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Developing endurance among children in preschool period

Razvoj vzdržljivosti predšolskih otrok

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Abstract

Introduction: Prior research generally confirms the importance of endurance exercises in pre-school period and suggests shorter and less intensive exercises. However, little research has been conducted to show and evaluate different types for developing endurance in preschool period. Our research aims to find out which type of exercise is more suitable for developing endurance for a preschool age child compared to an adult, taking into account developmental characteristics.

Material and methods: A total of 69 preschool children (40 children aged 3 years and 29 children aged 5 years) were included in the study. We measured their heart rates during two types of endurance exercises (uninterrupted walking vs "method of game"). We compared the average heart rate and the actual frequency curves.

Results: Endurance exercise according to the "method of game" allows the child to adjust the effort more individually compared to uninterrupted walking when both exercises are performed with a group of pre-school children. A comparison of heart rate curves showed that when children partook in the " method of game", they achieved different heart rate values at the same time. A further analysis of heart rate with 5 selected "time stamps" between the two exercises showed that children achieved statistically significant higher heart rates when performing the "method of game" (1': $Z = 2.20$; $p = 0.028$, $r = 0.19$; 3 ': $Z = 4.64$; $p = 0.00$, $r = 0.39$; 5': $Z = 3.23$; $p = 0.001$, $r = 0.27$; 8': $Z = 3.82$ $p = 0.00$, $r = 0.32$; 13 ': $Z = 3.33$; $p = 0.001$, $r = 0.28$). The comparison of the mean heart rate values over the entire 13-minute time interval between the execution of the "method of game" ($M = 143$, $SD = 14$) and uninterrupted walking ($M = 132$, $SD = 9$) was statistically significantly higher in favour of the "method of game" (Wilcox test: $Z = 5.83$, $p = 0.00$, $r = 0.24$). The Mann-Whitney-Test showed that 3-year-old children achieved statistically significantly higher average heart rate during the "method of game" ($Z = -2.34$ $p = 0.020$, $\eta^2 = 0.08$) as well as during uninterrupted walking ($Z = 3.17$ $p = 0.002$, $\eta^2 = 0.15$). No statistically significant differences between boys and girls were confirmed.

Conclusions: Based on the results obtained, we believe that endurance exercise according to the "method of game" is more suitable for a developing preschool child than uninterrupted walking. The "method of game" also allows the simultaneous implementation of endurance exercise in heterogeneous groups, since the children adapt to the effort themselves, regardless of age. We believe that other types of endurance exercises should be researched and all age groups of pre-school children should be included in the research.

Izvleček

Uvod: Pomen vzdržljivostne vadbe v predšolskem obdobju so potrdile že mnoge dosedanje raziskave. Predlagale so predvsem krajšo in manj intenzivno vadbo, manj pa je bilo raziskanega o ustreznosti različnih vrst vadbe za razvoj vzdržljivosti v tem obdobju. Raziskava želi ugotoviti,

katera vrsta vadbe za razvoj vzdržljivosti je najprimernejša za predšolskega otroka, upoštevajoč razvojne značilnosti, v primerjavi z odraslo osebo.

Material in metode: V raziskavo smo vključili skupaj 69 predšolskih otrok (40 otrok, starih 3 leta, in 29 otrok, starih 5 let). Med izvajanjem dveh vrst vzdržljivostne vadbe (enakomerne neprekinjene hoje in vadbe po »metodi igre«) smo merili njihov srčni utrip. Primerjali smo srednje vrednosti srčnega utripa in krivulje dejanskih frekvenc.

Rezultati: Vadba vzdržljivosti po »metodi igre« otroku omogoča več individualnega prilagajanja naporu v primerjavi z vadbo neprekinjene hoje, kadar obe vadbi izvajamo s skupino predšolskih otrok. Primerjava krivulj srčnega utripa je pokazala, da pri vadbi po »metodi igre« otroci dosegajo različne vrednosti srčnega utripa ob istem času. Nadaljnja analiza srčnih utripov ob 5 izbranih »časovnih štampiljkah« med obema vadbama je pokazala, da otroci med izvajanjem »metode igre« dosegajo statistično značilno višje frekvence srca (1`: Z = 2,20; p = 0,028, r = 0,19; 3`: Z = 4,64; p = 0,00, r = 0,39; 5`: Z = 3,23; p = 0,001, r = 0,27; 8`: Z = 3,82; p = 0,00, r = 0,32; 13`: Z = 3,33; p = 0,001, r = 0,28). Povprečne vrednosti srčnega utripa v celotnem 13-minutnem časovnem intervalu med izvajanjem »metode igre« (M = 143, SD = 14) in neprekinjene hoje (M = 132, SD = 9) je bila statistično značilno večja v prid »metodi igre« (Wilcox test: Z = 5,83, p = 0,00, r = 0,24). Mann Whitneyev test je pokazal, da so 3-letni otroci tako med "metodo igre" (Z= -2,34 p = 0,020, η^2 = 0,08) kot med neprekinjeno hojo (Z= 3,17 p = 0,002, η^2 = 0,15) dosegli statistično značilne višje povprečne vrednosti srčnega utripa. Med spoloma statistično značilnih razlik nismo potrdili.

