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Original article

THE RELATIONSHIP BETWEEN HEALTH-RELATED PHYSICAL AND BMI, COMPUTER GAMES, AND PHYSICAL ACTIVITY AMONG 7-YEAR-OLD CHILDREN FROM POLAND

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Abstract

Purpose. The objective of the study was determination of the effect of individual variables: physical activity, BMI, as well as the most popular form of inactive leisure – computer games, on the level of fitness approached according to the Health-Related Fitness (H-RF) concept in 7- year-old children from Polish rural areas.

Methods. A cross-sectional study was conducted 14773 children aged 7 year old including 7268 girls and 7505 boys from Poland. Measurements were performed of body weight and height, and the BMI calculated. Using the selected tests (Eurofit), trunk muscle strength, explosive leg power, arms and shoulder girdle strength, and flexibility were evaluated. Parents were asked to complete a questionnaire form, which included items concerning time devoted to computer games (CG), daily spontaneous physical activity (Spont.PA) and organized, adapted physical activity during the week (Add.PA). The effect of the time devoted to computer games, spontaneous PA and additional PA was assessed using analysis of covariance.

Results. The negative effect of time devoted to computer games was observed in the case of flexibility (p=.002) and trunk' strength (p=.021), and positive for arm movement speed (p=. 003). A positive effect of spontaneous physical activity (SPA) was noted in the case of flexibility (p=.032) and explosive strength of lower limb (p=.012). Additional physical activity were associated with higher level of trunk strength (p=.001). The significant interaction between CG and spontaneous PA were observed for flexibility (p=.007), between additional PA and spontaneous PA for: flexibility (p=.020), arms strength (p=.043).

Conclusions. This relationship between H-RF, and PA, and CG could be important to the health of children, particularly in obesity prevention.

Key words: Health-Related Fitness, preschool children, physical activity, sedentarny behaviours.

Introduction

Health-Related Physical Fitness involves human ability to be active during the day. It enables participation in duties related to learning and professional work, self-service operations, as well as the implementation of various forms of active recreation. There are tangible benefits of being efficient. First of all, the efficiency seen as one of the elements of health in a holistic approach shares responsibility for well-being. This is confirmed by numerous studies looking for links between efficiency and other elements of human health (Janssen, et al. 2010). In addition, maintaining an optimum fitness level allows the maintenance of specific immunity to certain diseases. In crisis situations, it helps to overcome stressors (Fogelholm, 2010). Thus, studies important for development of the theory of efficiency in terms of health emphasize the importance of strength, endurance, cardio- respiratory endurance, flexibility and body composition. Speed and coordination are important (Huang and Malina, 2007). Recent studies highlight its morphological and metabolic components, thanks to which it became possible to estimate the risk of becoming overweight and obese in populations of children, adolescents and adults (Osiński, 2003, Król et al. 2009).

Physical fitness is conditioned by many factors: genetic, morphological, and environmental. Physical activity (PA) is the main source of body motion produced by skeletal muscles and it requires energy consumption. In most children it takes the form of organized or spontaneous activity. In contrast, sedentary behavior (SB) is characterized by low energy expenditure of 1.5 Met or less (Owen et al. 2000) Huge technological advances that have taken place over the past few decades, helped to popularize a wide range of media, a priori forcing sedentary behavior. The most popular include watching television, electronic games, computer or reading. In economically developed countries, in nearly 98% of households with small children, there is at least one television set. 80 % of families have access to computers, while almost 50% have access to electronic games consoles (Vandewater et al. 2007). Such a large popularity of media has made upsetting ratio in terms of time spent on physical activity and sedentary behaviors. Recommendations of pediatric societies and the WHO on pointing time limit spent on moderate activity and/or intense activity of at least one hour a day and conscious limitation of daily participation related to the use of the media to a maximum of two hours are not met (Hagan et al. 2008). Definitely more time children spend on inactive forms of recreation, and physical activity is on average

