ASSESSMENT OF ENERGY EXPENDITURE OF SECONDARY SCHOOL STUDENTS DURING PHYSICAL EDUCATION CLASSES INCLUDING SELECTED ACTIVITY TYPES

OCENA WYDATKU ENERGETYCZNEGO LICEALISTÓW W CZASIE LEKCJI WYCHOWANIA FIZYCZNEGO NA PRZYKŁADZIE WYBRANYCH RODZAJÓW ZAJĘĆ

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SUMMARY • STRESZCZENIE

Aim of the study. The aim of the study was to monitor 45-minute physical education classes in order to assess energy expenditure as well as intensity of physical effort.

Material and methods. The research was carried out in April 2012 with a group of 32 students at one of the secondary schools in Biała Podlaska, Poland. Four types of classes were monitored: football, basketball, athletics, and gymnastics classes. Energy expenditure and physical effort intensity were measured with the GT3X+ accelerometer. Electronic medical scales and stadiometer were used to evaluate anthropometric parameters. Data was analyzed with the use of the ActiLife5 computer program and the Statistica 7.1 statistical program.

Results. Average energy expenditure measured during the monitored classes turned out to be very low: boys’ expenditure was calculated at 176 kcal and girls’ as 157 kcal. Nearly half of the time was spent with physical effort intensity which did not exceed 3METs. Classes involving team sports were the most beneficial in terms of physical effort intensity and energy expenditure.

Conclusions. The research results show that the effectiveness of physical education (PE) classes is very low as far as energy expenditure is concerned. Systematic monitoring of PE classes can help to plan intervention studies aimed at increasing the effectiveness of the classes.

Cel pracy. Celem prezentowanego badania był monitoring 45-minutowych lekcji WF, realizowany pod kątem wydatku energetycznego oraz struktury w zakresie intensywności wysiłku fizycznego.

Wyniki. Wydatek energetyczny uzyskany z pomiarów prowadzonych w czasie monitorowanych lekcji okazał się bardzo niski i wyniósł u chłopców 176 kcal, a u dziewcząt 157 kcal. Niemal połowa czasu lekcji realizowana była z intensywnością wysiłków, która nie przekraczała 3 MET. Najkorzystniejsze z punktu widzenia intensywności wysiłku oraz wydatek energetycznego były lekcje gier zespołowych.


Introduction

Physical activity is essential for appropriate development and early prevention of non-communicable diseases. Evaluating the impact of physical activity on the incidence of chronic diseases in adults has been one of the main tasks of epidemiology, especially in recent years [1]. The World Health Organization (WHO) experts recommend that young people should perform at least 60 minutes of physical activity at moderate to vigorous intensity every day [2]. Increasing the level of physical activity undertaken at such intensity is at present the core strategy of health promotion and early prevention of non-communicable diseases. It should be implemented in a person’s early years.

For more than 10 years, intensive scientific research has been conducted all over the world with the aim of finding the factors conditioning the epidemic growth of excess weight and obesity, especially among young people. These results convince us that one of the priorities in fighting this phenomenon should be to strive to implement recommendations for an appropriate level of physical activity [3].

In accordance with the current core curriculum [4], the weekly number of physical education classes (PE) in the secondary school is three (135 minutes). Physical activities carried out in this time could complete a minimum of weekly physical activity in about 30% of the time, provided that their implementation is appropriately effective. The aforementioned aspect has been discussed in Polish studies [5, 6, 7, 8, 9] as well as international studies [10, 11]. Their results show that the effectiveness of PE classes is unsatisfactory; however, it could be changed with an appropriate choice of the learning content.

We currently lack data (nationwide or regional) on the fulfillment of the WHO recommendations regarding the minimum level of physical activity undertaken by schoolchildren. Such data would allow us to assess to what extent physical education classes contribute to the minimum of the recommended weekly physical activity. The fragmentary study conducted among high school students in Białystok indicates that the proportion of physical effort performed by teenagers at school is the lowest in relation to the three remaining spheres of life (commuting, home, and free time) with regards to weekly energy expenditure [12, 13, 14].