Zaključki: Glede na prej dobljene rezultate menimo, da je vadba vzdržljivosti po »metodi igre« bolj primerna za razvijajočega se predšolskega otroka kot neprekinjena hoja. »Metoda igre« omogoča tudi hkratno izvajanje vzdržljivostne vadbe v heterogenih oddelkih, saj si obremenitev otroci prilagodijo sami, ne glede na starost. Menimo, da bi bilo treba raziskati tudi druge vrste vadbe za razvoj vzdržljivosti, v raziskavo pa vključiti tudi ostale starostne skupine predšolskih otrok.

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1 Introduction

Endurance is a functional ability of the organism to perform a movement activity with moderate intensity over a longer period of time (1,2). The efficiency of such exercise is limited by the respiratory, cardiovascular, thermoregulatory, and other systems (3) and is closely related to a variety of healthy lifestyle factors (4). According to Degens (5) and his conclusions on the endurance training of children for healthy ageing, aerobic exercise is still an efficient means of slowing down the loss of muscle mass and maintaining its function, thus improving the quality of life. Therefore, dynamic aerobic endurance is the one that should be promoted in the preschool period (2,6). However, the way in which such training is carried out differs between adults and children. It is a long-term, moderately intensive cyclical exercise (e.g. running, walking, cycling, etc.) that adults perform continuously, while children perform it more intensively and with more frequent breaks (2,6). This is due to a more specific function of the

cardiovascular, respiratory, neuromuscular, and thermoregulatory systems of children.

Antipuesto (7) and Kliegman, Stanton, St. Geme, and Schor (8) analysed the differences between the cardiovascular and respiratory systems of children and adults. In their opinion, the tongue is one of the limiting factors in the respiratory system of a preschool child. Airflow is lower in children than in adults because of the different proportions between the airways and the tongue (7). For this reason, breathing through the nose rather than through the mouth is more important for children (8).

Samuels and Wieteska (9) give guide values for differences in minute ventilation. It is known that minute ventilation is the product of the breathing rate in one minute and a breathing volume. Samuels and Wieteska (9) give mean values for the respiratory rate of children and adults. The respiratory rate per minute of a 3-year-old child is 25 to 30 breaths per minute, while in 5-year-old children it is slowed to a range between 20 and 30 breaths per minute, the respiratory rate of adults at rest is about 12 to 16 breaths per minute, which means that adults have more opportunities to increase the respiratory rate per minute compared to children (9). They argue that greater minute ventilation at rest in children is also due to greater metabolic consumption. However, they believe that children still have an apparently elastic chest. Therefore, increased breathing effort results in an obvious thoracic retraction, which reduces respiratory efficiency. All these facts point to the importance of more frequent breaks for children compared to adults.

Dotan, Mitchell, Cohen, Klentrou, Gabriel, and Falk (10) analysed different studies on the types of muscle fibres. They concluded that children have more type 1 muscle fibres. This makes them tired more quickly. However, their muscle fibres also regenerate faster, which is an additional reason for more frequent breaks.

Krost, Mistovich and Limmer (11) explained differences in heart function in adults and children. The heart of an adult responds to increased stress by increasing both heart rate and stroke volume, while the heart of a child can only respond to increased stress by increasing the number of heartbeats. This is the reason why a child has less ability to adapt compared to an adult. Fleming, Thompson, Stevens, Heneghan, Plueddemann, Maconochie, Tarassenko and Mant (12) and Agrawal (13) analysed the differences in heart rate between adults and children at rest and at the strain of 80%. They concluded that the heart rate of children who were 3 or 4 years old was 3 to 4 beats higher than that of children who were 5 or 6 years old.

Different stress tests in laboratories are used to measure how an adult's heart responds to a strain. There are not many stress tests for healthy children. Even paediatricians conclude that it is necessary to replace the stress testing with the measurement of heart rate in preschool children (8). The strain level is measured outdoors, usually with heart rate monitors (14), especially because they are more cost-efficient, while stress tests in a laboratory are also followed by measuring the oxygen saturation of blood, ECG, blood pressure, breathing (maximum oxygen uptake), etc. Regardless of the age, exercise intensity is usually defined by the percentage of maximum oxygen uptake (% VO_2max), maximum heart rate (% FSmax), and reserve heart rate (% HRres), but also as metabolic

equivalent (1 MET) (14). The same authors (14) suggested that the measurement of HRmax should be performed as an alternative to establish the submaximal intensity, as there is a linear relation between VO_2max and HRmax. However, there are not many comparisons between maximum oxygen uptake and heart rate in the preschool period (15).

To ensure an adequate level of effort, we must first know at least the individual HRmax, VO_2max, and two ventilation thresholds (16). The ventilation thresholds are most accurately determined by laboratory stress tests. The majority of the parameters can be obtained only in laboratories, and are not common in general practice (too expensive and too complicated) (17). Indirectly, however, some of the parameters can be calculated from a series of more or less reliable tests performed in the field, such as "UKK WALK TEST", "CONCONI TEST", "20mSRT-PREFIT", etc., with simultaneous measurement of HR (18,19). By drawing a curve from the data obtained (x-axis time, y-axis HR) the two ventilation thresholds can be figured out and the intensity of exercises can be divided into 3 zones (16). The endurance exercise is then performed with a combination of different "methods" (uninterrupted method, interval method, and Fartlek) at different levels of intensity oz. zones (20).