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lower than expected (Tremblay et al. 2011). American studies show that more than one third of preschool children significantly exceeds permitted time limits on media use (Harrison et al. 2011) Canadian research indicates, however, that children aged 6-10 spend about 500 minutes a day on inactive forms of recreation, with fulfilled requirements in terms of physical activity in boys group (Carson et al. 2013). Such unfavorable ratio since early age expose children to health consequences in various spheres of development. The most common include excessive aggression, lack of confidence, lack of concentration, back pain and especially children's exposure to overweight and obesity in the future, leading to a number of metabolic syndromes, which may result in early death (Ferreira et al., 2005).

Mutual relations between efficiency and physical activity and sedentary behaviors and BMI are already observed in childhood (Wrotniak et al. 2006). Higher level of efficiency generally involves high level of physical activity, organized and spontaneous (Williams et al. 2008, Tanaka et al. 2012). In addition, a longer time spent on physical activity limits sedentary behaviors (Hofferth, 2009). In contrast, low level of physical activity and the reported preference for media use (in addition to inadequate nutrition) impact on increasing the preferences of children and adolescents with overweight and obesity. Therefore, it is thought that physically inactive children, significantly exceeding the time limit for media use, an example of which are computer games, as well as those that show overweight and obesity will have a low potential for physical fitness in terms of strength, speed, agility and coordination (Martínez-Vizcaíno, Sánchez-López, 2008, Sacchetti et al. 2012).

There are not many modern publications raising issues mentioned above which apply to preschool-aged children (Graf et al. 2004, Niederer et al. 2012, Fitzpatrick et al. 2013). A diverse research methodology does not allow identification of the border, where the disruption of proper relations between PA, BM and SB leads to negative consequences in terms of effectiveness and starts the negative spiral of mutual interdependence. There is a lack of such research on Polish territory. The implemented research program for the diagnosis of children on the threshold of school on a random sample allows for a broader analysis of the selected problem.

The aim of the study is to estimate the mutual interdependence between the PF and PA (organized and spontaneous), SB and BMI in 7-year-old children from Poland. It should be emphasized that so far there has not been such a development for children aged seven from the rural Polish environment. It has been assumed that physical activity occurs along with higher level of physical fitness, whereas the time devoted to computer games significantly decreases physical fitness.

Methods

The research material are the results of 14773 children aged 7 years: 7268 girls and 7505 boys from Polish rural areas. The research program was carried out in 2006 in the months of April - June and September - November. The sample was representative for the areas of the country. The researchers took into account the division into regions, which was expressed by province, type of institution to which the child attends (kindergarten - school), and the place of residence, including the structure in division into villages and towns. Stratified sample without replacement on the basis provided by the SIO (Education Information System) and updated by GUS (Central Statistical Office) was used.

For anthropometric and physical fitness measurements a battery of EUROFIT tests was applied. For the analysis only those components were chosen, which related to the concept of Health Related Fitness (AAHPERD, 1984). Body height and weight were evaluated using the Martin instrumentation. Body building was based on BMI (body mass/height^2). Using the European test of Physical Fitness "Eurofit" the following were evaluated: abdominal muscle strength by sit-ups test in 30 seconds, lower limb explosive strength by jump out of place test, the strength of the shoulder girdle and arm by overhang on the bar. In assessing the morphological component flexibility test was done (Sit and Reach trial). To evaluate the motor components running speed and agility 10x5m shuttle run test was used. In the case of arms and shoulders strength a simplified version of the test was used: a straight arm hang trial.

