$, $p<0.05$) in their favorite programs, such as football, than in others, such as volleyball. During gymnastics classes, children were often sedentary or waiting in a queue for their practice because of

lack of facilities, which led to children being less active during PE classes. We found that students in bigger playgrounds spent more time in MVPA ($r=0.55$, $p<0.05$) and VPA ($r=0.67$, $p<0.001$). We also found a very big time difference in their actual class time, MVPA, and VPA among their different physical education classes, which also means children's physical activity levels can be improved if we take some right steps, such as improving the management of school physical education, improving the discipline of children, etc.

Conclusions

This indoor PE classes study supports the results that children are less active during their school physical education classes. School physical education is in a uniquely favorable position to increase physical activity and fitness for children. Considering the children's activity levels during school physical education and recess, it needs to improve both the quantity and the quality of school physical education to encourage children to engage in a substantial amount of physical activity both inside and outside school. Improving the management of school physical education and the discipline of students might be able to save the time being wasted in changing clothes and taking a bath; some health-enhancing programs also could be useful for school physical education.

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