These results, although derived from fragmentary studies conducted with population samples which do not meet the requirements of the representativeness of the general population, encourage reflection and urge further studies in this area to be undertaken. Such studies are not easy, as they require the use of proven tools that ensure obtaining highly accurate, reliable data on the intensity and duration of physical effort [15]. These parameters constitute a basis for calculating energy expenditure, which is the most important part of the detailed analysis of physical activity.

The accelerometer is currently one of the best tools to objectively measure the level of physical activity undertaken in various areas of everyday life. Positive results of stringent validation tests of physical effort intensity measurement with the use of these tools has led accelerometers to be considered the gold standard in the study of physical activity [16, 17, 18]. These tools are commonly used in studies that require a precise measurement of physical effort intensity and duration as well as energy expenditure without the need to use expensive and complicated laboratory methods [19, 20].

The aim of the study was to monitor 45-minute PE classes in order to assess students’ energy expenditure, and after analyzing the data, to answer the following questions:

1. What is the energy expenditure of pupils actively involved in the monitored classes?
2. What is the average intensity of the physical effort expended during the monitored classes?
3. What is the effectiveness of the lesson in terms of the physical effort intensity?
4. How much lesson time is used for the implementation of moderate to intense physical effort, which should prevail in physical activities conducted in this age group?
5. What is the structure of the lesson in terms of the physical effort intensity for boys and girls?
6. What kinds of lessons are the most effective in achieving the recommended effort intensity, ranging from moderate to intensive?

**Material and methods**

The research was conducted in April and May 2012 in one of the secondary schools in Biała Podlaska, Poland. The research material consisted of 32 randomly selected students (16 girls and 16 boys) in classes representing all levels of education (grades 1 to 3) and different profiles of education (humanities, natural sciences, mathematics, and physics). To evaluate the effectiveness of physical activities, four types of PE classes were selected: football classes (FB), basketball classes (BB), athletics classes (AT), and gymnastics classes (GM). Eight lessons (two of each type) were monitored with the purpose of evaluating energy expenditure of students selected for the study who were prepared to actively participate in the class. The main aim of all monitored classes was to perfect acquired technical elements.

In order to obtain data on the basic parameters of the body, which is necessary to calculate energy expenditure, each student was weighed with RADWAG WPT 200 electronic medical scales and measured with an SECA 213 stadiometer (Table 1).

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<td>height</td>
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Monitoring physical effort was performed with the use of a GT3X+ ActiGraf accelerometer. The accelerometers were attached to the right hip by means of rubber-coated tape, in such a way as to fit closely to the body. The students had their accelerometers attached a few minutes before the lesson, and removed after the lesson.

Data was analyzed using Actilife 5, a computer program used for reading and analyzing measurements recorded by accelerometers. Freedson's equations were used to calculate MET coefficient and energy expenditure [21]. The Statistica 7.1 software was used for statistical calculations.

Neither the teachers conducting the lessons nor the students in the lessons were informed about the objectives and purpose of the study.

**Results**

A detailed analysis of data obtained from the recording of the body movements showed that students' average energy expenditure was 166 kcal. In the group of boys, the index was higher by 19 kcal, mainly because of their greater body weight (Figure 1). The reverse results concerning physical effort intensity factor characteristic for boys and girls confirmed the calculations. For girls, the average value of MET was 4.0, while it was only 3.4 for boys (Figure 2). The latest models of accelerometers used in the study, working in three axes, made it possible to estimate the intensity of physical effort and its duration with very high accuracy. The results were used to devise the structure of the monitored lessons in terms of the total duration of physical effort, in different ranges of intensity, as well as in terms of their percentage distribution in a 45-minute lesson.

