Original Paper

Biomedical Human Kinetics, 1, 86 - 91, 2009

DOI: 10.2478/v10101-009-0022-x

Health-related intensity profiles of Physical Education classes at different phases of the teaching/learning process

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Summary

Study aim: To assess the intensities of three types of physical education (PE) classes corresponding to the phases of the teaching/learning process: Type 1 - acquiring and developing skills, Type 2 - selecting and applying skills, tactics and compositional principles and Type 3 - evaluating and improving performance skills.
Material and methods: A cohort of 350 schoolchildren, aged 13 years, from 3 selected urban schools in Poznań participated in the study. A total of 202 PE lessons was involved using heart rate (HR) monitors, one randomly selected subject per every class. Four intensity zones were assumed (<140, 140 – 159, 160 – 179, ≥180) and exercising time spent within each zone was measured.
Results: Type 2 classes induced the most pronounced cardio-respiratory responses irrespectively of the kind of sport activities thus enhancing the cardio-respiratory fitness.
Conclusions: Type 2 activities ought to be taken into consideration when designing PE curricula in order to avoid long runs of inadequate physiological stimuli.

Key words: Physical education – Exercising intensity – Teaching/learning process

Introduction

The physical education (PE) national curricula usually offer only the bare minimum of objectives followed throughout all schools. The objectives of individual classes, considering the needs of pupils, are being left up to the teachers. Lesson plans should be flexible enough to cater for pupils' individual needs on a daily basis. It is thus important to plan the exact amounts of time to practice and learn each specific task so as to meet the learning outcomes of the class and still have some health-related gains at the same time.

The growing prevalence of obesity is known to be related to a low involvement in PA [2,10,12,13,24] and the same is true for cardiovascular diseases, which are carried over from childhood into adulthood [3,11]. To make the matters worse, PE classes at school are the only form of organised physical activities for 60 – 70% (this may vary with age) of Polish children [27] whose interest in those activities declines with time down, only a few percent of schoolchildren remaining active in the last school years. The former 4 obligatory PE classes a week, lasting 45 min each, which was reasonably sufficient compared to other European countries [6], had been recently reduced to 2 obligatory classes with further 2 on a facultative basis. Another question is whether that time is used effectively since the turn-over rate of youths and adults participating in leisure-time PA declines and, in consequence, the health of the population is worsening.

The activities of moderate-to-vigorous intensity (140 – 160 bpm) were recommended as providing a stimulating aerobic impact on the physical or cardio-respiratory fitness of school youths [1,17,20,25]. We thus believe that such workloads are to be maintained for at least 50% of the total duration of a PE class. Up to now, the intensities of PE classes, as well as earlier monitoring of those classes in Poland [4,18,19,20,26] were not satisfying.

In other European counties the picture is more or less similar. In England [22], 80% of classes do not match the criterion of 50% lesson time with heart rate over 140 bpm. In France, Baquet, Berthoin and Van Praagh [2] recorded an average value of 134 bpm in traditional PE classes, in contrast to 154 – 158 bpm in an experimental group undergoing 10 weeks of health-enhancing exercises.

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Raudsepp and Pall [21] aimed at enhancing the health-related fitness and noticed that only 27% of the total lesson time was spent at intensity below 150 bpm. In earlier reports [4,5], 56.3% of the lesson time of traditionally led PE classes with Polish 13-year olds was under 140 bpm. However, sport-specific differences were noted. The outdoor track-and-field activities, or which included invasion games, were more intense than classes of gymnastics or table tennis.

Various forms of PA differ in physiological characteristics. Invasion games (e.g. basketball, football) involve quick transfer to the opponent's part of the court and back and employ large muscle groups requiring constant transportation of oxygen, while gymnastics classes are usually well-organised and disciplined, attention being paid to routine and safety precautions; there is more waiting and queuing for the go than actual practicing. This led us to formulation of a new hypothesis that the phase of a teaching/learning process needs be considered important in evaluating intensity of the lesson.

