

Effects of Physical Education on Objectively Determined Physical Activity in Primary School Children— Which Proportioning Is Best?

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Physical Education (PE) can foster regular physical activity (PA) in children. However, children engage in insufficient moderate to vigorous PA (MVPA) during PE. This study objectively investigated MVPA of children during a single, compared with double PE-period. In 294 children (7.1 ± 0.7 years) PA was objectively assessed. PE periods were determined and PA was individually calculated. Children spent 8.5 ± 7.3 minutes of each 45 minutes PE lesson in MVPA. Boys were significantly more active than girls ($p \leq .01$). All children participated in 135 minutes PE/week, 32.7% were scheduled one double and one single PE-period. Children, with a double PE-period and one single lesson engaged in significantly less MVPA than children, who had three single periods of PE (6.7 ± 6.9 minutes/45 minutes vs. 9.4 ± 7.4 minutes/45 minutes, respectively; $p \leq .01$) In conclusion, single periods of PE seem to be more effective in getting primary school children to engage in more MVPA than one double period per week.

Keywords: pediatrics, physical activity, sport, teaching

The positive effects of physical activity on health are well documented (Ekelund et al., 2012). Measurable benefits of regular childhood physical activity include reduced risk of osteoporosis and increased bone mass (Tobias, Steer, Mattocks, Riddoch, & Ness, 2007) as well as prevention of hypertension (Brage et al., 2004) and obesity (Wittmeier, Mollard, & Kriellaars, 2008). Further, it has been shown that there is a high likelihood, a physically active child will grow to be a physically active adult (Sevala et al., 2010). At the same time, with increasing age, the level of physical activity in children diminishes (Duncan, Duncan & Schofield, 2008), with the largest decline in moderate to vigorous physical activity (MVPA; Frömel et al., 2008). Current recommendations for preadolescent children are to accumulate at least 60 minutes/day of MVPA (WHO, 2010). However, currently merely

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42% of U.S. children aged 6–11 years and only one third of European children and adolescents are estimated to be sufficiently physically active (Ekelund et al., 2012; Troiano et al., 2008).

One opportunity for children to receive physical activity is through school physical education (PE). PE at school may play an important role in the socialization process into a physically active lifestyle (Jaakkola, Liukkonen, & Laakso, 2008); and is an educational and a public health resource (Sallis et al., 2012), providing children with opportunities to be physically active and teaching them the knowledge and movement skills leading to active lifestyles (Sanchez-Vaznaugh, Sanchez, Rosas, Baek, & Egerter, 2012). On the other hand, today children receive significantly less time for physical activity during the school day than they did a decade ago (Burton & VanHeest, 2007). Initiatives such as Healthy People 2020 (US Dept. of Health and Human Services 2010) recommended that PE is offered daily and consists of lessons which engage children in MVPA at least 50% of the time.

However, limited and hardly comparable data are available on the frequency and duration of PE classes in primary schools or on the level of activity children engage in during those classes. Coe and colleagues (Coe, Pivarnik, Womack, Reeves, & Malina, 2006) found low levels of activity during PE lessons in 11-year-old children. Those engaged in 19 minutes of MVPA per 55 minutes of PE. Another study found similar values with an average of 34% MVPA of lesson time for 11-year-olds (Fairclough & Stratton, 2005) but several other studies have shown that children may be more active during break times than during PE lessons (Nettlefold et al., 2010). Though far from conclusive, these findings lend support to the argument that PE has the opportunity to enhance children's activity levels. Particularly among the least active, for whom PE may be their only regular occasion for health-enhancing activity (Trudeau & Shephard, 2005).

In south-west Germany, the primary school curriculum regulates that three 45-minute PE periods have to be performed weekly. Yet, schools can organize those three periods—whether in three single periods or a double and a single period—in a way that fits with their timetables and PE hall availability. Still, so far no study has investigated whether children engage in (comparative) more MVPA during a single period of PE compared with a double period.

Therefore, this study was conducted to objectively determine children's amount of MVPA during regular PE lessons at primary schools and to conclude whether children accumulate a greater percentage of time in MVPA during multiple single PE lessons compared with double periods of PE.