Analysis shows that students were engaged in sedentary activities (intensity not exceeding 2 METs) during every lesson for an average of 9 minutes (that is, 20% of the lesson length) [22]. In total, 27% of the lesson (12 minutes) was devoted to activities of very low intensity, lower than required for regular walking (less than 3.0 METs). The longest period, 40% of the lesson (18 minutes), involved moderate effort implemented in the intensity of \(<3.0–6.0>\) METs. It should be noted that the mean metabolic rate fluctuated for a long time around the lower range limit designated for moderate effort. Only 13% of the lesson (6 minutes) was filled with the physical effort of high intensity (over 6.0 METs), which is the most desirable for this age group (Figures 3 and 4). Thus, in assessing the percentage distribution of the time that was used effectively – from the perspective of implementing the WHO recommendations – it was concluded that nearly half of the time (46.7%) of the monitored classes was "wasted" on sedentary activities.

Another problem analyzed on the basis of the obtained data concerned the physical effort of various intensity as performed by the respondents of the different genders. The results in this regard are consistent with the overall regularity described earlier. During their classes, girls spent less time on sedentary activities,
and expended much more effort on activities of moderate and high intensity (Figure 5).

**Discussion**

One of the most important issues that has been addressed in this study was to evaluate which lesson type (of the four monitored) provides the most efficient use of time in terms of physical effort expended by young people that helps them implement the recommended physical activity levels. Results showed that the team sports classes are more effective than track and field or gymnastics classes. The latter proved to be the least favorable from the standpoint of energy
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expenditure. Such consistency was observed in both groups (Figure 6).

The results indicate that the effectiveness of physical education as regards energy expenditure of students attending the classes is small, in particular for boys. For most of the monitored classes, the physical effort in both groups was expended at moderate to low intensity levels (less than 5 METs), while intensive to moderate levels of physical effort should dominate this age group [2]. Taking the structure of the whole lesson into consideration, almost half of the lesson time was inefficient in terms of energy expenditure, as there were too many fragments of low effort intensity. Mainly, these included activities such as checking attendance, as well as the teacher’s instruction, description, and demonstration involved with a particular exercise. At these moments, intensity of physical activity fluctuated between 1 to 3 METs. Researchers studying this issue agree that the activity in which the intensity of effort does not exceed the value of 3 METs should be classified as sedentary (up to 1.5 METs) or light (1.5–3.0 METs) [2, 23].

It should be noted that the classes conducted with girls have a more favorable energy expenditure struc-

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**Figure 3.** The time structure of the monitored lessons with regards to intensity of physical effort

**Figure 4.** The percentage structure of the monitored lessons with regards to intensity of physical effort
ture, and the physical effort is more often of moderate and high intensity. Of the four types of classes, those including team sports had a better structure of energy expenditure, while gymnastics classes were the least favorable in this respect. This result may indicate that both in the selection of learning content for each lesson as well as during its implementation too little attention is paid to the intensity curve. It is especially important in gymnastics and athletics classes, which incorporate interval training. This aspect of PE lessons has been emphasized by Bronikowski [5, 6, 7] and Pańczyk [8], who pointed to the different physiological effects of var-

Figure 5. The structure of the physical effort intensity during the monitored lessons for boys and girls

Figure 6. The distribution of particular categories of physical effort intensity depending on type of classes
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Conclusions

Based on these results, we can conclude that:
1. Opportunities offered by physical education classes for implementing expert recommendations on the minimum of weekly physical activity are not fully utilized.
2. Choosing classes based on team sports can improve the organizational structure of the lesson and its effectiveness in energy expenditure.
3. Systematic monitoring of physical education classes in every school with the use of objective tools can provide a basis for planning intervention studies and taking action to improve their effectiveness.
4. The study confirms that there is a need for the detailed monitoring of physical education classes, especially among secondary school students who are on the threshold of adult life, when the threat of sedentary lifestyle increases rapidly.

LITERATURE • PIŚMIENNICTWO