One of the main aims of the learning process is that pupils are able to transfer the skills and knowledge gained e.g. at school to the leisure activity model and the same applies to health gains. Thus, in order to enable pupils to make progress throughout the learning phases, the PE teachers need to keep increasing demands. According to Capel [7] "these can be broken into four aspects: a gradual increase in the complexity of the sequence of movement, an improvement in the demonstrated performance qualities; greater independence in the learning context and a gradual challenge to the level of cognitive skills required". Since this problem was neglected in previous studies in Poland [5,18,19,20,26] and elsewhere [2,8,9,21, 22], we decided to examine the relationships between phases of the teaching/learning process in physical education through the following strands: a) acquiring and developing skills, b) selecting and applying skills, tactics and compositional principles and c) evaluating and improving performance and intensity of workloads. It was hypothesised that lessons with dominant participation of acquiring and developing (Type 1 lesson) differ from the ones including more of selecting and applying skills (Type 2 lesson) and evaluating components (Type 3 lesson). The aim of the study was thus to describe the profiles of each lesson type and to determine time allocations of workloads to 4 pre-determined intensity zones in relation to the phases of the learning process.

Material and Methods

A cohort of 350 schoolchildren, aged 13 years (first form of lower secondary school), from 3 randomly selected urban schools in Poznań participated in the study in 2006/2007. A total of 202 PE lessons were observed and monitored. All parents submitted their written consents; the study was approved by the local Ethics Committee. Class activities conformed to the conventional, specific methodology and were run by fully qualified PE teachers.

The intensity of PE activities was monitored using sport testers (Polar S 610i, Finland) worn by one randomly selected pupil at each of the 202 PE classes lasting 45 min. Four zones of intensity were discerned, based on the heart rate reserve (HRres) principle. Ball State University Formula [23] was used to establish the maximal heart rate (HRmax) for age category 13 years: HRmax = 214 – 0.8·13 = 201 bpm (boys) or
209 – 0.7·13 = 197 bpm (girls). Resting (pre-class) rates were measured 3 min before each class; average value amounted to 85 ± 5 bpm [5]. The following intensity zones were established:

Zone 1 – workloads of low intensity, <140 bpm (below 50% HRres),

Zone 2 – workloads of moderate intensity 140 - 159 bpm (51-65% HRres),

Zone3 – workload of moderate-to-vigorous intensity, 160 – 179 bpm (66-80% HRRes),

Zone 4 – workload of vigorous intensity, ≥180 bpm (above 81% HRres) [23].

Three types of lessons, their planning and emphasis based on the so-called strands were discerned according to the English national curriculum [7]:

Type 1 lesson (Strand 1) – acquiring and developing skills (A&D);

Type 2 (Strand 2) – selecting and applying skills, tactics and compositional principles (S&A);

Type 3 (Strand 3) – evaluating and improving performance skills with emphasis on evaluation (E&I). The 4th strand (knowledge and understanding of fitness and health) was not included as not being commonly used in PE classes in Poland.

Student's *t*-test for independent data was used to assess the differences between lesson types at given intensities. The level of $p \leq 0.05$ was considered significant.

Results

In Table 1 are presented numbers of monitored PE classes, classified by their types and kind of sport activities, in Tables 2 and 4 – mean heart rates recorded for those categories, and in Tables 3 and 5 – mean durations of exercising at various intensities recorded for class categories.

Table 1. Numbers of monitored PE classes classified by their types and kind of sport activities

Subject	Activity Gender	Type 1	Type 2	Type 3
Basketball	M	10	13	8
	F	11	11	7
Volleyball	M	8	6	7
	F	8	7	6
Athletics	M	10	9	5
	F	8	11	6
Gymnas-tics	M	7	7	9
	F	7	11	10
Total	M	35	35	9
	F	34	40	29

Legend: M – Boys; F – Girls; Type 1 - Acquiring and developing skills; Type 2 – Selecting and applying skills, tactics and compositional principles; Type 3 – Evaluating and improving performance skills with emphasis on evaluation

Table 2. Mean values (±SD) of heart rate in boys aged 13 years during different types of PE activities