Methods

Participants

Baseline measurements of a subsample of 294 primary school children (7.1 ± 0.7 years; 48% male) who participated in the school-based health-promotion program "Join the Healthy Boat" (Dreyhaupt et al., 2012) in south-west Germany were used for analysis. 27.2% of children came from families with migration background (i.e., parents or child born abroad), reflecting the overall rate of children with migration background in the participating schools (24.3%). For further demographic details see Table 1. Although the majority of participating schools (56%) was located in

Table 1 Participant's Characteristics and Demographics

	Boys	Girls	All
Number (n; %)	140 (47.6)	154 (52.4)	294 (100)
Age (years)	7.2 (0.7)	7.1 (0.7)	7.1 (0.7)
Height (cm)*	124.2 (6.5)	123.2 (6.3)	123.7 (6.4)
Body Mass (kg)*	25.1 (5.3)	24.4 (4.9)	24.7 (5.1)
BMIPCT	49.7 (26.9)	47.7 (29.0)	48.6 (28.0)
Overweight/Obese (%)	5.7/4.3	5.2/4.6	5.5/4.4
First grade (n; %)	66 (47.1)	74 (48.1)	140 (47.6)
Migration background (n; %)	27 (23.3)	41 (30.6)	68 (27.2)
Low income families (n; %)	11 (10.3)	21 (16.4)	32 (13.6)

Notes: Values are displayed in mean and *SD*; BMIPCT = BMI percentiles; low income = below 1750€/month *) significant gender differences, $p \leq .05$

rural areas compared with suburban and urban areas, the average school had 223.2 (± 147.1) students and 11.2 (± 6.6) classes. Parents' written informed consent as well as child assent was obtained before data collection. In addition, parents had to agree separately to their children's physical activity being monitored objectively. The study was approved by the Ministry of Culture and Education as well as the University's ethics committee and is in accordance with the declaration of Helsinki.

Anthropometric Measures

Children's height (cm) and body mass (kg) were taken in vest, shorts and bare feet by trained technicians during a school visit according to standard procedures (Malina, 1995). Standing height was measured to the nearest 0.1 cm using a stadiometer (Seca 213, Seca Weighing and Measuring Systems, Hamburg, Germany). Body mass was obtained with electronic scales (Seca 862, Seca Weighing and Measuring Systems, Hamburg, Germany) to the nearest 0.05 kg. Subsequently body mass index (BMI) was calculated and converted to BMI percentiles (BMIPCT) using German reference data (Kromeyer-Hauschild et al., 2001). Overweight and obesity was determined above 90th and 97th percentile (BMIPCT), respectively.

Physical Activity

Physical activity was assessed using a multisensor device (Actiheart, CamNtech Ltd., Cambridge, UK). This chest-worn accelerometer measures bodily movement simultaneously with heart rate (Brage, Brage, Franks, Ekelund, & Wareham, 2005). Energy expenditure was predicted with Actiheart's captive software (Version 4.0.73), utilizing participant's characteristics such as age, height, body weight and gender in addition to heart rate and movement counts to determine exercise intensity. The Actiheart has previously been shown to predict energy expenditure in children validly during six common activities in free-living situations (Corder et al., 2007).

Activity levels were classified according to Pate et al. (1995) as sedentary (< 1.5 METs), light (1.5–3 METs), moderate (3–6 METs), and vigorous (> 6 METs).

In the current study, the participants whose parents agreed for the student to be monitored wore the multisensor device for six consecutive days with recording intervals set to 15 seconds, being the lowest possible interval this monitor offers. To be included in the analysis, at least three days with valid data for more than 10 hours were required. First and last recording days were excluded from analysis to antagonize the novelty factor on the first day, whereas the last day never showed 10 hours of recording. In addition, to record data of all three PE lessons, the monitors were always fitted on days on which no PE was scheduled. Children's data were only analyzed if all PE periods in that week were attended and recorded.

