ENERGY EXPENDITURE IN PRESCHOOL CHILDREN DEPENDING ON VARIOUS TEACHING METHODS WHEN PRACTICING THE ABC GYMNASTICS PROGRAMME

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Abstract

The aim of the study was to determine whether obstacle course and circuit training are efficient teaching methods as forms of exercise in terms of their intensity, monitored by using energy expenditure measuring devices. The key differences in energy expenditure between the two teaching methods were examined. The BodyMedia SenseWear equipment for measuring energy expenditure was used to acquire data from two practice sessions. A sample of participants included 24 five-year-old children from one kindergarten in Ljubljana, although complete data from both afternoon practice sessions was obtained only from 12 children. The study has shown that obstacle course and circuit training are adequate teaching methods, as moderate to vigorous intensity was achieved with both methods when practicing the ABCs of gymnastics. The average energy expenditure has exceeded 7 MET in the main part of two practice sessions for both obstacle course and circuit training. The results showed no statistically significant differences in energy expenditure between genders or the specific teaching method used.

Keywords: *preschool children, ABC gymnastics, energy expenditure, exercise intensity, obstacle course*

INTRODUCTION

Regular physical activity is an important indicator of a person´s healthy lifestyle, as it has a positive impact on the physical and motor development of children and adolescents (Goldfield, Harvey, Grattan, & Adamo, 2012) and contributes significantly to the reduction of diseases and mortality in adulthood (Hadžić et al., 2014; Carson et al., 2017). At the same time, regular physical activity has a positive impact on other developmental areas in children – cognitive, emotional, and social (Aalizadeh, Mohamadzadeh, & Hosseini, 2014). These areas are interrelated, especially in the preschool years when changes in one area influence changes in others (Rostami & Ghaedi, 2016).

Any physical activity that is caused by skeletal muscles and results in energy expenditure above resting levels is defined as physical activity (Hollis et al., 2017). Physical activity of younger children differs in many ways from that of other age groups (e.g., youth or adults). Preschool children enjoy playtime and particularly activities requiring locomotion of the entire body and natural forms of movement

(Škof, 2016; Trevlas, Matsouka & Zachopoulou, 2003). Natural movement develops motor and functional abilities in children and represents the foundation for learning various sports skills (Lubans, Morgan, Cliff, Barnett, & Okely, 2010), among others also gymnastic abilities. Artistic gymnastics as an elite sport is not considered an activity with an emphatically playful character, yet its implementation in the classroom can be simple, natural, and fun. Indirect preparation for learning gymnastic skills can be implemented with the help of gymnastic exercises and content included in obstacle courses (Novak, Kovač, & Čuk, 2008).

Gymnastic contents offer a great range of locomotor and stability movements. Their implementation and content can have a positive impact on children´s development (cognitive, affective and social) (Baumgarten & Pagnano-Richardson, 2010).

In the ABC gymnastics programme children learn to use and perform natural movement forms (running, jumping, hopping, climbing, rolling, swinging, etc.) efficiently. They are performing movements through play while trying to complete a variety of motor tasks. This greatly influences children's movement to gradually become relaxed and efficient (Lovrić, Jelaska, & Bilić, 2015). The ABCs of gymnastics most commonly includes obstacle course and circuit training as teaching methods. In the former, children perform motor tasks through stepwise continuous movement over a prepared course while overcoming various obstacles (Culjak et al., 2014). In the latter, children are divided into several groups at different practice stations; these are logically positioned in the room so that children can perform the set motor tasks and then in groups change places in an orderly sequence after a set time. Both teaching methods help improve children's motor skills (Lovrić et al., 2015).

The implementation of the ABCs of gymnastics or other similar sport programs for preschool children has a positive influence on the children's physical and motor as well as emotional, social and cognitive development (Culjak, Delas Kalinski, Kezic & Miletic, 2011). Therefore, it is important to measure, monitor, assess and manage their biological growth and all developmental aspects (Culjak, Miletic, Delas Kalinski, Kezi, & Zuvela, 2014). Motor activity represents a complex process; therefore, its measurement is also complex. Several aspects of physical activity can be assessed: the type, content, duration, and intensity (Rowlands & Eston, 2007). The intensity of physical activity can broadly be defined as light, moderate or vigorous, based on the difference in energy expenditure during exercise and rest; this is defined as a metabolic equivalent of the task or MET (Hadžić et al., 2014), which is expressed as the resting energy expenditure multiplication rate.