Activity Subject	Type 1	Type 2	Type 3
Basketball	141.1 ± 8.9	154.7 ± 14.7**	133.3 ± 7.6^{oo}
Volleyball	122.7 ± 7.1	137.8 ± 6.3*	111.7 ± 14.1*^{oo}
Athletics	138.6 ± 9.5	152.6 ± 9.8**	147.6 ± 12.0
Gymnastics	128.2 ± 3.7	133.4 ± 16.8	119.3 ± 8.2^{o}

Significantly different: from Type 1 value: * p<0.05, ** p<0.01; from Type 2 value: ^{o} p<0.05, ^{oo} p<0.01; For other explanations see Table 1

Highest mean HR was recorded in boys in Type 2 lessons (selecting and applying skills), whereas the lowest one in Type 3 lessons (evaluation) in all sport activities except athletics. Basketball classes had highest intensity profile. Significant differences between various types of lessons were noted in all sport activities (Table 2).

In all kinds of PE classes most time was spent on low-intensity activities (Zone 1). Again, significant differences between various types of lessons were noted at given intensity zone in all sport activities (Table 3); only basketball, volleyball and athletics activities of Type 2 took more than 50% of the lesson time at higher intensities, i.e. at HR exceeding 140 bpm.

Like in boys, highest mean HR was recorded in girls in Type 2 lessons, whilst the lowest in Type 1 lessons (except gymnastics). Athletics classes had highest intensity profile. Significant differences between various types of lessons were noted in all sport activities (Table 4).

Table 3. Mean values (±SD) of exercising time spent by boys aged 13 years in 4 intensity zones

Activity Zone	Type 1	Type 2	Type 3
Basketball			
1	23.2 ± 7.7	16.4 ± 5.9*	25.3 ± 3.3**
2	11.4 ± 5.1	11.4 ± 5.1	9.8 ± 5.7
3	7.4 ± 4.7	9.9 ± 4.6	8.4 ± 4.0
4	3.0 ± 5.3	7.2 ± 7.3	1.9 ± 2.6
Volleyball			
1	32.8 ± 5.8	22.3 ± 7.2**	36.9 ± 6.3^{oo}
2	9.8 ± 4.6	14.5 ± 7.6	6.1 ± 4.3^{o}
3	2.3 ± 1.5	5.8 ± 3.0**	0.7 ± 1.1^{oo}
4	0.3 ± 0.5	2.7 ± 3.7	1.3 ± 3.0
Athletics			
1	25.2 ± 7.5	18.8 ± 5.5	21.2 ± 8.5
2	11.5 ± 4.3	12.2 ± 5.8	10.4 ± 3.0
3	6.1 ± 4.7	7.6 ± 1.4	5.6 ± 5.6
4	2.2 ± 2.7	6.4 ± 4.1*	8.0 ± 5.0*
Gymnastics			
1	33.0 ± 3.4	29.0 ± 8.6	38.3 ± 6.4^{oo}
2	8.9 ± 2.1	9.0 ± 4.9	3.2 ± 3.3**^{oo}
3	2.4 ± 2.4	4.6 ± 4.4	1.7 ± 2.3
4	0.7 ± 0.8	2.4 ± 3.6	1.8 ± 2.4

Legend: HR (bpm) ranges in zones: 1: ≤140; 2: 141 – 160; 3: 161 – 180; 4: >180; Significantly different: from Type 1 value: * p<0.05, ** p<0.01; from Type 2 value: ^{o} p<0.05, ^{oo} p<0.01; For other explanations see Table 1

Table 4. Mean values (±SD) of heart rate in girls aged 13 years during different types of PE activities

Activity Subject	Type 1	Type 2	Type 3
Basketball	128.3 ± 8.2	152.8 ± 8.9**	132.7 ± 4.7
Volleyball	116.6 ± 7.4	135.4 ± 8.9**	130.0 ± 2.2**
Athletics	127.0 ± 7.6	155.5 ± 7.5**	137.8 ± 10.1*^{oo}
Gymnastics	121.5 ± 8.0	125.4 ± 11.8	112.7 ± 8.5^{oo}

For explanations see Table 1

Again, in all kinds of PE classes most time was spent on low-intensity activities (Zone 1); significant differences between various types of lessons were noted at given intensity zone in all sport activities (Table 5); only basketball, and athletics activities of Type 2 took more than 50% of the lesson time at higher intensities, i.e. at HR exceeding 140 bpm.

