



The association between the level of physical activity with spinal posture and physical fitness parameters in early adolescence

Udruženost nivoa fizičke aktivnosti sa stavom kičmenog stuba i parametrima fizičke sposobnosti i ranoj adolescenciji

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Abstract

Background/Aim. A low level of physical activity and sedentary lifestyle affects the body posture in adolescents. The aim of this study was to assess the core relation between the level of physical activity and spinal posture as well as physical fitness parameters in 11–14 years old teenagers. **Methods.** The cross-sectional study included 532 children, aged from 11 to 14 years. The study was carried out at three Lithuanian schools in 2011–2013. The Youth Physical Activity Questionnaire (YPAQ) was used to assess physical activity. Spinal posture was assessed according to the Hoeger visual posture assessment method. Physical capacity was evaluated using a 6-min walking test (6 MWT) and by calculating maximum oxygen consumption (VO₂max). Other physical fitness such as the general balance, flexibility, explosive leg power and abdominal muscle endurance were evaluated by applying the European Fitness Test (Eurofit). According to time spent doing moderate to vigorous intensity physical activities (MVPA), the sample was divided into 2 groups – a low activity level group and moderate to vigorous intensity physical activity level group. We compared the spinal posture evaluation results and

physical fitness parameters between groups as well as correlations between the duration of MVPA, spinal posture evaluation results and physical fitness parameters. **Results.** The study showed that 22.2% of teenagers had a low physical activity level and 16% of teenagers had an incorrect posture. The teenagers of low physical activity group were less physically fit and had the poorer posture than teenagers in the MVPA group. During the 6MWT, the teenagers in the low physical activity group walked on average 63.2 m less ($p = 0.002$), and their VO₂max was 0.8 mL/kg/min lower ($p = 0.006$) than that of teenagers in the MVPA group. The teenagers in the low physical activity group also did not perform as well in the explosive leg power and abdominal muscle endurance tests compared to teenagers in the MVPA group. Correlations between the duration of MVPA and spinal posture evaluation results as well as some physical fitness parameters were very weak. **Conclusion.** The teenagers of low physical activity were less physically capable and had poorer posture than the teenagers in the MVPA group.

Key words: adolescent; exercise; physical fitness; posture; spine.

Apstrakt

Uvod/Cilj. Nedovoljna fizička aktivnost i sedentaran stil života utiču na stav kičmenog stuba kod adolescenata. Cilj rada bio je da se proceni povezanost nivoa fizičke aktivnosti i stava kičmenog stuba, kao i parametara fizičke sposobnosti kod mladih u ranom adolescentnom dobu (11–14 godina života). **Metode.** Studijom preseka obuhvaćena su 532 adolescenta, uzrasta 11–14 godina. Studija je sprovedena u tri litvanske škole, u periodu od 2011. do 2013. godine. Za procenu fizičke aktivnosti korišćen je Upitnik fizičke aktivnosti omladinaca – *the Youth Physical Activity Questionnaire* (YPAC). Fizička aktivnost je procenjivana korišćenjem šestominutnog testa hodanja i određivanjem maksimalne potrošnje kiseonika (VO₂max).

Ostali parametri fizičke sposobnosti, kao što su opšti balans, savitljivost, eksplozivna snaga noge i izdržljivost trbušnih mišića procenjivani su primenom Evropskog testa fizičke sposobnosti – *the European Fitness Test* (Eurofit). Prema vremenu posvećenom fizičkoj aktivnosti ispitanici su podeljeni u dve grupe – grupa sa niskim nivoom fizičke aktivnosti (I grupa) i grupa sa umerenim do visokim nivoom fizičke aktivnosti (II grupa). Upoređivani su rezultati stava kičmenog stuba i parametara fizičke sposobnosti među grupama, kao i povezanost trajanja fizičke aktivnosti umereno-visokog intenziteta, stava kičmenog stuba i parametara fizičke sposobnosti. **Rezultati.** Ukupno 22,2% adolescenata imalo je nizak nivo fizičke aktivnosti, a 16% nepravilan stav kičmenog stuba. Ispitanici I grupe bili su manje fizički sposobni i imali su lošiji stav kičmenog

stuba od ispitanika II grupe. Za vreme šestominutnog testa hodanja, adolescenti I grupe hodali su prosečno 63,2 m manje ($p = 0,002$) i njihov $VO_2\max$ bio je za 0,8 mL/kg/min niži od $VO_2\max$ adolescenata II grupe ($p = 0,006$). Adolescenti I grupe bili su slabiji u eksplozivnoj snazi nogu i testu izdržljivosti trbušnih mišića u poređenju sa adolescentima II grupe. Nađena je slaba korelacija između trajanja fizičke aktivnosti umerenog do jakog intenziteta i stava kičmenog stuba, kao i nekih para-

metara fizičke sposobnosti. **Zaključak.** Adolescenti sa slabom fizičkom aktivnošću bili su manje fizički sposobni i imali lošiji stav kičmenog stuba nego adolescenti sa fizičkom aktivnošću umerenog do jakog intenziteta.