Bates (2006) divides various methods of measuring energy expenditure during different physical activities into subjective and objective. In the former methods, study participants (or their parents) describe participation in recent physical activities using questionnaires, diaries, or reports. This method has some shortcomings related to the accuracy of individuals´ perceptions (Oliver, Schofield, & Kolt, 2007). Subjective methods are therefore mostly used with adults, while they are less reliable with children under 10 years of age (Bates, 2006) when parents report on their children´s physical activity (Colley et al., 2012). Objective methods, on the other hand, assess physical activity using various devices that measure the duration, intensity, and type of physical activity. These methods use objective indicators that are not subject to human influence; such data are much more reliable than data obtained through subjective assessment (Cliff, Reilly, & Okely, 2009).

Recent studies in the field of children´s physical activity is increasingly using devices to measure energy expenditure, which allows for more precise and empirical processing and presentation of results (Bedenk, Karpljuk, & Videmšek, 2019; Cliff et al., 2009). Nowadays, data collection is carried out by various equipment, such as Fitbit, Garmin Fitness Band, Nike+ FuelBand, BodyMedia SenseWear, ActiGraph, ActivPal, GeneActive and all sorts of other measuring apparatus (Hills, Mokhtar, & Byrne, 2014; Stålesen, Vik, Hansen, & Berntsen, 2016).

The World Health Organisation (2020) as well as the Slovenian guidelines for physical activity of children and youth (Bratina et al., 2011) recommend that the content of physical activity for children should be designed in such way that it has a positive impact on cardiovascular and muscular performance and bone health. Children and adolescents should engage in more than 60-minutes of moderate to vigorous (MVPA) intensity physical activity every day of the week (Fulton, Garg, Galuska, Rattay, & Caspersen, 2004; Strong et al., 2005). In children, running, jumping, leaping, climbing, etc., are considered as moderate to vigorous intensity activity (Cliff, & Janssen, 2019).

Gymnastic contents offer a great range of locomotor, stability, and body control movements. Consequently, their implementation and the content can positively impact on children´s development. In organising the exercise classes, various teaching methods. can be used. The purpose of this study was to determine whether obstacle courses and circuit training are efficient teaching methods of exercise for preschool children in relation to their intensity, which was monitored using energy expenditure measuring devices. In addition, the study examined differences in energy expenditure between males and females.

METHODS

This study included 24 five-year-old children from Oton Zupančič Ljubljana kindergarten. The children practiced the ABCs of gymnastics in two sessions; however, acceptable measurement data for both sessions were acquired only for 12 children – 5 boys and 7 girls. The children did not participate in gymnastics or any other organized physical activity programme.

Measurements were carried out during two practice sessions at the Faculty of Sport, University of Ljubljana. The children's parents were informed about the purpose and procedures of data collection and written consent for the children's participation in the study was obtained. Prior to the first measurement session, children's body height and weight were measured for better accuracy of data. The equipment used were digital scales Sanitas (model SBF 70, Sanitas, Madrid, Spain) and a wall-mounted height measuring tape. Average body weight of participants was 22.3 kg and average height 117.6 cm. No statistically significant differences were found between the genders ($p<0.05$).

Physical activity was measured with a multisensory equipment Bodymedia SenseWear Fit Core (SWA; BodyMedia Inc., Pittsburgh, USA). The functioning of the SWA measuring equipment is based on recognition of energy expenditure patterns and the estimation of physical activity. Several non-invasive biometric sensors are used for measuring various physical indicators (heat current, galvanic skin response, skin temperature, air temperature near participant's skin and physical activity measured by dual axis accelerometer). The measuring device uses algorithms to calculate data collected from several sensors, whilst at the same time considering gender, age, height and weight in order to calculate energy expenditure. The SWA measuring equipment has often been used in the past to estimate energy expenditure in children and youth (Sorić et

al., 2015) and has been shown to be a reliable measuring device both in adults (St-Onge, Mignault, Allison, & Rabasa-Lhoret, 2007; Berntsen et al., 2010) as well as in children (Arvidsson, Slinde, Larsson, & Hulthén, 2009; Calabró, Welk & Eisenmann, 2009; Dorminy, Choi, Akohouse, Chen & Buchowski, 2008). Children wore the measuring equipment on the triceps of the right arm and only data from children who wore it continuously throughout the entire session were included in our analysis.