The tests were conducted by previously trained physical education teachers. The test procedure required them to give prior notification of the list of institutions in which the research was conducted. Parents completed a questionnaire survey. Using the categories: not at all a few minutes a day, an hour a day, more than an hour a day, they assessed the involvement of children in computer games. Spontaneous motor activity was assessed using the categories: physically inactive, physically active for up to an hour a day, active all the time. Organized activity was determined based on the following description categories: does not participate in the organized activities, participates 1-2 times a week and participates more than twice a week. These categories were the basis for the division into the respective groups in the course of further statistical analysis. In selected by independent variables groups, basic statistical characteristics were calculated (arithmetic means, standard deviations, 95%CI). Analysis of covariance implemented. The Generalised Linear Model that was used to assess the effect of PA and CG category on each of the parameters, controlling for body size (BMI) separately for each parameter. Additionally, the model included effects of two second order interactions: between PA spontaneous and

additional and CG. Significant interactions were presented on graphs.

Results

Table 1 shows physical fitness characteristics of seven year old children from rural areas. Differences between boys and girls turned out to be statistically significant. Boys compared to girls developed higher level of speed components such as the speed of limb movement (p=0.046) and running speed (p=0.000), as well as strength components such as static arm strength (p=0.000), abdominal muscles strength (p=0.000) and explosive leg power (p=0.000). In terms of flexibility (p=0.000) and balance (p=0.000) girls demonstrated significantly higher level than boys.

Table 1. H-RF characteristics among 7-year-old children

Physical Fitness	Boys			Girls			t	p
	$\bar{x}$± sd	M	95%CI	$\bar{x}$± sd	M	95%CI		
Total balance [n/min]	15.37±7.39	15.00	15.15-15.58	14.28±7.41	14.00	14.07-14.48	**-7.1818**	**0.000**
Arm speed movement [sec]	25.17±6.13	25.02	25.03-25.30	25.36±5.90	25.17	25.23-25.49	**1.9920**	**0.046**
Flexibility [cm]	15.36±5.37	15.00	15.24-15.47	16.78±5.20	17.00	15.66-16.89	**16.7926**	**0.000**
Explosive strength of lower limb [cm]	100.11±20.3	101.0	99.67-100.56	92.66±18.35	93.00	92.25-93.08	**-23.9948**	**0.000**
Trunk strength [n/30sec]	10.39±4.47	10.00	10.29-10.50	9.89±4.37	10.00	9.78-9.99	**-6.6294**	**0.000**
Arm's strength [sec]	31.41±22.65	26.10	30.91-31.91	27.22±20.28	21.94	26.76-27.68	**-12.1156**	**0.000**
Running speed and agility [sec]	27.15±4.21	26.57	26.06-27.24	27.82±4.04	27.38	27.73-27.91	**10.1592**	**0.000**

The analysis of covariance revealed that the level of physical fitness components (Table 2, Figures 1-10) was not always notably influenced by independent variables, but models (except for general balance) proved to be statistically significant: the speed of arm movement: F(12; 9560)=4.0189, p=0.000, flexibility: F(12;9591)= 3.3627; p=0.000, explosive leg power (12;9591)=10.1701; p=0.000, abdominal muscles strength: F(12;8351)=4,1766, running speed F(12;9574)=3.0132; p=0.000, and static arm strength: F(12;9518)=25.7572, p=0.000. However, the coefficient R^2 (ranging from: 0.030 for abdominal muscles strength to: 0.002 for flexibility) is relatively low, which means that both predictors, excluding BMI impact, to a certain degree determine proportion of integer variable for specific H-RF components.

The time devoted to computer games turned out to be an important factor influencing abdominal muscles strength (p=0.0216), flexibility (p=0.0024) and the speed of arm movement (p=0.0038) – (graphs 1-2,7). Longer exposure to a computer screen notably increases the speed of arm movement. Computer games variable for flexibility and abdominal muscles strength seems to be a negative predictor as it significantly weakens abdominal muscles and decreases the average results of sit and reach, which is to measure flexibility in lumbar region.

Spontaneous physical activity became important for achieving high average results in flexibility (p=0.0328) and explosive leg power tests (p=0.0126) - (graphs 3,6). Children described by their parents as "active all the time" proved lower level of flexibility but on average produced better results of standing broad jump which measures leg muscles strength. Additional physical activity appeared to be a significant predictor for abdominal muscles strength (p=0.0012) - graph 8.