Physical Education

PE was only taught by qualified PE teachers with a minimum of five years teaching experience. To assess "normal" nonintervened PE, no instructions were given regarding the content of those lessons. However, the primary school curriculum suggests teaching the enjoyment of physical activity and games as well as basic motor skills without major equipment at the beginning of an academic year, in which period data collection took place. Data on content taught during PE lessons was based on information given by the teachers. Using timetables provided by the participant's teachers, times of individual PE lessons were identified. During a school visit, trained staff determined the size of the PE hall (in m²) and ensured that the equipment available complied with curriculum requirements. All PE lessons were held inside and consisted—irrespective of single or double—of short games, teaching motor skills such as throwing and catching (including ball handling), as well as running, jumping, moving within a defined space and balance exercises.

Data Analysis

Individual activity times and intensities were calculated for each child for their weekly PE lessons. Variables were grouped in three single periods versus one double and one single period of PE and gender was grouped in boys versus girls; weight status was grouped using median split of BMIPCT. All statistics were performed with SPSS Statistics 19 (SPSS Inc., Chicago, IL, US) using a significance level of $p \leq .05$. Descriptive statistics were calculated (mean values and standard deviations). Mann-Whitney-U-Tests were used to examine group differences after Kolmogorov-Smirnov-Tests have shown nonnormal distributions of the data. Effect sizes (d) were categorized into small ($d=.2$), medium ($d=.5$) and large effect size ($d=.8$).

Results

All children participated in 135 minutes PE a week, 32.7% of children were scheduled one double period of PE in addition to one single PE lesson, the other two thirds of children were scheduled three single lessons of PE. On average there were 19 ± 2.5 students in a class and Table 1 shows a summary of the participants' anthropometric characteristics for which no significant gender differences were found.

Examining physical activity intensity, during a regular PE lesson, children spent 8.5 ± 7.3 minutes of their 45-minute PE lesson in MVPA. Table 2 shows that boys were significantly more active than girls ($t(1) = 7.830, p \leq .01, d=.3$). Further, that children who had a double period of PE in addition to one single period, engaged in significantly less MVPA than children who were scheduled three single periods of PE ($t(270) = 1.795, p \leq .01, d=.2$).

When comparing data of those children, who were scheduled a single PE period in addition to a double period of PE, the time they engaged in MVPA during a single period was significantly more than the time spent in MVPA during a double period (8.9 ± 9.7 minutes/45 minutes vs. 4.1 ± 5.0 minutes/45 minutes for a single and a double period of PE, respectively; $t(25) = 2.709, p \leq .01, d=.7$). Therefore, children who had a double and a single period of PE spent 14.5% of their PE lessons in MVPA, whereas children who only had single periods of PE spent 20.8% of their 45 minutes in MVPA (Figure 1).

This also resulted in a difference in total time per week spent in MVPA during PE. Children accumulated on average 25.5 ± 22.0 minutes of MVPA during their weekly PE lessons. Children with only single lessons spent 28.1 ± 22.1 minutes of their weekly PE in MVPA, whereas children with a double and a single period of PE spent 19.8 ± 20.8 minutes of PE per week in MVPA.

Looking at double periods only, no significant difference was found for the amount of MVPA spent during the first and second half of the double period (8.4 ± 9.3 minutes during the first half vs. 10.3 ± 9.9 minutes during the second half). In addition, comparing the amount of MVPA during single lessons of children who were scheduled single lessons only, with the amount of MVPA during single lessons of those being offered single and double periods, no significant difference was found (9.4 ± 7.4 minutes vs. 8.9 ± 9.7 minutes for children with single periods only and single and double periods, respectively).

PE lessons—irrespective of single or double—consisted of short games, teaching motor skills such as throwing and catching (including ball handling), as well as running, jumping, moving within a defined space and balance exercises. No correlation was found for the content taught during a single period compared with

Table 2 Time Spent in MVPA During 45 Minutes of PE

	Time spent in MVPA during PE	
	Minutes per 45 min lesson	% per 45 min lesson
All	8.5 (7.3)	19.0
Boys	9.7 (7.6)	21.6
Girls	7.5 (7.0)	16.6
One double and one single period	6.7 (6.9)	14.9
Three single periods	9.4 (7.4)	20.9