The practice session was divided in three parts: the warm-up period with a running game, the main part, and the cool-down period with relaxation. The first session included obstacle course, whereas a week later, circuit training was used in the main part of the session. Both teaching methods used were very similar contents – natural forms of movement, such as fast walking, running, jumping (straight, pike, tuck, straddle, split, half turn), crawling, climbing, gymnastic elements, such as: rolling (forward, backward, log rolls, on left and right), cartwheel, walking on balance beam (on toes and hills), swinging on gymnastic rings (frontwards and backwards), support on horizontal bars, arm hang, walking on all fours (forward, backward, to side), arms support (donkey kicks), etc.

Both practice sessions were 45 minutes long and the measurements were carried out during the entire sessions (45 minutes). In order to examine the differences between the teaching methods, the main part of each session (obstacle course or circuit training) was analysed separately.

Data on physical activity was analysed with the use of the Bodymedia SenseWear Professional 8.1. programme package (Bodymedia SenseWear Pro Armband; BodyMedia Inc., Pittsburgh, USA). Energy expenditure was expressed in kilojoules (kJ), whilst MVPA was defined as a physical activity that exceeded metabolic rate of 3 MET. Collected data were analysed with the use of the IBM SPSS 25.0 statistical package (IBM Inc. Armonk, USA). Simple descriptive statistics and the normality of data distribution were calculated. In order to compare the differences in energy expenditure between the two practice sessions and specifically between the two teaching methods, the t-test for dependent samples was used. On the other hand, the t-test for independent samples was also used to compare the differences between energy expenditure in girls and boys. Statistically significant differences between the variables were accepted at 5% risk level ($p \leq 0.05$).

RESULTS

The results of the study are presented below.

Table 1 shows the difference in energy expenditure (kJ), number of steps and MET between the two chosen teaching methods (obstacle course, circuit training). Our results did not reveal statistically significant differences in any of the observed variables. Insignificant tendency of differences was shown in the number of steps ($t = 2.060$, $p = 0.064$), as it was revealed that children performed 184 steps more in obstacle course than in circuit training. Nevertheless, the observed differences were not sufficiently expressed to reach statistical significance.

Table 2 presents the differences between the boys and the girls in energy expenditure, number of steps and metabolic equivalent (MET) for obstacle course and circuit training respectively. The results did not reveal statistically significant differences between boys and girls in any of the observed variables. In circuit training, insignificant difference in the value of metabolic equivalent was revealed between the genders ($t = 2.027$, $p = 0.070$) as boys had on average 1.27 units higher energy expenditure than girls.

Table 1
Comparison of energy expenditure, number of steps and MET between obstacle course and circuit training.

Variable	*μ*	N	*SD*	*t*	*p*
Energy expenditure (kJ) – obstacle course	274.92	12	33.64	–1.263	0.233
Energy expenditure (kJ) – circuit training	300.67	12	75.11		
Number of steps – obstacle course	1161.75	12	361.58	2.060	0.064
Number of steps – circuit training	977.17	12	399.47		
MET – obstacle course	7.12	12	0.95	–0.984	0.346
MET – circuit training	7.64	12	1.21		

Key: μ – average; *SD* – standard deviation; *t* – test statistics; *p* – statistical significance

Table 2
Comparison between boys and girls in energy expenditure according to energy expenditure, number of steps and MET depending on the chosen teaching methods.

Variable	Gender	N	*μ*	*SD*	*t*	*p*
Energy expenditure (kJ) - obstacle course	Boys	7	280,43	36.05	0.654	0.528
	Girls	5	267.20	32.17		
Energy expenditure (kJ) - circuit training	Boys	7	330.00	68.02	1.743	0.112
	Girls	5	259.60	70.42		
Number of steps - obstacle course	Boys	7	1182.57	383.10	0.226	0.826
	Girls	5	1132.60	370.88		
Number of steps - circuit training	Boys	7	965.29	423.58	–0.116	0.910
	Girls	5	993.80	411.25		
MET - obstacle course	Boys	7	7.03	0.89	–0.365	0.723
	Girls	5	7.24	1.13		
MET - circuit training	Boys	7	8.17	0.96	2.027	0.070
	Girls	5	6.90	1.22		

Key: μ – average; *SD* – standard deviation; *t* – test statistics; *p* – statistical significance

Table 3
Comparison of energy expenditure, number of steps and MET for the entire duration of training sessions.