Ključne reči:
adolescenti; vežbanje; sposobnost, fizička; telo, držanje; kičma.

Introduction

Physical activity in youth is associated with many health benefits in school-aged children and young people^{1,2}. Despite the known importance and associated benefits of regular physical activity in promoting lifelong health and well-being, some studies suggest that levels of physical activity decline dramatically during adolescence^{3,4}. The World Health Organization (WHO) recommends for children and teenagers to apply at least 60 min of moderate to vigorous intensity physical activity daily⁵. However, data suggest that the majority of young people do not meet these guidelines, with approximately 80% of 13–15 year olds worldwide who are insufficiently physically active⁶.

Childhood and adolescence is a period of rapid growth and development, since the dramatic physiological and psychological changes take place at these ages. Most postural problems occur in this period. The body posture depends on many factors, but it is worth emphasizing that a low level of physical activity and sedentary lifestyle also has a significant impact on the postural parameters^{7,8}.

Physical fitness is considered to be a useful health marker already in childhood and adolescence⁹. Physical fitness is generally considered to be “the ability to perform daily tasks without fatigue.” Muscular strength, muscular endurance, cardiovascular endurance, joint flexibility, and body composition are the health-related fitness components of fitness¹⁰. Physical fitness is in part genetically determined, but it can also be greatly influenced by environmental factors. Physical activity is one of the main determinants^{11,12}.

However, little is known about the relationship between the physical activity level and spinal posture as well as the physical fitness parameters such as physical capacity, balance, flexibility, muscle power and endurance in the stage of early adolescence.

Methods

Study design and population

The cross sectional study was carried out at three Lithuanian schools in 2011–2013. The study was performed by the cluster sampling method. All schoolchildren in the 5th–7th grades were invited to participate. The participation rate was 84.7%. The study population consisted of 532 children, aged from 11 to 14 years (12.99 ± 0.96 years).

The subjects were examined during the first half of the day during the physical education classes and according to

the research protocol. The Youth Physical Activity Questionnaire (YPAQ) was filled in at home by the respondents with the help of their parents.

The subject's selection criteria were: 11–14 year old teenagers and the written parental permission. The subject's rejection criteria were: teenagers younger than 11 and older than 14 years of age; unwillingness to participate in the study; teenagers excused from participating in physical education classes.

The study was conducted with the approval of the Lithuanian Bioethics Committee (Protocol No.1.17/3/2011). The informed consent was obtained in written form from the parents of each participating child.

Assessment of physical activity

The study used YPAQ¹³. The questionnaire listed various physical activities, and participants had to indicate the frequency and duration of the activities they undertake over the course of a week, indicating the activities they undertake on weekdays and weekends. This questionnaire was also used to evaluate the nature, frequency and duration of physical activities and passive activities in various settings, e.g., at school and during free time¹⁴.

Every activity was assessed based on the Compendium of Energy Expenditures for Youth (2008)¹⁵ according to the appropriate Metabolic Equivalent for Task (MET) level, and the intensity of physical activity was also assessed. Activities were categorized according to intensity into low-intensity (< 3 MET), medium-intensity (3–6 MET) and vigorous intensity (> 6 MET) groups.

Time spent doing medium to vigorous intensity physical activity (MVPA) and screen time was calculated based on the data collected from the questionnaire. The total time spent doing MVPAs was determined by summing up the duration of MVPAs over the course of one week. The MET min of physical activity were calculated by using the following formula: duration \times frequency \times MET intensity¹⁵. Based on the modified recommendations for the evaluation of physical activity¹⁶, the participants were categorized according to their total MVPA into physical activity levels: I – low physical activity < 1,260 MET-min/week; II – moderate-vigorous physical activity > 1,260 MET-min/week.

The questionnaire was translated into the Lithuanian language. The back translation was performed, compared and discussed. The cultural adaptation was performed and the final version of questionnaire was conducted, and tested during the pilot study.