Uninterrupted exercise for adults is usually performed individually. Exercises are most often performed under the first ventilation threshold (app. 75-80% of HRmax). However, it can be performed at different intensities. The exercise is mainly characterized by cyclical, repetitive movements, which usually last at least one hour (20). During the performance of such exercise, an attempt to maintain approximately the same effort is made.

We must ensure that the development of endurance in the preschool period is within the 80% HRmax range (21). In general practice, however, it is not possible to ensure individual uninterrupted movement, which is why the educators adjust the pace to the weakest during hikes, walks, mountaineering, and short runs (6). However, such an effort is not sufficiently intensive for the development of other children's endurance (17).

A "method of game" can be suitable for individual exercise with a group of children during developing endurance. This exercise is described under the concept "Game - movement - development" (male). The comparison of heart rate curves conducted on a small sample (6) indicates that the heart of a 3- or 6-year old child responds in a similar way as the heart of an adult responds to a Fartlek (6). Fartlek represents a combination of low- and high-intensity exercise, as it can include both brisk walking and sprinting in one exercise and is an effective means of developing basic endurance (22). Because of all the content, length, and intensity combinations, it is often used as a universal tool for the development of endurance (20). It is essential that the range and length are not precisely determined and the intensity is determined spontaneously (22). The "method of game" differs from the Fartlek mainly in performance. The "method of game" is usually performed with a whole group of children while individual exercise is typical during Fartlek.

The "method of game" is a way of learning in the preschool period, and it is based on the concept of Game-Movement-Development. According to this "method", a child develops the motor skill that the educator wants to develop in a child, which also implies obeying

the rules of the game. The child reacts in an unobtrusive way to the rules and environment, and the educator at the same time can take into account the individuality of each child. In the "method of game", the educator must be included in the game as a person in the game or must take over the role of a so-called environment. This enables him or her to change the level of difficulty or to adapt it to children at any time. In addition, the beforehand prepared environment facilitates children to search for creative motoric solutions by themselves within the game, to set pauses, their duration, frequency, and intensity. By correctly devised game rules, the educator boosts motivation, which makes children repeat the running to succeed in the game. For example, the child's goal is to succeed in the game (to rescue the princess from the dragon's castle), and the educator's goal is that the child scuds or walks the distance as many times as possible, climb the hill or stairs to higher floors (23).

The main difference between uninterrupted walking and exercise according to the "method of game" lies in the individual determination of the effort. With uninterrupted walking, the pace is usually determined by the educator, whereby the weakest limb is usually taken into account. With the "method of game" the pace of walking as well as the length is determined by the children themselves, similar to Fartlek.

Due to anatomical and pathophysiological differences between adults and children, as well as due to differences in physical fitness between children in the same group and the need to develop endurance within the entire group of children at the same time, it seems that uninterrupted walking may be less suitable for developing endurance in preschool. Considering that children themselves determine the intensity during exercise according to the "method of game", we want to investigate whether they achieve higher or lower effort than with uninterrupted walking, where the intensity is usually determined by the educator.

2 Material and methods

2.1 Participants

The study included 69 preschool children (40 3-year-old and 29 5-year-old children; 44.9% of girls and 55.1% of boys) from four different kindergartens in the central Slovenian region. All four kindergartens had approximately the same outdoor conditions (a small grassy hill with a lawn of at least 20 by 20 metres around it) to implement the "method of game" and 1 km of the straight sidewalk (mostly macadam) to perform uninterrupted walking. Both exercises were carried out as part of the regular programme without any significant changes to their activities.

The Commission for Ethical Issues in the field of sport at the Faculty of Sport, University of Ljubljana, approves the conduct of research (No. 1466, dated 26 September 2019).

2.2 Instruments

During the research, children wore heart rate sensors (H7, Polar), connected to fitness monitor tracker (Polar loop, Polar Electro Oy, Kempele, Finland). The heart rate (HR) was measured in 5-s periods. After finishing the individual exercise, we downloaded the data from the heart rate monitors to the computer using the Polar FlowSync programme and classified the data according to research codes.

2.3 Procedures

Children's parents or caregivers were informed about the goals of the research. They completed a short survey questionnaire about the child's health status and signed consent for testing. To ensure anonymity, a research code was assigned to each child. The code was linked to the heart rate monitor. The research was conducted in compliance with personal data protection.

The variable sample includes the heart rates of all children measured during two different types of endurance exercises: **(1) the uninterrupted walking**, which consisted of a 1 km of walking in 13 minutes, and **(2) the "method of game"** – regarding this method, only 13 minutes of the main part of the hour were included in the research. With the first exercise (the uninterrupted walking), the strain was determined by time and distance whilst with the second exercise (the "method of game"), it was defined by time and the rules of game.