Notes: Values are displayed in mean and *SD*

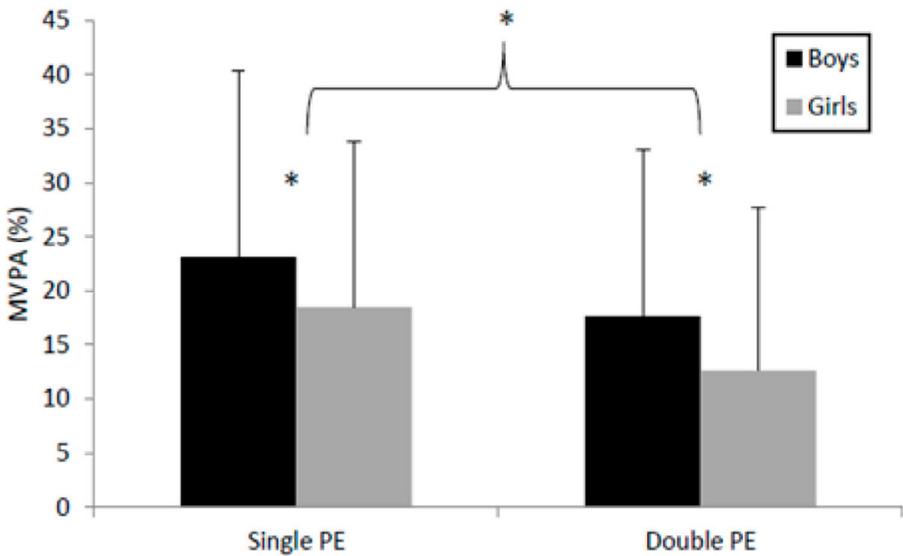


Figure 1 — Children's percent moderate to vigorous physical activity (MVPA) during physical education (PE). (*) significant differences, $p \leq .05$

a double period of PE. Nor did weight status (shown in Table 1), content taught and size of available PE hall (mean: $340.7 \pm 205.2 \text{ m}^2$) influence children's physical activity or time spent in MVPA during PE.

Discussion

To our knowledge, beside the objective determination of children's amount of MVPA during regular PE lessons, this is the first study investigating whether primary school children accumulate more time in MVPA during multiple single PE lessons compared with double periods of PE. These results indicate that all here examined children received 135 minutes PE per week and averaged 8.5 minutes of MVPA during each PE lesson, 19% of available time. This is considerably short of recommendations suggesting PE lessons at schools should engage children in MVPA at least 50% of the time (US Dept. of Health and Human Services, 2010). Children in this study also engaged in significantly less time in MVPA during PE lessons than children in previous studies. For example, Coe et al. (2006) assessed physical activity intensity during 55-minute PE lessons using questionnaires, where 9-year-olds spent 19 minutes (34.6%) in MVPA. Another large study using direct observation investigated 9-year-old primary school children's physical activity during PE lessons showing similar results (The National Institute of Child Health and Human Development Study of Early Child Care and Youth Development Network (NICHD SECCYD), 2003). This discrepancy could reflect the different assessment methods

used. Looking at objective measurements, Fairclough and Stratton (2005) attained very similar results with 17.5 minutes (34.3%) per PE lesson in 11- to 14-year-olds using heart rate monitoring. Yet, more recent data using accelerometry, even suggest that children's MVPA levels during PE were no higher than 11% and 13% of total time spent in PE (Nettlefold et al., 2010). Our results of 19% of PE time spent in MVPA are therefore not dissimilar from those samples.

Nonetheless, the main difference in physical activity levels and time spent in MVPA during PE was due to the organization of PE classes in single or double periods. Here, it was shown that children who had PE three times a week for 45 minutes each (single periods) averaged significantly higher levels of physical activity during those lessons than children who had PE only twice a week for one double period and one single period. Therefore, the average time spent in MVPA during PE classes was also significantly higher in those children who had three single periods of PE compared with those who had PE twice a week for one double and one single period (9.4 minutes (20.8%) vs. 6.7 minutes (14.8%), respectively). Similarly, the average time spent in MVPA for children who were scheduled a double period of PE in addition to a single period, was also significantly higher during the single period. This suggests that with regards to accumulation of MVPA during PE, children benefit more from single lessons of PE than from double periods. Current literature does not offer an explanation for these findings but children seem to use the limited time they have during a single PE period for more intense physical activity than they do when offered more time during a double period. Neither stamina, nor motivation, appear to be the reason since there was no difference in time spent in MVPA during the first or second 45 minutes of a double PE period. In addition, assumptions that children lose much time by getting changed and transferring from classroom to PE hall cannot be supported since the potentially available time for MVPA during double periods compared with single periods of PE should be greater. This study therefore adds valuable information to the existing research in physical activity intensity during PE lessons in primary schools and offers new opportunities for health-enhancing physical activity interventions focused around PE.