Assessment of spinal posture

Spinal posture was assessed according to the Hoeger and Hoeger¹⁷ visual posture assessment method. The positioning of ten body segments was awarded 1, 3 or 5 points, where 1 is poor, 3 is average and 5 is good. Head, shoulder, spine, hips, knee and ankle positions were assessed in the frontal plane; neck and upper back, trunk, abdomen, lower back and legs were assessed in the sagittal plane. General posture evaluations were calculated by adding the total number of points acquired from the evaluation of body segments: 50-45 points – excellent posture, 44-40 points – good, 39-30 – average, 29-20 – poor, less than 19 – extremely poor.

Assessment of physical fitness parameters

The 6-minute walking test (6 MWT) was used to assess physical capacity. This test is reliable for evaluating the physical capacity not only for the patients with a wide range of diagnoses but also for the healthy children¹⁸⁻²⁰. During the test, the participants were separated into groups of 8. The participants were instructed to walk for 6 min along the boundary lines of a standard volleyball court (54 m). The test results were registered as the distance travelled in 6 min, expressed in m.

Physical capacity was also assessed by a maximum oxygen consumption ($VO_2\max$), which was calculated with the results of the 6MWT and data about the body mass index (BMI) entered into a formula developed by Vanhelst et al.²¹: $VO_2\max$ (mL/kg/min) = $26.9 + 0.014 \times \text{distance travelled during the 6MWT (in m)} - 0.38 \times \text{BMI (kg/m}^2\text{)}$.

Physical fitness was also evaluated by applying The European Fitness Test (Eurofit)²² in the following order:

Flamingo Balance Test

The test assesses general balance. During the test the participant must stand on a balancing beam of a set height on one leg. Ability to balance was measured by recording the number of attempts (not falls) to maintain balance on the balancing beam in 1 min, with the time recorded by chronometer.

Sit-and-Reach Test

The test of flexibility during which the participant reaches their hands as far as they can while sitting on a horizontal surface with their legs straight. The result recorded is the furthest point reached by the tips of the fingers, measured in cm. For the result to be accurate, the participant must maintain this position for about 2 sec. The test is slowly carried out twice (the sec time after a brief resting period). The better result is recorded (measured in cm reached on the cm ruler on top of the measurement box).

Standing Long Jump Test

The test assesses explosive leg power in the act of jumping from a standing position and pushing off with both feet. The test is carried out twice, and the greater distance jumped is recorded in cm.

Sit-ups Test

The test evaluates abdominal muscle endurance. The participants must complete as many sit-ups as possible in 30 sec. Correct position: straight back, fingers interlocked behind the head, knees bent at a 90 degree angle, sole of the foot on the floor. The participant must lie back and touch the exercise mat with their shoulders, and then sit up into the initial position with their elbows touching their knees. The participants must do a preparatory sit-up before the test begins. The recorded result is the number of correctly completed sit-ups in 30 sec.

Statistical analysis

The statistical analysis was carried out with the IBM SPSS 20 software package.

A descriptive statistical analysis of the data was conducted, calculating the arithmetic mean of quantitative data, standard deviations (SD), minimum (min) and maximum (max) data limits and frequency distributions of qualitative data.

The one-sample Kolmogorov-Smirnov test was used to test the goodness-of-fit of the data distribution to a standard normal distribution. The parametric analysis (Student's *t*-test) was applied in order to compare the indicators from the normal distribution, and nonparametric analysis (Mann Whitney *U*-test) was applied to the nonnormal distribution and ordinal variables.

The Pearson's and Spearman's correlation coefficients (*r*) were used to determine the correlations (with the Pearson's coefficient for normally distributed interval variables and the Spearman's coefficient for interval variables that do not satisfy the condition of normality and ordinal variables). The correlation was very weak if *r* < 0.2; weak if *r* was in the interval of 0.2–0.39; moderate if *r* was in the interval of 0.4–0.69; strong if *r* was in the interval of 0.7–0.89 and very strong if *r* was greater than 0.9. The differences considered statistically significant if *p* was less than 0.05 (*p* < 0.05).

Results

The analysis of physical activity data demonstrated that the teenagers spent from 7.1 min to 408.6 min doing MVPA every day (91.4 ± 66.8 min on average). On weekends, the teenagers spent more time (16.2 min on average) doing MVPA than on school days.

The subjects were classified into low-activity group and MPVA (Table 1).