All children were monitored during both exercise models. They partook scheduled exercise sessions on two different Wednesdays of May 2016 at 10 AM; the first week they partook in uninterrupted walking; the following week they partook in "method of game". The activities with younger and older children were performed separately. Both exercises were performed by qualified students of Preschool education (UL, PeF), in the presence of the preschool educator in the kindergarten and under the supervision of the researcher.

To avoid any risk, all children had to wear sports shoes and sports clothes. The children knew both exercises, as they were often performed in all kindergartens. To avoid injuries when implementing the "method of game", we have chosen the grassy lawn in front of the kindergartens and macadam sidewalk when implementing uninterrupted walking.

(1) The uninterrupted walking

The uninterrupted walking applied through a moderately intensive walk on a distance of 1 km for 13 minutes. It was indeed a modified walking test on 2 km "UKK WALK TEST" (18). We wanted to create artificial conditions by shortening the distance and increasing the time. Such conditions should be appropriate for preschoolers proportionally to the differences between metameres of children and adults. The test was modified and it was conducted through walks and excursions. The student made sure that the children walked in a group at an average speed of 4.6 km/h and all did 1 km in 13 minutes at the same time.

(2) The "method of game"

The same content for all children was chosen when performing the exercise according to the "method of game", namely, "The delivery of postal items". The student was a "postman". The children were "letter-carriers". The postman always had enough different envelopes with different degrees of urgency. The letters had to be delivered to the right addresses. The titles were distributed in the outdoor playground of each kindergarten. The children could choose to whom they brought which letter, how often they chose a letter, how quickly they wanted to pick up a new letter. So they could determine the intensity of the exercise, the dosage, and the type of movement.

2.4 Statistical analysis

To analyse the differences in heart rate (HR) responses to these two types of exercises, we transformed the data into

heart rate curves and compared them at the same points in time. The heart rate was measured in 5 seconds intervals during both exercises.

From a sample of 69 children we randomly selected 10 3-year old children and 10 5-year old children. We formed 10 pairs. Each pair had one 3-year-old and one 5-year-old child. We plotted 40 graphs.

The first 10 graphs show the response of the hearts of two children (pair) during uninterrupted walking at the same time (simultaneously). The next 10 graphs show the response of the hearts of the same pair of children during the "method of game". Simultaneous representations of the response of each child's heart to both exercises are shown in the last 20 diagrams. (Due to limited article space, only 3 out of all will be presented for illustration in the Results.)

For statistical analyses, we used statistical package SPSS 20 (SPSS Inc., Chicago, IL). We obtained 312 (2 x 156) heart rate values for each child during both exercises.

To determine the individuality of the effort during exercises, we randomly selected "time stamps", namely at the 1st, 3rd, 5th, 8th and 13th minute. We made a printout of all heart rates at the selected "time stamp" and calculate descriptive statistics (HR means ± SD). Normality assumptions for all data were tested using Shapiro Wilk (S-W) Test. Since the distribution was not normal, we run nonparametric tests. Wilcoxon Rank Sum Test was used to determine whether the difference in heart rates was statistically significant at the same "time stamp". A p-value of 0.05 or lower was considered statistically significant. Effect size was tested with r square; 0.10 < 0.3 (small effect), 0.30 < 0.5 (moderate effect) and >= 0.5 (large effect).

For all subsequent statistical treatments, we took all data from both exercises. We calculated the average heart rate for each child individually, separately according to the type of exercise. The data were summarised using routine descriptive statistics (HR means ± SD). Normality assumptions for all data were tested using Shapiro Wilk (S-W) test. Since the distribution was not normal, we run nonparametric tests.

To compare the differences in average heart rate during the two exercises, we used Wilcoxon Rank Sum. A p-value of 0.05 or lower was considered statistically significant. Effect size was tested with r square; 0.10 < 0.3 (small effect), 0.30 < 0.5 (moderate effect) and >= 0.5 (large effect). To compare the differences (separately between boys and girls and separately between 3- and 5-year old children) in average heart rate during the two exercises, we used the Mann-Whitney Test. A p-value of 0.05 or lower was considered statistically significant. To measure the effect size, Eta square (η^2) was calculated.

3 Results

The results are presented in figures (graphs) and tables. First of all, due to limited article space, we show only three (3) graphs with comparisons of the heart reactions for a randomly selected pair of children (one pair). The first graph (Figure 1) shows the difference between the heart curves during uninterrupted walking, the second (Figure 2) during the "method of game", and the third (Figure 3) shows the difference in heart rate response to the two types of exercise for the senior child from a pair.

Figure 1 shows the differences in heart response during the uninterrupted walking between two preschoolers.