Table 5. Mean values (±SD) of exercising time spent by girls aged 13 years in 4 intensity zones

Zone	Type 1	Type 2	Type 3
Basketball			
1	32.2 ± 6.7	15.1 ± 6.3**	30.6 ± 3.1^{oo}
2	8.94.4	12.5 ± 5.4	8.3 ± 1.7
3	3.7 ± 3.7	10.2 ± 5.6**	3.3 ± 1.9^{oo}
4	0.2 ± 0.4	7.3 ± 7.0**	2.9 ± 2.3
Volleyball			
1	39.4 ± 3.8	25.7 ± 10.4**	29.8 ± 2.5*
2	5.3 ± 3.8	11.4 ± 7.7	6.7 ± 2.1
3	0.4 ± 0.7	5.6 ± 6.1*	5.2 ± 2.1*
4	0.0 ± 0.0	2.3 ± 3.5	3.3 ± 2.8
Athletics			
1	30.6 ± 9.4	16.9 ± 5.6**	24.2 ± 9.7
2	10.8 ± 7.5	13.3 ± 4.1	12.5 ± 7.5
3	3.1 ± 1.8	9.9 ± 4.0**	6.0 ± 3.5^{o}
4	0.5 ± 0.8	4.9 ± 4.2*	2.3 ± 2.7
Gymnastics			
1	37.4 ± 5.4	36.2 ± 4.1	39.6 ± 3.9
2	5.4 ± 2.5	4.9 ± 2.0	3.7 ± 3.2
3	1.6 ± 2.9	2.2 ± 2.4	1.3 ± 1.6
4	0.6 ± 1.0	2.1 ± 3.9	0.4 ± 0.9

Legend: HR (bpm) ranges in zones: 1: ≤140; 2: 141 – 160; 3: 161 – 180; 4: >180; Significantly different: from Type 1 value: * p<0.05, ** p<0.01; from Type 2 value: ^{o} p<0.05, ^{oo} p<0.01; For other explanations see Table 1

Discussion

The use of heart rate measurements to assess the intensity of workloads in physical activities was rightly questioned by some researchers [16] due to the variety of factors influencing cardiac function – a broad range of individual emotional and physiological responses to physical movements, somatic differences, structure of body mass components, etc. Yet, heart rate measurements are among the most efficient ways in a field research, enabling the monitoring of responses to physical work stimuli and of fatigue. In this study, maximal oxygen uptake, known to be associated with HR, was not considered in our research and the same applied to relating the HR intensity zones to energy sources.

The question of the adequacy of physiological workloads in various PE classes has to be dealt simultaneously with providing appropriate cognitive stimuli; both have to be carefully considered in rational planning and organisation of the teaching/learning process. In some PE lessons, e.g. invasion games, achieving the moderate-to-vigorous work intensity is more likely than e.g. in gymnastics [4,22]. Physical education classes with enhanced aerobic training were reported to bring about positive cardiorespiratory effects in prepubertal boys and girls [15]. On the other hand, only folk dance lessons were not associated with satisfying amounts of moderate intensity work in Greek children [14]. As shown in our study, the level of intensity was related not just to the form of activity (sports) but also to its phase in the teaching/learning process.

Acquisition of skills (Strand 1) requires time and developing them calls for changes in the context and variations of their use. On the other hand, showing expertise in *selecting* (Strand 2) the most suitable tactical solutions to the momentum of a game is certainly more challenging and requires a broad repertoire of skills in a variety of areas. It is also at this stage when the pupil is expected to prove some competence in *analysing, observing and applying* (also Strand 2) actions to the context being created on the spot. Thus, the skills the pupil has learnt so far need be developed to the degree to be used subconsciously yet efficiently in a real game situation. But the most difficult level of the teaching/learning process is probably shaping the ability of evalu*ating effectiveness* (Strand 3) of own actions. Critical reflection on one's actions (e.g. execution of a task or skill) requires good analysing and observational skills and acquaintance with the mastery performance patterns. This takes time and slows down the flow of the intensity. But all the phases of the learning process, when interwoven in the lesson, would influence the flow of the progression process as much as the application of other physical workloads. It is obvious that in course of one lesson the pupils learn skills from different learning levels. Combining it into a process of something more than just a mere motor skill performance is the gist of Pedagogical Content Knowledge (PCK) of given teacher.