Interaction between the time that children devoted to computer games and spontaneous physical activity proved statistical significance in one case only, and it was related to flexibility (p=0.0079). Spontaneous physical activity, even in case of children playing computer games, determined better results in flexibility tests. On the other hand, lack of spontaneous activity notably decreases flexibility, which is particularly visible in physically non-active children and those who devote more than one hour to sedentary behaviours.

Flexibility (p=0.0206) and static arm strength (p=0.0433)-(graph 5,9) are determined by spontaneous

and additional physical activity. In children who did not attend additional physical activities, better average results arose from increased spontaneous activity. In children who regularly took part in arranged physical activities high level of spontaneous activity did not determine better results in both H-RF components.

Discussion

Based on representative sample, the research which involves correlation between specific components of physical fitness and physical activity as well as the time devoted to computer games proves previous observations related to the influence of both predictors on motor potential of pre-school children (Williams et al. 2008). However, R^2 calculated and corrected for each model indicates that variability of physical fitness components results from environmental, biological or genetic factors. In terms of quality and quantity, motor abilities of pre-school children are changing dynamically. Gaining experience by pre-school children which is essential for a good start at school seems to be determined by optimum level of motor abilities (Hardy et al. 2009). According to some researchers, family environment, including SES and communication abilities, are important factors which determine physical fitness, (Okely, Booth, 2004). However, physical activity and sedentary behaviours tend to play a very important role (Williams et al. 2008). Physical fitness contributes to the level of low-to-moderate physical activity in subsequent stages of development (Telama et al. 2005) and physical activity limits the time devoted to sedentary behaviours.

The research proves that in seven year old children computer games determine only 3 out of 7 physical fitness components such as flexibility, abdominal muscles strength and the speed of arm movement. What is more, a significant interaction between computer games and spontaneous physical activity was proved only for flexibility. The comparative analysis of the research results seems to be difficult because there are not many publications which discuss the issue of correlation between the use of computer and physical fitness. Additionally, various methods of data collection (questionnaire, parental time use diary, accelerometer etc.) as well as the age of children, statistical methods and environmental factors such as living conditions do not allow research findings to be fully interpreted. What is more, existing research provides contradictory conclusions. Armstrong et al. (1998) suggested significant relationship between watching TV (children reports) and the results of 1 mile run/walk, whereas for muscular strength/endurance and flexibility similar relationship was not found. Similarly, Cliff et al. (2009) in their research did not prove any relationships. However, the research of Fitzpatrick et al. (2013) reveals that each hour spent in front of the TV in early childhood may later result in weakening the strength of lower limbs measured by standing broad jump test by approximately 3 cm. This leads to the conclusion that in the perspective of several years long-lasting exposure to the use of media has negative impact on physical fitness, which is proved by the research conducted among older children (Tucker et al. 2013). Daily engagement in sedentary behaviours for more than 2 hours tends to decrease the level of physical fitness in young people including flexibility in the lower spine which may lead to the higher frequency of low back pain (Calvo-Muños et al. 2013). Although the observations involved young people, it may be assumed that patterns related to the correct posture when using a computer are typically developed in early childhood. Therefore, habitual, improper position while sitting at a computer will result in serious health problems, the first symptom of which may be low level of flexibility in the lower back region.