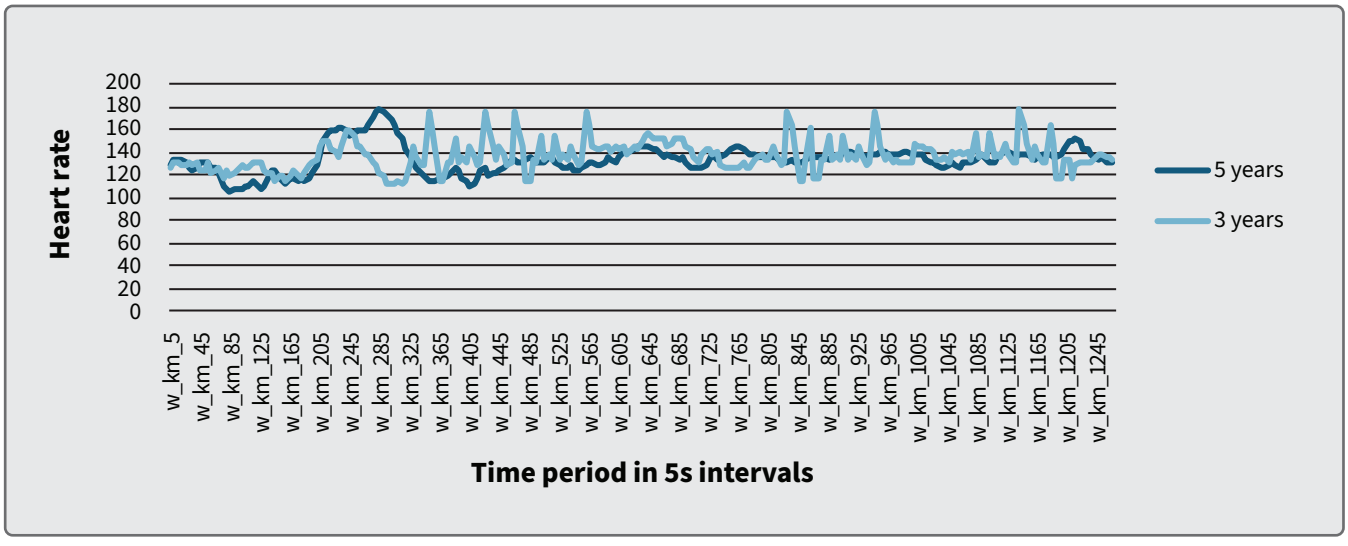

Figure 1: The presentation of heart response during the uninterrupted walking from a randomly chosen pair (one 3- and one 5-year-old preschooler).

According to this chart, the heart rate of the younger child varied more frequently than the heart rate of the older child(ren). However, also in the older child, the frequency was not steady, as we could expect in adults. Based on a more accurate analysis of these two curves, the average value of the older child was for 3 strokes per minute lower than the one of the younger child. The older child's chart has only one emphasised and more durable higher heart rate, while the chart of the younger child has a more frequent and shorter higher heart rate.

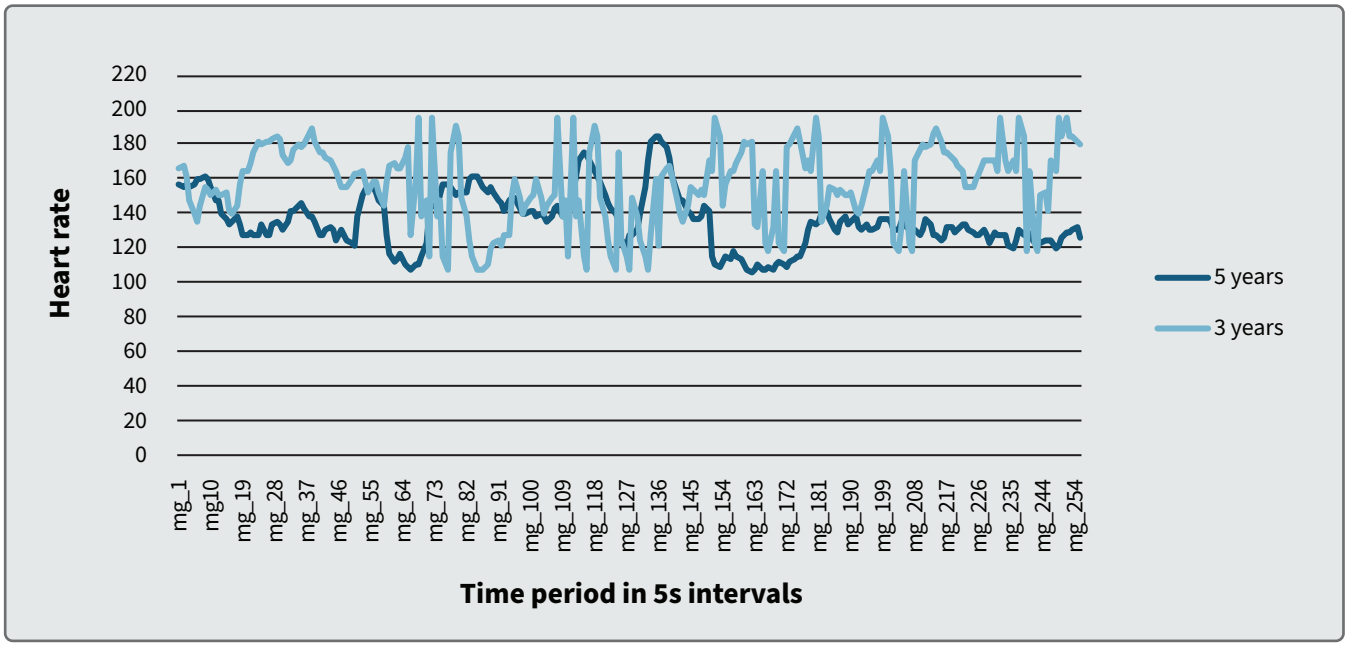

Figure 2: The presentation of heart response during the "method of game" from randomly chosen pairs (one 3- and one 5-year-old preschooler).