Variable	*μ*	N	*SD*	*t*	*p*
Energy expenditure (kJ) during the entire session (obstacle course)	486.50	12	65.51	–2.161	0.054
Energy expenditure (kJ) during the entire session (circuit training)	553.33	12	123.81		
Number of steps during the entire session (obstacle course)	1652.58	12	441.16	–1.414	0.185
Number of steps during the entire session (circuit training)	1819.42	12	619.89		
MET during the entire session (obstacle course)	7.27	12	0.84	0.212	0.836
MET during the entire session (circuit training)	7.18	12	1.10		

Key: μ – average; *SD* – standard deviation; *t* – test statistics; *p* – statistical significance

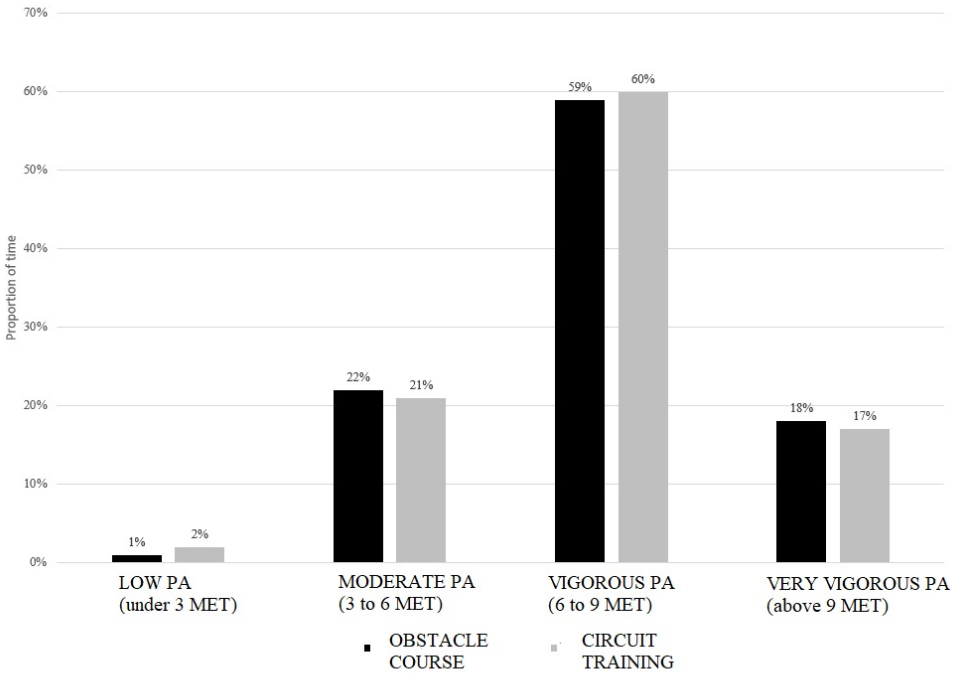

Figure 1. Comparison of intensity between practice sessions.

The study also compared energy expenditure during the entire practice sessions, where the ABC gymnastics programme was implemented using either obstacle course or circuit training teaching method. In both sessions, the warm-up part of the session consisted of two running games and gymnastic exercises, whereas a relaxation game was used in the cool-down part of the session.

The results have shown no statistically significant differences in any of the observed variables. Nevertheless, a strong tendency for the appearance of significant differences was noticed in variable energy expenditure for the entire duration of training sessions (t = -2.161,; p = 0.054). This variable was larger by 66.83 kJ when the main part of the session included circuit training. Similarly, the variable

number of steps when the main part was circuit training was higher by 167 steps for the entire session then when the main part included obstacle course.

A comparison between boys and girls was carried out for variables energy expenditure, number of steps and the value of metabolic equivalent. The results did not reveal any statistically significant differences between the genders in any of the observed variables.

Furthermore, the aim of the study was also to find out the degree of intensity when practicing the ABC gymnastics programme, when the main part of the session included obstacle course or circuit training teaching method respectively.

The results have revealed very similar intensity of practice sessions, regardless of the type of teaching method used. For the most part of both practice sessions children performed physical activities of vigorous intensity, as their level of metabolic equivalent was between 6 to 9 MET (Figure 1).

DISCUSSION

As kindergarten curriculum does not specify the amount of physical activities and due to research findings showing that only a few kindergartens have daily organised physical activity (Videmšek et al., 2014), afternoon hours with organised practice sessions are very important. One of such practices was examined in the present study, namely the ABC gymnastics programme, which incorporates natural forms of movement (walking, running, jumping, crawling, climbing, rolling etc.) to a great extent and presents a joy and challenge to children. It represents an important developmental encouragement, as it influences all areas of child's development (Culjak et al., 2014). Additionally, it strengthens and safeguards health, it forms habits and behavioural patterns, which are crucial for ensuring healthy lifestyle in all age periods.