The time devoted to computer games is not only associated with negative influence on health-related fitness components. It also increases the speed of arm movement. It is possible that repeated use of a computer mouse improves not only

Table 2. Results of analysis of covariance physical fitness parameters (separately).

	df	F	p
		Total balance	
BMI	1	1,2445	0,2646
Computer games	2	2,4692	0,0847
Spontaneous physical activity	1	0,8408	0,3592
Additional physical activity	1	0,1939	0,6597
CG x PAspont.	2	2,7210	0,0658
CG x PAad.	2	1,0511	0,3496
PAspont x PAad	1	0,0127	0,9102
		Arm movement speed	
BMI	1	13,038	**0,0003**
Computer games	2	5,567	**0,0038**
Spontaneous physical activity	1	0,064	0,8006
Additional physical activity	1	1,569	0,2103
CG x PAspont.	2	0,381	0,6829

CG x PAad.	2	2,833	0,0588
PAspont x PAad	1	1,566	0,2108
		Flexibility	
BMI	1	11,844	**0,0005**
Computer games	2	6,028	**0,0024**
Spontaneous physical activity	1	4,556	**0,0328**
Additional physical activity	1	1,687	0,1940
CG x PAspont.	2	4,833	**0,0079**
CG x PAad.	2	0,986	0,3729
PAspont x PAad	1	5,359	**0,0206**
		Explosive strength of lower limb	
BMI	1	150,391	**0,0000**
Computer games	2	0,727	0,4835
Spontaneous physical activity	1	6,213	**0,0126**
Additional physical activity	1	1,048	0,3058
CG x PAspont.	2	0,825	0,4380
CG x PAad.	2	1,677	0,1869
PAspont x PAad	1	0,004	0,9481
		Trunk strength	
BMI	1	9,1476	**0,0024**
Computer games	2	3,8351	**0,0216**
Spontaneous physical activity	1	0,6095	0,4349
Additional physical activity	1	10,4633	**0,0012**
CG x PAspont.	2	1,0785	0,3401
CG x PAad.	2	1,9182	0,1469
PAspont x PAad	1	0,1276	0,7209
		Arm's strength	
BMI	1	298,264	**0,0000**
Computer games	2	0,711	0,4913
Spontaneous physical activity	1	1,353	0,2447
Additional physical activity	1	0,234	0,6282
CG x PAspont.	2	0,869	0,4192
CG x PAad.	2	0,064	0,9380
PAspont. x PAad.	1	4,081	**0,0433**
		Running speed and agility	
BMI	1	55,817	**0,0000**
Computer games	2	2,025	0,1319
Spontaneous physical activity	1	0,247	0,6192
Additional physical activity	1	2,397	0,1216
CG x PAspont.	2	1,415	0,2428
CG x PAad.	2	0,045	0,9560
PAspont x PAad	1	2,378	0,1231

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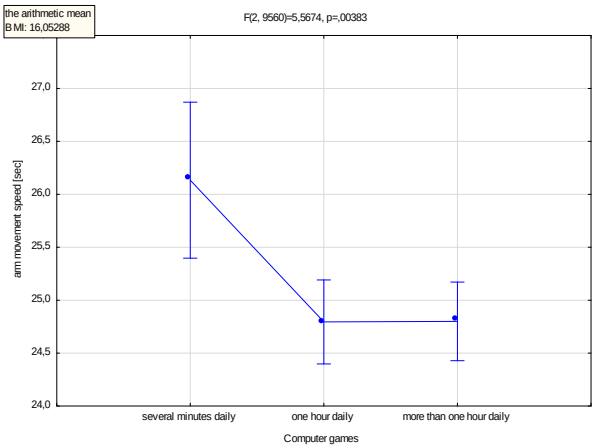
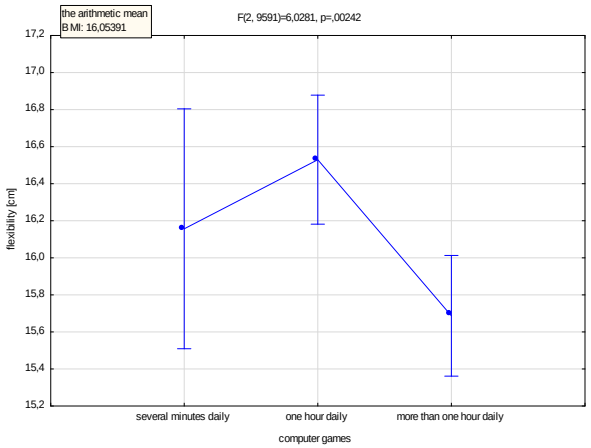
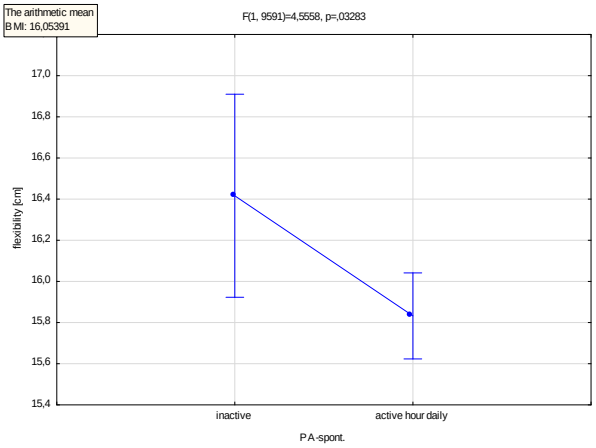