The results of this study indicate that planning and providing lesson contents based on *acquiring and developing* levels of learning either exclusively or including only the *evaluating and controlling* of a situation (e.g. motor or skill tests) are insufficient for stimulating health-related fitness and, in a long run, may hamper receiving adequate physiological stimuli by pupil's body, thus resulting in a decrease of physical fitness, especially endurance. Monotonous rehearsing the same tasks has more in common with military drills than with shaping motor intelligence and health-related competences. Applying appropriate skills to given sporting situation requires selecting abilities as much as understanding the tactics of a game. This can be achieved only by changing context, making it challengeable and motivating for the pupil to learn cognitively even if the emphasis is on motor learning. Highest intensity profiles were typical of classes with Strands 1 and 2 predominating; this does

not, of course, suggest avoiding lessons (or individual activities) aimed at e.g. sensitising or reflecting actions.

It ought to be remembered that the objective of school PE is not only the performance of health-related activities and their intensity but, above all, the shaping of lifelong physical activity patterns. However, when designing lesson plans, the allocation of time to *acquiring*, *developing* and to *mastering* skills needs be carefully considered as this will influence the flow of classes and determine their intensity. It is thus important not only to acknowledge differences in the intensity profiles of specific sport-based classes [4,5] but also other educational aspects of the process. In order to keep reasonable proportions of high (moderate-to-vigorous), medium and low intensities of classes, the heart rates stimulating the cardio-respiratory fitness threshold, the teacher has to take into consideration also the phase of the teaching/ learning process. And it is up to the teacher's PCK to improve the flow of the lesson so as to make it comprehensible (e.g. by better organisation of the classroom, more equipment used, smaller group size, more frequent alternations of the tasks and, most importantly, by providing an interesting content – new games, attractive forms of activities, personalised objectives). This indicates a possible route for further research on the intensity profiles of physical education. In conclusion, more Strand 2 activities in PE classes would result in higher HR which is appropriate for stimulating the cardio-respiratory fitness of school youths. Thus, when planning the PE teaching/ learning process, various types and forms of physical activity need be taken into consideration in order to avoid long runs of inadequate physiological stimuli.

References

1. Armstrong N., J.R.Welsman (2006) The Physical activity patterns of European Youth with reference to methods of assessment. *Sports Med*. 36:1067-1086.

2. Baquet G., S.Berthoin, E.Van Praagh (2002) Are intensified physical education sessions able to elicit heart rate at a sufficient level to promote aerobic fitness in adolescents? *Res.Q. Exerc.Sport* 73:282-288.

3. Boreham C., J.Twisk, L.Murray, M.Savage, J.JStrain, G.Cran (2001) Fitness, fatness and coronary heart disease risk in adolescents: the Northern Ireland Young Hearts Project. Med.Sci,Sports Exerc. 33:270-274.

4. Bronikowski M. (2005a) How much physical activity a week to improve the health-related fitness of Polish schoolchildren? *Phys.Educ.Sport* 49:93-97.

5. Bronikowski M. (2005b) Wysiłki fizyczne stymulujące pracę układu krążeniowo-oddechowego w lekcjach wychowania olimpizmu u 13-letnich chłopców. *Antropomotoryka* 29: 31-41.

6. Bronikowski M., M.González-Gross, K.Kleiner, E.Knisel, I.Martinková, A.Stache, A.Kantanista, D.Cañada Lòpez, A.Konlechner (2008) Physical activity, obesity and health programs in selected European countries. *Studies in Physical Culture and Toursim* 15:9-18.

7. Capel S. (2005) Learning to Teach Physical Education In the Secondary School. A Companion to School Experience. Routledge Falmer, London and New York.

8. Fairclough S., G.Stratton (2005) "Physical education makes you fit and healthy". Physical education's contribution to young people's physical activity levels. *Health Educ.Res.* 20:14-23.