The sample of measured subjects in the present study included 5-year-old children, whose bodies and particularly central nervous system are in the period of early childhood that is extremely susceptible to environmental effects (Sheridan, Konopasky, Kirkwood & Defeyter, 2016). As development in this period is dynamic and holistic, physical activity plays a key role in this process. The study has shown that preschool children when practicing the ABC gymnastics programme reach and even exceed the recommendations for physical activity of children and youth (Cliff & Janssen, 2019; Hadžić et al., 2014; Strong et al., 2005), both when obstacle course or circuit training teaching methods are used. Out of two 45minutesessions, 27 minutes of activity were practiced in a state of vigorous intensity, 10 minutes in moderate and 8 minutes in very vigorous intensity.

When comparing energy expenditure for the entire duration of practice sessions, it has been revealed that the choice of the teaching method (obstacle course or circuit training) did not produce any differences in energy expenditure or intensity of exercising. In both cases the value of metabolic equivalent (MET) was above 7, meaning that on average the activity was performed in a state of vigorous intensity. It has also been found that in both practice sessions of ABC gymnastics programme no significant differences were noticed between boys and girls.

One of the important goals of the study was to find out whether obstacle course and circuit training are efficient teaching methods to teach the ABCs of gymnastics to preschool children and provide enough intense activity. Thus, the expenditure of energy in children in the main part of each session was compared and similar results were revealed for both teaching methods. The main parts of each session also revealed a metabolic equivalent above 7 (vigorous intensity activity). In addition, it has been found that there were no significant differences in any

of the observed variables. A tendency for the appearance of significant differences was noticed only in the variable number of steps, as it was revealed that children performed on average 184 steps more when obstacle course was used. Similarly, the only noticeable difference between the genders was revealed in the MET value, where boys showed a slight tendency toward significant differences in the activity intensity.

The expenditure of energy in children and youth at rest is higher than in adults; it is usually also higher in boys than in girls (Bitar, Fellmann, Vernet, Coudert, & Vermorel, 1999). Presumably there are several reasons for this; on one hand, they are undoubtedly related to the high energy consuming growth and maturation processes. On the other hand, children have a different proportion of inner organs, shorter legs and lower muscle mass, all of which is manifested in larger differences between energy expenditure at rest and when being active compared to adults. During adolescence, the expenditure of energy at rest starts to decrease and becomes similar to that of adults (Roemich et al., 2000).

According to several authors (Pate, O´Neill, & Mitchell, 2006; Ridley, Ainsworth, & Olds, 2008), the bottom level of moderate intensity activity is set too low; as such, it had to be increased so that in children the value of metabolic equivalent for light intensity activity should be set at 4 MET or less, for moderate intensity between 4 and 7 MET, for vigorous intensity between 7 and 9 MET and for very vigorous intensity activity above 9 MET (Van Loo et al., 2018; Cliff and Janssen, 2019). Even when considering this recommendation, the ABC gymnastic practice sessions, examined in the present study, fulfilled the recommendations set for sports sessions, where children should engage at least 50% of their sports time in activities of moderate to vigorous intensity (US Department of Health and Human Services, 2008). The study by Puyau et al. (2016) revealed the highest value of measured metabolic equivalent in 3- to 5-year-old children at 6.8 MET and the highest heart rate at 250 bpm (beats per minute). Younger children reach higher frequency of heart rate than adults and at the same time they also reach it in shorter time; thus, the borderline value of heart rate frequency in sedentary and moderate intensity activity is around 110 bpm, between light and moderate intensity around 140 bpm and between moderate and vigorous intensity around 160 beats per minute (Butte et al., 2014).

Similar study, although carried out on a sample of 6- to 10-year-old school children, was carried out by Plut (2017), who evaluated the amount and intensity of motor activity of children during two physical education sessions of the same content but using two different teaching methods (obstacle course and circuit training). The study also found that participating children met the minimal recommendations, namely, more than 50% of practice session was carried out at an activity level of moderate to vigorous intensity. Children have manifested higher intensity and larger amount of work in practice session with circuit training, whilst there were no key differences in energy expenditure between genders.

Numerous research studies show that children do not meet the recommendations during their physical education lessons (Fairclough & Stratton, 2006; Hollis et al., 2016) and that they are for the better part of these lessons physically inactive (Volmut, 2014). The reasons for children's inactivity could be various: the choice of teaching methods; provision of PE lessons by regular classroom teacher rather than specialist physical education teacher, teacher’s inexperience, etc. (Volmut, 2014; Fairclough & Stratton, 2006; McKenzie et al., 1996).