These results call for continued advocacy to improve and maybe restructure the curriculum of PE so primary school children have the opportunity to engage in activities in which they will obtain more MVPA more often. One study however, has shown that the low physical activity levels during PE can result from some students spending more of a PE class listening to instructions or waiting for a turn to use gymnastic equipment, than being active (NICHD SECCYD, 2003). In their study, children spent approximately a third of total PE time organizing the lesson or listening to instructions. This suggests cause for concern since a recent prospective tracking study has shown that, although weekly physical activity in childhood was not associated with adult activity, school PE on the other hand predicted adult total weekly physical activity (Cleland, Dwyer & Venn, 2012). This again, highlights the importance of physical activity during PE and emphasizes the responsibilities teachers have when teaching PE. However, it is not solely the teacher's responsibility to ensure children have plenty opportunities to engage in sufficient physical activity during PE, but also the state's and community's. In the US, it has been shown that children are more likely to accumulate increased weekly PE minutes in states with defined policies and laws that govern regular PE at primary schools (Slater et al., 2012). Still, more than 30% of US primary

schools failed to have a PE requirement (Lee, Burgeson, Fulton & Spain, 2007), highlighting that this is an issue which requires attention on more than just state level. Government, communities, schools as well as individual teachers have to get involved to provide a well-thought-out framework which enables children to be more physically active at school and especially during PE. The results of this research provide some suggestions on how to structure weekly PE periods so that it facilitates more MVPA during PE.

All children in this study were taught by expert PE teachers, which has shown to increase children's energy expenditure and the amount of time children spend in high activity levels during PE compared with classroom teachers teaching PE (NICHD SECCYD, 2003). Since data collection took place at the very beginning of the academic year and approximately half of the children were first graders, who have sometimes had their very first PE lessons while being monitored, it can be assumed that teachers were trying to accustom them with the concept of PE during that time.

One strength of this research however, is that primary school children's physical activity levels were assessed during "normal", nonintervened PE lessons using a multisensor device, which has been found to be a highly reliable and valid measure of physical activity in children (Corder et al., 2007). In this respect and in combination with a relatively large sample size, it provides a representative picture of the intensity and duration of children's physical activity engagement during curricular PE in the south-west of Germany. In addition, the assessment of physical activity over multiple days allowed estimation of the variability of activity levels during the different weekly PE lessons. However, several aspects should be considered when interpreting these findings. First, the data are cross-sectional, although this study tracked children's activity levels during one week including three PE lessons, long-term assessments may have enabled PE lessons to be observed more closely to receive more in-depth results. Second, it is possible the PE lessons were taught differently, and children acted differently as a result of some children being monitored by multisensor devices. Third, no quantitative information about the time children spent being instructed, getting changed and being active was provided by the teachers and neither heart rate, nor accelerometry provide any contextual information about the monitored lessons. Future work is needed to determine whether such low levels of MVPA as found in this study are typical of PE in other regions in Germany. Best combining objective measures with observation to enable categorization of PE activities as well as content and other factors such as different teaching influencing physical activity levels during PE.

Conclusion

The present study adds information about physical activity levels of primary school children during PE, indicating that PE lessons should become more active to increase those low levels of MVPA during PE. PE at school clearly has the capacity to engage children in health-enhancing physical activity. However, on the basis of these findings, it is clear PE can only supplement children's daily time of physical activity. Governments and communities should provide more and well-thought-out structures requiring schools to provide PE more often to enable them

to establish environments that support physical activity, especially during PE. PE teachers on the other hand should be encouraged to provide more opportunities during their lessons for children to be physically active for longer periods of time. The findings of this research therefore suggest engaging primary school children in multiple single periods of PE per week, rather than a double period, to increase their time spent in MVPA during PE lessons.

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