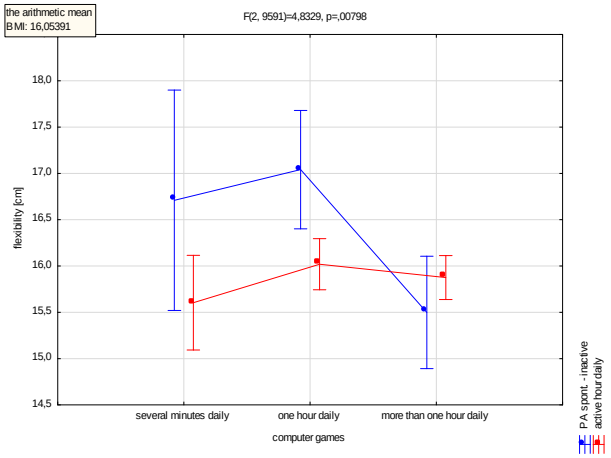
Graph. 1. Arm movement speed and CG



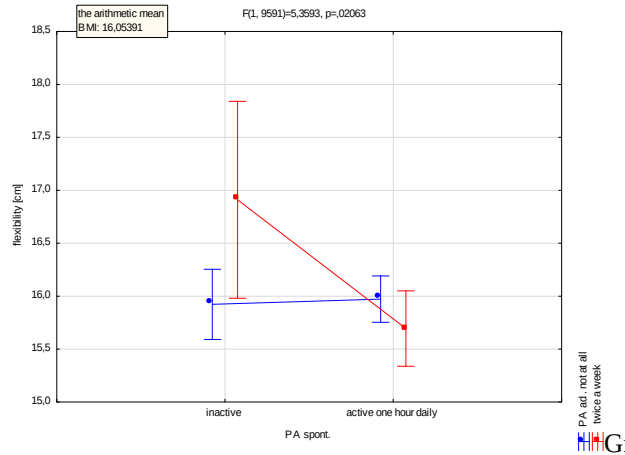
Graph. 2. Flexibility and CG



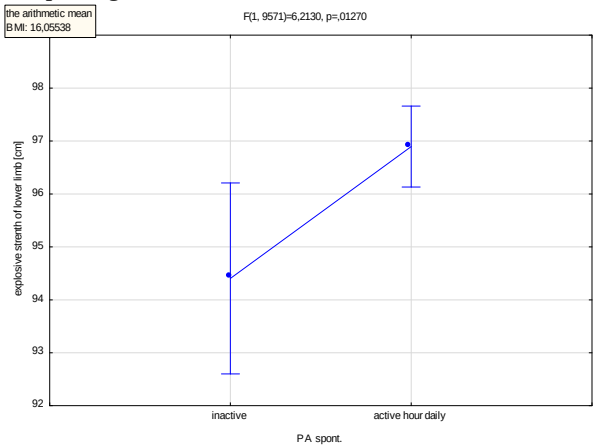
Graph. 3. Flexibility and PA (spont.)



Graph. 4. Flexibility: interraction between PA(spont.) x computer games



Graph. 5. Flexibility and interraction between PA (spont.) x PA (ad.)



Graph. 6. Explosive strength of lower limb and PA (spont.)

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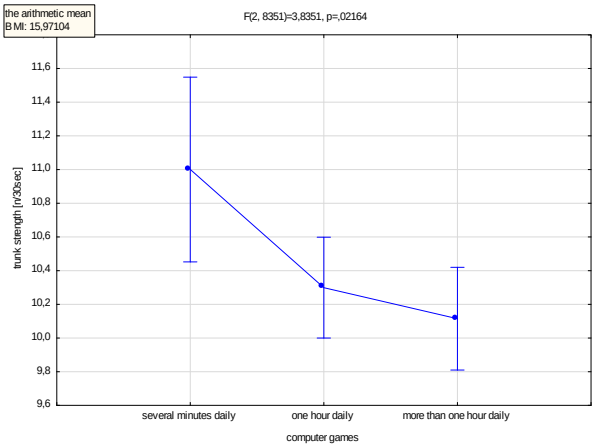
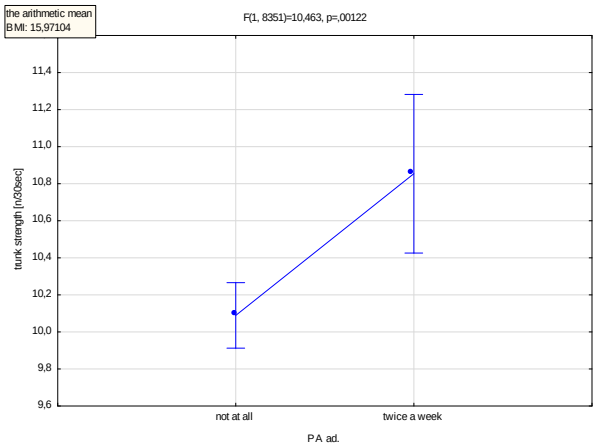
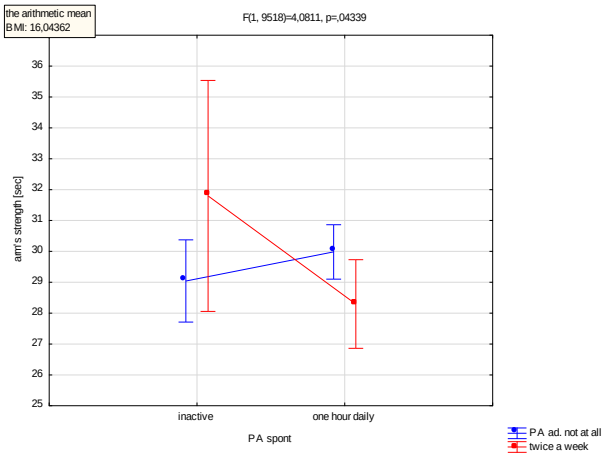


Graph.7. Trunk strength and CG



Graph. 8. Trunk strength and PA (ad.)



Graph. 9. Arm's strength and interraction between PA (spont.) x PA (ad.)

CG-computer games; PA (spont.)- spontaneous physical activity; PA (ad.)-additional physical activity preciseness and accuracy, but also eye-hand coordination which is essential in plate tapping test to measure speed of arm movement (Donker, Reitsma, 2007).

There is a common view that pre-school age is characterised by natural physical activity and optimum age remain unanswered.

The research revealed that physical activity reported by parents, including daily spontaneous activity and weekly prior arrangements for physical activity, significantly determine four H-RF components: abdominal muscles power, shoulder girdle strength, explosive power of lower limbs and flexibility. Physical activity arrangements play an important role in increasing the level of abdominal muscles strength, whereas spontaneous physical activity, even excluding the influence of body size factor, tends to develop explosive power of lower limbs and flexibility.

In terms of flexibility and arm strength -related potential of physical fitness (Nyquyen et al. 2011). Obviously, it is difficult to establish a cause and effect association between physical activity and physical fitness. Hence, the question arises whether children are more active due to the high natural motor abilities or they are more physically fit because of the high level of spontaneous physical activity. These concerns significant interactions were noticed between spontaneous and arranged physical activity. Spontaneous physical activity is based on numerous essential motor skills (Hardy et al. 2010), including locomotor skills along with jumps as well as stability skills such as sit-ups/bends. Probably, due to the common occurrence of these tasks in games and other activities, even seven year old children who enjoy playing more than other kids are able to develop high level of the above-mentioned skills. The influence of length proportions factor cannot be excluded, too (Szopa et al. 1996). It is also worth noticing that both motor tasks have been included in numerous tests which measure children's fundamental motor skills and health-related fitness (Cools et al., 2009). Other motor tasks e.g. sit-ups to measure abdominal muscles power and arm hang require training to be mastered. Moreover, strength is important to perform these tasks. Hence, additional physical activity may help perform these tasks properly.

The research findings related to seven year old children do not have points of reference in publications. That is because accelerators were mostly used to identify the level of physical activity. Additionally, pre-school children were tested to measure fundamental motor skills. The methods and point scales used for

assessment may be compared with the results of author's research, but interpretation of the research data should be considered as a source of information. The analysis of research related to Polish children seems to prove similar findings to the research which involves foreign children. The results of the research into the impact of physical activity on the level of motor abilities confirm previous observations related to associations of physical activity with motor abilities in prepubertal children. The research conducted by Williams et al. (2008) proved correlation between motor abilities and physical activity. Physically fit children tend to be more often engaged in physical activity. High level of locomotor skills motivates pre-school children for taking up moderate-to-vigorous physical activity. Wrotniak et al. (2006) also noticed associations between low physical activity and high BMI along with low physical fitness in children.

According to Cliff et al. (2009), there is a strong correlation between moderate-to-vigorous physical activity and motor abilities of pre-school children. Boys are reported positive while girls negative correlation. Also in older, 8-9 year old children significant relationship was observed between participation in additional sports activities and daily physical activity. It turned out that significant correlation between arranged and spontaneous physical activity was proved for flexibility (boys and girls), arm strength as well as explosive power of lower limbs (only boys) (Sacchetti et al. 2012).

Interactions between spontaneous and arranged, additional physical activity reported by parents seem to be difficult to interpret as well as their correlation with flexibility and arm strength. It is commonly known that regardless the type, physical activity should be a positive predictor of physical fitness irrespective of age. The only point of reference may become the research conducted by Cliff et al. (2009) in which negative correlation between motor abilities and girls' physical activity was reported. As mentioned above, due to different research methods, it is difficult to interpret these findings properly. However, it is probable that this finding could be the consequence of multiple correlations, which may have created alpha inflation and resulted in Type 1 error. What is more, data interpretation does not consider associations between BMI and physical activity. On the other hand, it may be assumed that too high level of physical activity may cause stress for a child, manifested by lower average results in these tests.

Conclusion

The research which involved seven year old children partially proved assumptions.

1. Positive influence of physical activity on strength components was noticed.
2. The time devoted to computer games proved negative correlations only with flexibility and abdominal muscles strength, whereas positive correlations were found for the speed of arm movement.

To sum up, it should be claimed that since early childhood a particular attention should be paid to the issue of developing physical fitness in children since it leads to the sense of health. It also allows children to participate fully in school activities as well as in various forms of sports and recreation. It is pre-school age when children tend to be very sensitive, they also gain experience and learn proper patterns of behaviour. Therefore, it is important to take up actions among children aimed at promoting active leisure and limiting sedentary behaviours associated with the use of media, which will result in lower frequency of overweight and obese children.

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