The teenagers in the low physical activity group made up 22.2% of the sample population, with the teenagers in the MPVA group taking up the remaining 77.8%.

The analysis of posture evaluation in the different physical activity groups demonstrated that the posture of teenagers in the low physical activity group was evaluated as poorer than that of teenagers in the MPVA group: the average sum of Hoeger points received by the teenagers in the low physical activity group reached 36.7 ± 7.7 points, whereas the teenagers in the MPVA group were evaluated with an average of 39.1 ± 7.2 (*p* = 0.008).

Table 1
Characteristics of adolescent groups according to different intensities of physical activity

Characteristics	Group (intensity)	
	low n = 118 (22.2%)	moderate-vigorous n = 414 (77.8%)
Age (year), mean \pm SD	12.89 \pm 1.09	13.02 \pm 0.97
Gender, n (%)		
girls	83 (70.3)	205 (49.5)
boys	35 (29.7)	209 (50.5)

SD – standard deviation.

Table 2
Spinal posture assessment in different body segments

Body segments	Spinal posture (%)		
	poor	average	good
Frontal plane			
head	3.6	30.8	65.6
shoulders	8.7	66.1	25.2
spine	3.6	66.1	30.3
hips	2.9	45.8	51.3
knees and ankles	4.4	33.9	61.7
Sagittal plane			
neck and upper back	2.9	32.9	64.2
trunk	3.9	37.2	58.9
abdomen	2.9	38.3	58.8
lower back	7.7	51.6	40.7
legs	2.2	20.8	77.0

Table 3
Physical fitness parameters in teenagers

Physical fitness parameters	Min–max	Mean \pm SD
6 MWT distance (meters)	340.0–980.6	625.2 \pm 146.4
VO ₂ max (mL/kg/min)	21.6–34.8	28.4 \pm 2.6
Balance (n/min)	1.0–40.0	13.7 \pm 6.9
Explosive leg power (cm)	29.0–225.0	157.6 \pm 25.7
Flexibility (cm)	2.0–43.0	22.3 \pm 7.8
Abdominal muscle endurance (n ¹ /30 s)	12.0–90.0	26.7 \pm 5.9

SD – standard deviation; 6MWT – 6 min walking test; VO₂max – maximum oxygen consumption; n – number of attempts (not falls) to maintain balance; n¹ – number of correctly completed sit-ups.

The results of the spinal posture assessment in different body segments are presented in Table 2.

The analysis demonstrated that the shoulders in the frontal position and the lower back in the sagittal position received the least points: 8.7% of teenagers had poor shoulders position and 7.7% of teenagers had poor lower back position. The analysis of distribution according to the general posture evaluation showed that 53% of the participants had excellent or good posture, 31% had average posture and 16% had poor or extremely poor posture.

The analysis of physical fitness parameters revealed that the distance travelled during the 6MWT ranged from 340.0 to 980.6 meters. The teenager's VO₂max ranged from 21.6 mL/kg/min to 34.8 mL/kg/min. The results of the other physical fitness parameters (balance, flexibility, explosive leg power, abdominal muscle endurance) are presented in Table 3.

A statistically significant and positive but very weak link was identified between the spinal posture results and the duration of MVPA ($r = 0.186$; $p < 0.001$) (Figure 1). This indicates that the posture of teenagers who were more physically active received higher evaluations.

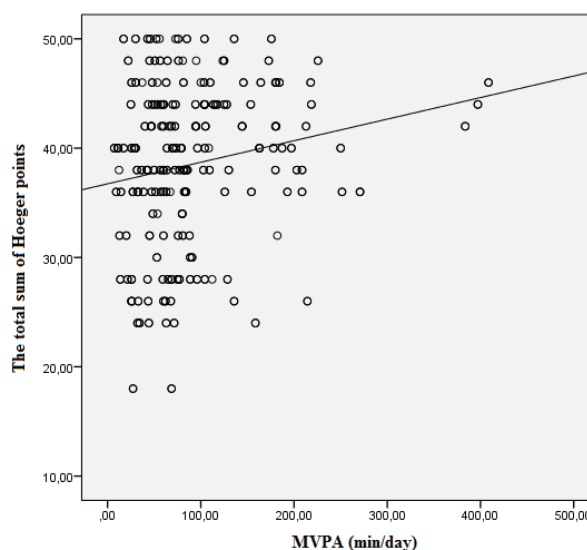


Fig. 1 – