ESTABLISHING PHYSICAL ACTIVITY OF 3RD – 4TH – GRADERS WITH ACCELEROMETERS

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ABSTRACT

Adolescents' physical activity is and must be an essential part of their daily routine for proper and balanced growth and development. The use of accelerometry, a method that records the motor activity time spent in a lying or sitting position over twenty-four hours, is well-known. The actual data about a person's movements enables us to be accurate and even to analyze the quantity and quality of those movements. We examined 135 children (mean age 129 months) with accelerometers Axivity model AX3, positioned around the wrist around the non-dominant arm. Based on consults, we established average values per twenty-four hours, namely – an average of 38.32% of the time children spent in a sitting position, 6.41% (92 min) they were engaged in a low activity, 15.42% (222 min - in a moderate activity, 1.79% (26 min) - in a high activity; and 38.06% of the time they spent sleeping. We found a weak correlation dependence r = -.263 (95%) between the body fat and the duration of the time spent in high activity.

Keywords*: physical activity, accelerometer, IMU, children*

INTRODUCTION

Monitoring physical activity based on accelerometry has become a preferred method in several physical activities (Schneller, 2017). Physical activity is "any movement of the body provoked by the contraction of skeletal muscles which increases the energy consumption above the basic level" (Caspersen et al., 1985). Total physical activity is characterized by evaluating its intensity, duration, frequency, and kind of activity done. It can be estimated with subjective and objective methods, one of which is measurement units (Arvidsson et al., 2019).

Some innovative research done in recent years in America and Western Europe emphasizes the advantage of extracurricular activities as a practical teaching approach since they show an increase in children's physical activity (Schneller et al., 2017; Beames et al., 2011; Dillon et al., 2006; Waite et al., 2013).

This research aimed to establish the motor activity of 3rd – 4th – graders and to create an evaluation scale based on the data obtained from the inertial measurement units, the data about the body contents, and the extracurricular activities.

METHODS

Participants

We traced the physical activity of 135 3rd and 4th graders studying at schools in Sofia. Their mean age was ten years and nine months, height 148.02 ± 6.97 cm, and weight 39.27 ±8.88 kg. Of all the researched individuals, 54% were female, and 46 % were male. We made a body composition analysis of the children's bodies and placed inertial measurement units (IMU) with the inbuilt accelerometer on their non-dominant arms. Those were like bracelets adhering to the wrists so they could reduce their free movement to the fullest extent. The devices were worn day and night over seven days. The children were ad-

vised not to remove them from their wrists. After receiving the devices from the children, we downloaded the information recorded on them with special software (OmGui) later used to process and analyze the data.

Body composition

The spectral segment analysis of the body was made with standard equipment produced by the company InBody, model InBody 230 (InBody USA). This analysis helped us obtain results about the distribution and relation of fats, muscle mass, and water in the body. Used normative for all parameters are taken from the Inbody system and their protocols.

Accelerometry

The three-axis inertial measurement units (IMU) we used were produced by the English company Axivity, model AX3 (Axivity Ltd), which could record on the accelerometer up to ±16G, frequency of the accelerometer of up to 3200Hz, inbuilt memory for 512MB and battery life of up to 30 days.

Table 1. *Physical activity levels defined by IMU sensors and their sample activity*

Degree of activity	Threshold MET unit	Sample activity
Sedentary	..... < 1.5	Sitting, lying position
Light activity	1.5 > ..... < 3.99	Walking, strolling
Moderate activity	3.99 > ..... < 6.99	Running with a slow pace
Vigorous activity	7.00 <	Sprint, boxing, jumping

1 MET = 3.5 mlO_2 . kg^-1 . min ^-1, which is equivalent to 58.2 W/m^2 or the ratio of the produced energy per surface unit of an average sitting person.

Questionnaire

A simple questionnaire was used to know the level of physical activity children do after school lessons. It included two questions that their parents answered so we could receive more objective data. The answers included data about the number of practices per week and the duration of each session.