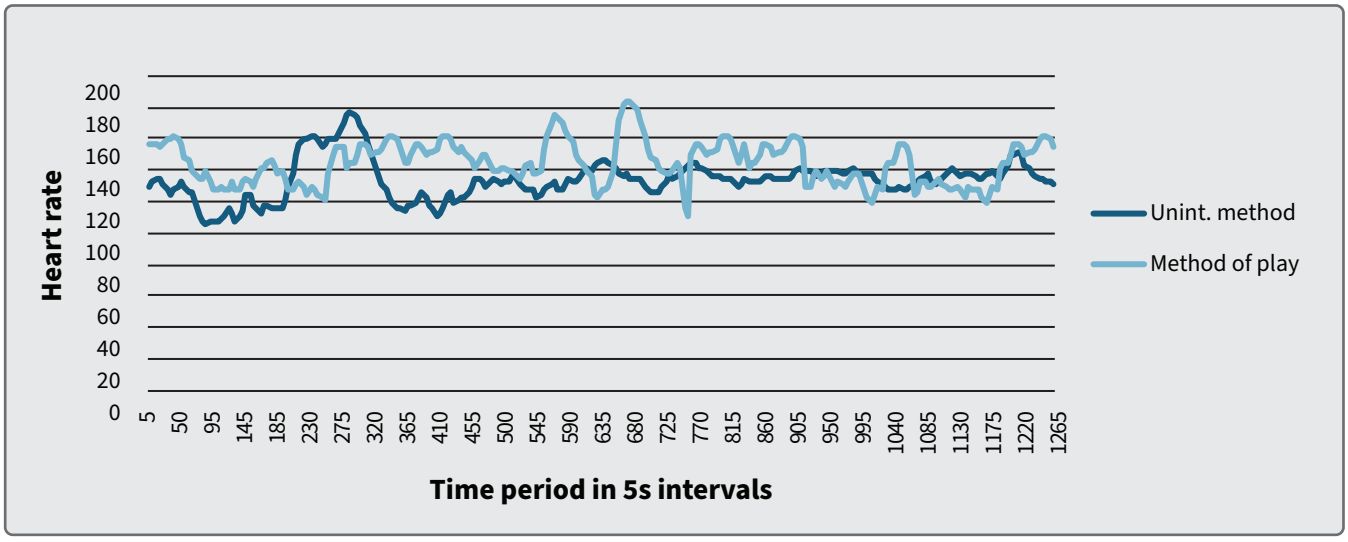

Figure 3: The comparison of heart response with the uninterrupted walking and "method of game" in the same 5-year old child.

Figure 2 refers to the same couple of two preschoolers as with the uninterrupted walking (Figure 1). Again, we have a sample which indicates that also with this type of exercise the younger child performed a more intensive movement activity. It shows that the younger child did not stop at a higher level of intensity or took the necessary rest at once.

After analysing all the other 9 graphs plotted from HR, obtained during "method of game", we came to the conclusion that a child can adjust its own intensity of movement at any time and therefore the individual stress is guaranteed by the feeling of tension and the need for rest.

The third graph (Figure 3) shows the differences in the reaction of the heart of a 5-year-old child (from the previously selected and represented couple) to two different types of exercises.

According to the analysis of all 20 individual graphs (for illustration, only one of them is presented in Figure 3), we concluded that the curves obtained by measuring the children during uninterrupted walking is more linear than those obtained during the "method of game". An increased heart rate during the "method of game" indicates that children were moving more often and with more intensity than during uninterrupted walking. However, they also rested more often during the "method of game" than during uninterrupted walking.

To support the above claims from the graphs that the "method of game" allowed the child to individualise the exercise more than uninterrupted walking (more breaks, more different intensities at the same time) and still develop medium to high endurance, we have created five "time stamps" (at 1, 3, 5, 8 and 13 minutes) and calculated average HR and SD at all selected points in time (Table 1).

When we observed the differences in the average of HR (but especially in SD) between all children at the same time point, we found out that heart rates during the "method of game" differed more than during the uninterrupted walking (at 1` SDmg-$SD_{uw}$ = 21-10; 3`SDmg-SD_{uw} = 23-9; 5` SDmg-$SD_{uw}$ = 30-18; at 8` SDmg-SD_{uw}= 26-10; at 5` SDmg-SD_{uw} = 24-8).

Table 1: Average HR values for all children at selected "time stamps" (i.e. at the 1st, 3rd, 5th, 8th and 13th minute).