9. Gavarry O., T.Bernard, M.Giacomoni, M.Seymat, J.P. Euzet, G.Falgairette (1998) Continuous heart rate over 1 week in teenagers aged 11-16 years. *Eur.J.Appl.Physiol*. 77:155-132.

10. Goran M.I., K.D.Reynolds, C.H.Lindquist (1999) Role of physical activity in the prevention of obesity in children. *Int.J. Obes*. 23:18-33.

11. Goran M.I., M.S.Treuth (2001) Energy expenditure, physical activity, and obesity in children. *Ped.Clin.North America* 48,:931-53.

12. Grund A., H.Krause, M.Siewers, H.Rieckert, M.J.Muller. (2001). Is TV viewing an index of physical activity and fitness in overweight and normal weight children? Publ.Health Nutr. 4:1245-1251.

13. Hill J.O., H.R.Wyatt, W.G.Reed., J.C.Peters (2003) Obesity and the environment: where do we go from here? *Science* 299:853-855.

14. Kossiva I., D.Hatziharistos (2004) The effect of different physical education lessons in the activity levels of Greek high school children. In: V.Klissouras, S.Kellis, I.Mouratidis (eds.), Sport Science Through the Ages. Pre-Olympic Congress. Thessaloniki, pp. 433-444.

15. Mandigout S., A.Melin, A.M.Lecoq, D.Courteix, P.Obert (2002) Effect of two aerobic training regimens on the cardiorespiratory response of prepubertal boys and girls. *A.Pediatr*. 91:403-408.

16. Mleczko E., J.Żarek (1991) Wykorzystanie sport-testera i mikrokomputerów w pomiarach obciążeń treningowych. *Sport Wyczynowy* (9-10):25-37.

17. Osiński W. (2001) Aktywność fizyczna, sprawność i zdrowie – szczególne zadania wychowania fizycznego. Monografie nr 333, AWF Poznań, pp. 5-21.

18. Pańczyk W. (1999) Biologiczno-zdrowotne i wychowawcze efekty lekcji wychowania fizycznego w terenie i w sali. PTNKF Zamość.

19. Perkowski K. (1998) Efektywność form i rozwiązań aktywności fizycznej w wychowaniu fizycznym dzieci i młodzieży. *Trening* (2-3):89-111.

20. Raczek J. (1986) Problem skuteczności obciążeń na lekcji wychowania fizycznego. [In:] Lekcja Wychowania Fizycznego. WSP Kielce, pp. 151-161.

21. Raudsepp L, P.Pall (1998) Physical activity of children during physical education classes. *Biol.Sport* 15:265-270.

22. Stratton G. (1997) Children's heart rates during British physical education lessons. *J.Teaching Phys.Educ*. 16:357-368.

23. Swaim D., S.Edwards (2002) Middle School healthy hearts in the zone – a heart rate monitoring program for lifelong fitness. Human Kinetics, USA.

24. Trost S.G., L.M.Kerr, D.S.Ward, R.R.Pate (2001) Physical activity and determinants of physical activity in obese and non-obese children. Int.J.Obes. 25:822-829.

25. World Health Organization (2006) Physical activity: a basic requirement for health. WHO Regional Office for Europe, Copenhagen.

26. Woynarowska B., S.Kozłowski, K.Kamińska, M.Brzeziński (1982) Obciążenie wysiłkiem fizycznym na lekcjach wychowania fizycznego chłopców otyłych i bez nadwagi. *Wychowanie Fizyczne i Sport* 26:35-41.

27. Woynarowska B., J.Mazur (2000) Zachowania zdrowotne i zdrowie młodzieży szkolnej w Polsce i innych krajach. Tendencje zmian w latach 1990-1998. Uniwersytet Warszawski, Warszawa.

Received 29.08.2009
Accepted 24.11.2009

The study was supported by grants No. N404 31/2397 of the Polish Ministry of Science and Higher Education and European Union Grant No. 128737-CP-1-2006-1-DE-Comenius-C21: „Health(a)ware an experienced-based learning and teaching approach for physical and health education"