Statistical analysis

The SPSS 19 (IBM, USA) was used for all statistical analyses. Data are presented as mean ± SD. The assumption of normality was tested with the Kolmogorov-Smirnov test on each variable. The level of statistical significance was set at $p < .05$. A Pearson product-moment correlation was used to determine the relationship between variables between the two tests. The magnitude of correlation was qualitatively ranked according as follows: $r \leq 0.1$, negligible; $0.1 < r \leq 0.3$, week; $0.3 < r \leq 0.5$, moderate; $0.5 < r \leq 0.7$, strong; $0.7 < r \leq 0.9$, very strong; and $r > 0.9$, almost perfect.

Table 2. *Researched indicators in the study*

№	Research indicator	Measurement unit	Precision
1	Average time spent in a sitting position per day	minutes	1 minute
2	Average time spent in light activity per day	minutes	1 minute
3	Average time spent in moderate activity per day	minutes	1 minute
4	Average time spent in vigorous activity per day	minutes	1 minute
6	Average time sleeping per day	minutes	1 minute
7	Body mass	kg	0.1 kg
8	Body mass index		0.1
9	Percent of fat mass	%	0.1%
10	Muscle mass	kg	0.1 kg
11	Attending extracurricular sports activities	Number	1
12	Number of extracurricular activities per week	Number	1
13	Duration of each extracurricular activity	min	30 min

RESULTS

The researched physical activity among children. The method for establishing the physical activity with inertial measurement units shows the actual activity done without indirect methods.

Some devices were not worn all the time by 9.3% of children, and their results were excluded from the analysis.

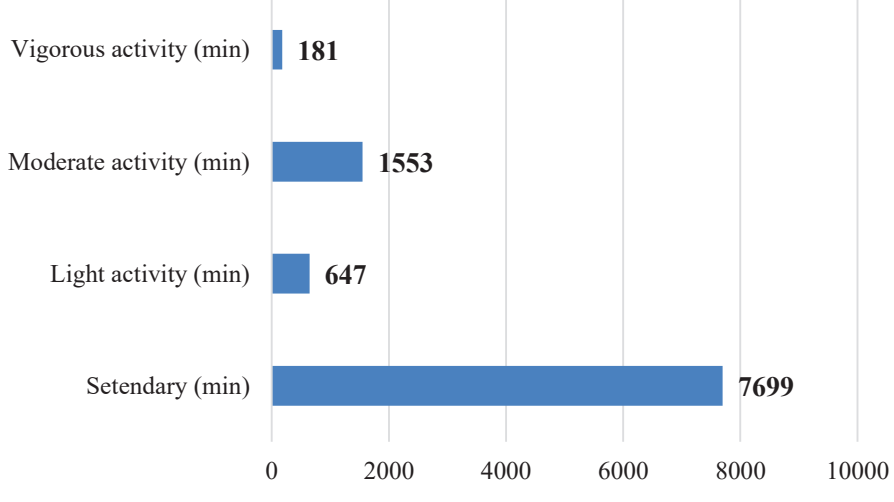

Figure 1. *The average duration of different activities over seven days*

The body analysis of the researched individuals is an inseparable part of the analysis for establishing their physical activity and determining its extent. Because of that, we can summarize the following results from the segmented body analysis.

Table 3. *Data from segment body analysis*

Degree of activity	Average Body Mass (kg)	Average Body mass index	Average % of fat mass	Average muscle mass (kg)
Low	33.81 ±5.06	15.16 ±1.19	11.06 ±4.68	15.38 ±2.44
Normal	41.58 ±7.17	18.86 ±1.88	17.89 ±6.34	16.95 ±3.58
High	54.55 ±8.05	25.361 ±2.91	31.53 ±9.03	18.45 ±7.21

As we can see in Figure 1, the other 89% (127 children) provided data that enabled us to analyze their activity and to determine that over seven days; they spent an average of 7699

min (76.4%) in sitting or lying position, 647 min (6.4%) engaged in light activity, 1553 min (15.4%) in moderate activity, and 181 min (1.8%) in vigorous activity.

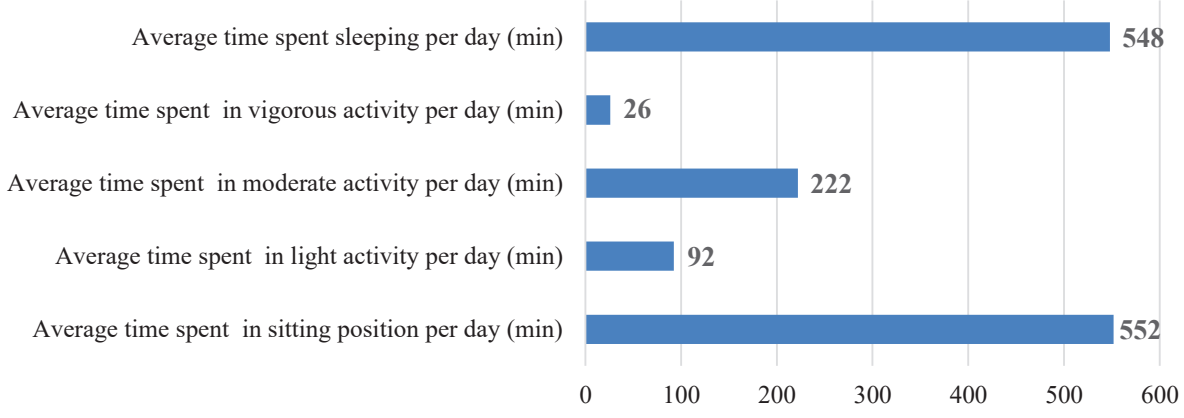

Figure 2. *Average duration of different activities over 24 hours*

The average values per day are presented in Figure 2, namely – an average of 38.32% in 24 hours the children spent in a sitting position, 6.41% (92 min) in light activity, 15.42% (222 min) in moderate activity, 1.79% (26 min) in vigorous activity, and 38.06% sleeping.

Table 4. *Correlation matrix of researched parameters*

	Average time spent in a sitting position per day (min)	*Average time spent in light activity per day (min)*	*Average time spent in moderate activity per day (min)*	*Average time spent in vigorous activity per day (min)*	*Average time spent sleeping per day (min)*	*Attending extracurricular sports activities*	*Number of extracurricular activities per week*	*Duration of each extracurricular activity*
Average time spent in a sitting position per day (min)	1							
Average time spent in light activity per day (min)	-.536	1						
Average time spent in moderate activity per day (min)	-.823	.664	1					
Average time spent in vigorous activity per day (min)	-.431	-.127	.324	1				
Average time spent sleeping per day (min)	-.209	-.337	-.343	-.074	1			
Attending extracurricular sports activities	-.203	.349	.306	-.128	-.155	1		
Number of extracurricular activities per week	.160	-.323	-.250	.137	.140	-.817	1	
Duration of each extracurricular activity	-.206	.039	.170	.154	.044	.166	.407	1

DISCUSSION

Identifying ways to encourage physical activity and reduce sedentary time during childhood is a topical issue in the field of public health (Schmutz et al., 2017). Mattocks et al. (2008) surveyed many years tracing pregnant women's physical activity and, afterward, their children's physical activity. They found a moderate relation between the mother and the 11-12-year-old children, which supposes that active parents are likely to raise active children. Therefore, helping parents increase their

physical activity can encourage children's activity as well also encourage children's activity Edwardson, Gorely (2010). Healthy behaviors, such as engaging in physical activity, are created in the early years and can be traced to childhood, adolescence, and maturity.

Children's physical activity and sedentary behavior should be measured precisely to trace their relation to health. Accelerometry provides objective and accurate body movement measurements, which can lead to significant conclusions regarding behavior (Verloigne et al., 2011). In the available literary sources, we found numerous surveys on motor activity of all age groups carried out with different aims and directed to sports, clinical practice, and prevention and encouragement of motor activity.

The most extensive surveys were done with three models of accelerometers - ActiGraph GT3X, Axivity AX3, and ActivPAL Micro4. Minimal differences have been obese in evaluations of the three accelerometers' physical behavior. On average, for 24 hours (1440 min), the absolute difference among the accelerometers is 1.2 min (0.001) for rest, 3.4 min (0.02) for standing, 3.5 min (0.06) for movement, 1.9 min (0.03) for walking, 0.1 min (0.19) for running, 1.2 min (0.19) for climbing stairs, 1.9 min (0.07) for cycling (Patrick et al., 2019).

In most surveys, the accelerometers are positioned above the right thigh (Migueles et al., 1999); however, according to Westerte (1999), the proximity of the sensor to the person's center of gravity is optimal. However, the correlation between the inertial sensors positioned on the thigh and wrist is strong in diverse everyday activities. The accelerometers on the wrist can be favorably compared to those on the thighs regarding moderate activity ($r = .88$ $p < .001$) and moderate to energetic physical activity (Scott et al., 2017). In our study, the accelerometer device was put on the wrist of the non-dominant hand.

High physical activity among children leads to improvement in numerous health directions: improvement of the physical level of the organism (cardio-respiratory and muscle condition), blood pressure, bone strength, cognitive results, psyche, and health (reducing the symptoms of depression), and primarily decreasing obesity.

The recommendations of the World Health Organization (WHO) for minimal levels of physical activity are the following:

- Children and adolescents should perform physical activities for at least 60 min a day weekly – starting from moderate to high intensity, primarily aerobic.
- High-intensity aerobic activities which stabilize muscles and bones should be included in children's activity at least three times a week.

The students participating in our investigation have an average sedentary time of 7699 min/week (76.3% of the test time), including sleep. They do light activity average of 674 min/week (6.4%), moderate activity, 1553 min/week (15.4%), and only 181 min/week (1.7%) in vigorous exercise.

The data from segmental analyses present the body content, and we can say that a significant percentage of the children - 73.3% were with a low relative weight of muscle mass, and 77.7% were with a normal or high percentage of body fat. It is indicative that although as many as 9.6% of the children were overweight, 100% showed high body fat values. Among 56.6% of the children with average body weight, there was a higher percentage of fat than the normal one, and 0% of them had a lower percentage of body fat than the normal one. These figures should indicate the incorrect distribution of the body contents caused by the improper way of life and diet.

The correlation analysis showed a weak dependence between "Average time spent in high activity" and "% of body fat" r = -.263, at a significance level of 0.01.

Extracurricular activities are a priority for most educational programs because they improve physical activity among children. We found that 62 (59%) of the children do sports as part of their extracurricular activities, and 43 (41%) - do not.