Stamp time	Exercise	N	Mean value	Std. deviation	Min	Max	Wilcoxon Rank Sum	
							Z	sig.
1st min	"method of game"	69	132	21	102	179	2.20	0.028
	uninterrupted walking	69	125	10	102	158		
3rd min	"method of game"	69	135	23	107	181	4.64	0.000
	uninterrupted walking	69	119	9	105	149		
5th min	"method of game"	69	140	30	95	195	3.23	0.001
	uninterrupted walking	69	125	18	104	169		
8th min	"method of game"	69	145	26	110	193	3.82	0.000
	uninterrupted walking	69	129	11	111	143		
13th min	"method of game"	69	145	26	105	186	3.33	0.001
	uninterrupted walking	69	133	8	122	153		

Legend: N – number of replies; Min – minimum value; Max – maximum value; Z – value of Wilcoxon Rank Sum; sig. - statistical significance – a p-value of 0.05 or lower was considered statistically significant.

Wilcoxon Rank Sum test showed that differences at all points in time were statistically significant (at 1`: Z = 2.20; p = 0.028, r = 0.19; 3`: Z = 4.64; p = 0.00, r = 0.39; 5`: Z = 3.23; p = 0.001, r = 0.27; 8`: Z = 3.82; p = 0.00, r = 0.32; 13`: Z = 3.33; p = 0.001, r = 0.28).

Table 2 shows that the average heart rate of all participants during the performance of the "method of game" was 143, with a standard deviation of 14. The average heart rate of all participants during uninterrupted walking was 132, with a standard deviation of 5. This illustrates the fact that uninterrupted walking is less intense and results in a smaller range of heart rate. This is further illustrated by the minimum and maximum heart rate. The difference between the minimum and maximum heart rate during the "method of game" (HR max: 178 – HR min: 110) was 68 beats, while during the uninterrupted walking it was 28 beats (HR max: 146 – HR min: 118).

The distribution was not normal, so we used the Wilcoxon Rank Sum test to

Table 2: Average heart rate during 13 minutes of uninterrupted walking and "method of game".

	N	Mean value	Std. deviation	Min	Max	Wilcoxon Rank Sum	
						Z	sig.
"Method of game"	69	143	14	110	178	-5.83	0.000
Uninterrupted walking	69	132	5	118	146		

Legend: N – number of replies; Min – minimum value; Max – maximum value; Z – value of Wilcoxon Rank Sum; sig. - statistical significance – a p-value of 0.05 or lower was considered statistically significant.

Table 3: Average heart rate for boys and girls during uninterrupted walking and "method of game".

		N	Mean value	Std. deviation	Min	Max	Mann-Whitney test
"Method of game"	Boys	38	143	14	110	178	0.491
	Girls	31	142	14	110	178	
	Total	69	143	14	110	178	
Uninterrupted walking	Boys	38	133	6	118	146	0.132
	Girls	31	130	4	123	136	
	Total	69	132	5	118	146	

Legend: N – number of replies; Min – minimum value; Max – maximum value; sig. - statistical significance – a p-value of 0.05 or lower was considered statistically significant.

identify statistical differences. Wilcoxon Rank Sum test showed that differences were statistically significant ($Z = -5.83$; $p = 0.001$, $r = 0.24$). On average, the children experienced a higher intensity when endurance was implemented according to the "method of game". Given the differences between the minimum and maximum values, the effort would not be constant.

Table 3 shows heart rate average values of boys and girls obtained during uninterrupted walking and the "method of game". We applied the Mann Whitney test to verify whether the differences in the average heart rate between boys and girls regarding the type of exercise were statistically different. From the results of Mann Whitney test, we can notice that there is no significant difference between girls and boys neither during uninterrupted walking nor during the "method of game".

We analysed differences between age groups in the same way as we analysed differences between boys and girls.

Table 4: Average heart rate for 3- and 5-year old preschoolers during uninterrupted walking and "method of game".

		N	Mean value	Std. deviation	Min	Max	Mann-Whitney test
"Method of game"	3-year	40	146	17	110	178	0.020
	5-year	29	139	7	128	150	
	Total	69	143	14	110	178	
Uninterrupted walking	3-year	40	133	3	125	136	0.002
	5-year	29	130	7	118	146	
	Total	69	132	5	118	146	

Legend: N – number of replies; Min – minimum value; Max – maximum value; sig. - statistical significance – a p-value of 0.05 or lower was considered statistically significant.

Table 4 shows that 3-year-old children had higher heart rate average values during both types of exercises in comparison to 5-year-old children. The difference during the "method of game" was 7 strokes per minute, whereas, during the uninterrupted walking, this difference was lower and equal to 2 strokes per minute. The Mann Whitney Test indicates statistical significant differences in average of heart rate between age during the "method of game" ($Z = -2{,}34$ $p = 0.020$, $\eta^2 = 0.08$) and uninterrupted walking ($Z = 3.17$ $p = 0.002$, $\eta^2 = 0.15$).

4 Discussion

The study examined the reactions of the heart of preschool children to two different types of endurance exercise (i.e. uninterrupted walking vs "method of game"). Endurance itself is a functional ability of an organism to perform a movement activity with moderate intensity for a longer time (1,2). The reaction of the body to given stress (strain) is called effort (22). Usually, the strain is determined by the speed of the movement, length , frequency, type of exercise, etc. In our study, the strain for the first exercise (uninterrupted walking) was 1 km walking for 13 minutes. For the second exercise ("method of game") the reverse reaction (effort vs strain) was desired to achieve. The child should determine the strain themselves during the implementation of the "method of game" according to the effort they experienced at that moment.

The discussion is divided into three paragraphs according to the main research question which one of the two exercises is more suitable for developing endurance in preschoolers. In the first part, the connection between the graphs and the Table 1 with the **individuality** of the exercise is shown. In the second paragraph, the results of Table 2 are related to the exercise **intensity**. The third paragraph, based on the results of Tables 3 and 4, points out the **universality** of the "method of game" and its relation to Fartlek.

Measuring adult HR, the steady-state is established by performing a cyclic movement at a constant speed on the aerobic threshold (24). By comparing our results obtained by measuring HR during uninterrupted walking for 1 km at 4.6 km/h speed, all children failed to reach steady-state. The heart rates of 3-year old children varied more frequently compared to 5-year old children. However, also all graphs of 5-year old children were not steady, as we could expect in adults. According to the first part of our results (Figures 1-3 and Table 1), where we wanted to explore the possibilities of adapting the intensity to the **individual**, we noticed that children at the same time ("time stamp") associated more variegated HR during the "method of game" than during uninterrupted walking. We concluded that just by shortening the time of exercise and decreasing the distance of walking, we only shorten the time of developing aerobic activity. The reasons for the inability to perform exercises in a steady-state are sought in incompletely mastered walking as well as in the anatomical and physiological differences between children and adults. Dotan, Mitchell, Cohen, Klentrou, Gabriel and Falk (10) concluded that children have more muscle fibres of type 1. Because of that, they get tired more quickly. However, their muscle fibres also reinvigorate faster, which is an additional reason for more frequent pauses. The analysis of heart stroke curves measured

during the "method of game" might indicate that this is exactly the reason for more frequent rests and quick increase of heart rate after rest. Krost, Mistovich and Limmer (11) also analysed the differences in cardiac function between adults and children. According to them, the heart of an adult responds to an increased strain by increasing both the heart rate and stroke volume, while a child's heart can respond to the increased strain only by increasing the number of heart strokes. This might be the reason for considerable fluctuations in heart rate.

In the second paragraph, the **intensity** between exercises regarding strain determiner is discussed. According to the results from Table 2, children experienced a higher intensity when endurance was implemented according to the "method of game" in comparison to uninterrupted walking. Preschool teachers need to ensure safety when organizing uninterrupted walking. All children need to walk in a group with the same pace (17). Since they have different levels of walking ability (6), different physical conditions (17), and differently developed cardiovascular and respiratory systems (10-14), the preschool teacher cannot take all these individual differences into account. As a rule, they select the child who has the least developed endurance and does not give others the appropriate intensity.

In the third paragraph, the results in Tables 3 and 4 are compared with Fartlek, which is considered as a **universal** method of endurance development. Aerobic endurance development exercises are more and more sophisticated and include strains for both aerobic and anaerobic metabolism. Roughly, they can be divided into three methods, namely: the uninterrupted exercise, interval exercise and Fartlek (which is the game of agility). Stöggl and Sperlich (24) concluded that the combination of all methods was important for aerobic endurance development in adult sportspersons. Gregorc and Humar (6) compared a pre-schooler's heart response with the »method of game« with adults' heart responses with all three endurance development methods and concluded that a child's heart response was most similar to adult's heart response when performing the Fartlek exercise. In our study, the 3-year-old children achieved higher average heart rate during both exercises in comparison to 5-year old children; during the "method of game" ($Z = -2.34$ $p = 0.020$, $\eta^2 = 0.08$) as well as during uninterrupted walking "($Z = 3.17$ $p = 0.002$, $\eta^2 = 0.15$) (Table 4). However, a small variance was clarified. However, we believe that it would make sense to carry out uninterrupted walking with both younger and older children in a different way. The preschool teacher should guide the children to safe walking paths on which they should be allowed short runs, breaks, alternating fast and slow walking. Based on the results of Table 3 (no statistically significant differences between boys and girls were confirmed), it makes no sense to divide the children by gender.

This study has four main limitations:

- the first is a relatively limited number of participants;
- the second is short-term observation, with no answer to long-term endurance;
- the third is only two different types of exercises;
- and the fourth is measuring intensity only through heart rates.

Further prospective studies may answer some of these questions.

5 Conclusions

The intention of this research was to explore the adequacy of using different methods for developing endurance for preschool children than for adults. By observing how children's hearts respond to developing endurance using "method of game" and uninterrupted walking, we linked the results to some aspects of a child's development characteristics and made three highlights:

- None of the children reached the "steady-state" HR during uninterrupted walking, especially among the 3-year-old children.
- The "method of game" was associated with a higher average and variable heart rates compared to uninterrupted walking, which is also characteristic of Fartlek.
- Rather than choosing a suitable type of endurance exercise, a different way of implementation is important.

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