The present study has found that boys and girls do not differ in energy expenditure during practice. Similar

findings have been shown also by Puketa (2015) on a sample of 1- to 5-year-old children; by Žerjal (2016) and Vorwerg, Petroff, Kiess, and Blüher (2013) on a sample of 3- to 6-year-old children; Plut (2017) on a sample of 6- to 10-year-old children, and Baron (2016) on a sample of 11-year-old children. In contrast, the results of some other Slovenian and foreign researchers revealed that boys were more active than girls in all age periods (Brasholt et al., 2013; Klasson Heggebø & Anderssen, 2003). The reasons for the differences between the genders in the amount and intensity of sports activity can be found in the interconnected combination of biological, physiological, social and environmental factors (Timmons, Naylor, & Pfeiffer, 2007).

The organisation of a practice session is very important to provide adequate motor efficiency when exercising. In planning and implementation of practice sessions, various teaching methods can be used (Culjak et al., 2014); selecting the most appropriate one leads to a safe, intensive and interesting implementation of sports exercise. When considering the energy expenditure aspect, tt has been found that both obstacle course and circuit training are very efficient methods in realisation of the ABC gymnastics programme for preschool children.

The study has proven that children in the ABCs of gymnastics use a lot of energy, regardless of whether obstacle course or circuit training are used as a teaching method. Due to the complexity of the motor tasks involved, children also develop motor abilities important for gymnastics, mainly motor coordination, flexibility and strength. In the Slovenian guidelines for physical activity of children and youth, it has been emphasised that children should participate 2- to 3-times per week in strength sessions, as these additionally and importantly improve the efficiency of aerobic exercising (Hadžić et al., 2014).

Success or efficiency of exercising rests undoubtedly with teachers, who should adequately plan and implement practice sessions that are adapted to the children's developmental level. As professionally carried out sports activities of preschool children that include basic elements of different sports disciplines are becoming progressively more popular, the requirement for their quality is also increasing. As such, it is recommended that the ABCs of gymnastics are adapted to the interests, developmental levels and needs of children, as only in this way the optimal development and positive influence on health of children will be facilitated.

When carrying out the measurement part of the present study, some difficulties arose that were previously noticed by Bedenk et al. (2019) who also measured the expenditure of energy in preschool children. Particularly disrupting was the fact that the measuring equipment is not adapted to the developmental level of preschool children. Occasionally, the measuring device slipped off the upper arm, resulting in incorrect data collection, which consequently led to the exclusion of such participants from the study. Furthermore, some children at first refused to wear the measuring devices as they did not understand their purpose. Other children were occasionally distracted by the device itself and transferred their attention from practice to the sound or flashing light emitted by the operating device. Some children were not present at both practice sessions. Consequently, the study initially included 24 children, yet only data from 12 children was correctly recorded in both sessions. Due to the abovementioned specific research difficulties, only a small sample of 7 boys and 5 girls was finally included in the data analysis. As a result, the authors recommend that a study on a larger, more representative sample is conducted in the future. However, there are also some other well-known limitations regarding the

measuring procedure: 1) children were aware that they were being measured and monitored, which might have resulted in changes in their habitual PA patterns; 2) biomechanical and physical factors could affect the results as higher mass gives lower acceleration and increased height of children produces longer pendulum; 3) the validity of the measuring device has not been verified on preschool children; 4) the sample size was too small and consequently is not representative; 5) the arm worn device is more sensitive to the arm movement, therefore the results could be overrated (Quante et al., 2015).

CONCLUSION

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The present study demonstrated and confirmed that both obstacle course and circuit training are appropriate teaching exercise methods to achieve suitable intensity in the ABC gymnastics programme. In both practice sessions, children were active for more than half of the time at a level of moderate to vigorous intensity - that met and exceeded the minimum recommendations for exercise. Nevertheless, such exercise represents only a portion of the physical activity in children who should be physically active at least 60 minutes every day on a level of moderate to vigorous intensity.

Due to the listed positive effects of physical activity in children, it is a desire of the authors that all children would meet the recommended daily activity in the future. The authors believe that questionnaires used for the acquisition of qualitative data about the type and form of physical activity in children should be simultaneously supplemented with objective measures of children´s physical activity. Consequently, further research should be conducted with the use of devices specifically adapted to the developmental level of children to measure their energy expenditure. As the present study only included complete results for 12 children, they cannot be generalised, although they do open up various professional and research questions for the future.

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