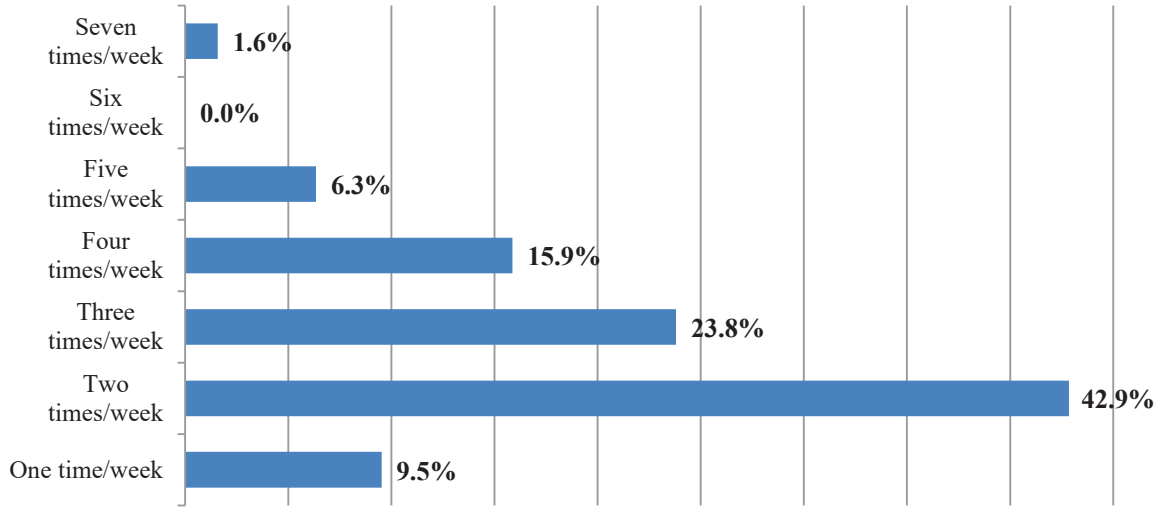

Figure 3. *Proportion of the extracurricular sports activities done over a week*

The data presented in Figure 3 shows that 42.9% practiced sport twice a week, 23.8% - three times, and 15.9% - four times a week. The duration of these activities done by the children was approximately 97 min long.

The children who were engaged in extracurricular sports activities and were overweight constituted 53.8% of all children whose weight was above normal, and only 63% of the children, who were normal weight, were engaged in extracurricular sports activities; 50 % of the children with high levels of percentage of body fats were actively practicing different kinds of sports. This data was presented in absolute values in Table 5.

Table 5. *Table of frequencies of extracurricular activities*

Attending extracurricular sports activities	Frequency	Number of extra-curricular activities per week	Frequency	Duration of each extracurricular activity (min)	Frequency
Yes	62	0	42	0-30	42
No	43	1	6	31-60	2
		2	27	61-90	30
		3	15	91-120	14
		4	10	121-150	8
		5	4	151-180	2
		6	0	181-210	3
		7	1	211-240	1
				>240	3

Regarding the data from Table 4, there was a moderate correlation between "Average time spent in low activity per day" and "Attending extracurricular sports activities" r = -.349, at a significance level of 0.05, also with "Number of extracurricular activities per week" – r = -.323 at significance level 0.05. The same correlations are defined between "Average time spent in moderate activity per day" to "Attending extracurricular sports activities." and "Number of extracurricular activities per week".

CONCLUSION

All researched children were with motor activity above the minimal requirements of the WHO, but only 8.0% were engaged in over 60 min motor activities with high intensity; 17.6% of the children were engaged in motor activities in increased intensity in the range of 30 and 60 min per day; 60.2% were engaged in high-intensity activities for less than 30 min a day. We did not obtain data about 13.9% of the researched individuals in this relation.

The body contents showed that 9.6% of the analyzed children were overweight and that all children had a higher percentage of body fats than normal. The results for the children with normal weight showed that 56.6% had a percentage of body fat above the norm and muscle mass below the norm for this age.

The extracurricular sports activities were practiced by 57% of the researched individuals, and 67.2% practiced from 1 to 3 times weekly. The other 32.8% practiced from 4 to 7 times a week. The sports activities correlate weakly, with a reversed dependence, to the average time spent in low activity per day and with a direct dependence on the skeletal muscle mass.

The children were engaged in a high-intensity motor activity for over 30 min. Only 7% of all researched individuals and only 12 (34%) had a higher body fat percentage than the normal one; 60% were doing sports.

Based on these summarized results, we recommend significantly reducing the time spent sitting in front of digital devices and TV and increasing children's movement. Also, the obtained results should serve as a reference point for future surveys with a more significant number of subjects aimed at creating evaluations of the level of motor activity and body contents of children.

There are several limitations of this study. First, we were able to do research at only one school. Another limitation was that we received only 52% of the parental agreement for their children's involvement in the survey. Further research should be done with a bigger sample and at a greater number of schools to justify the obtained results.

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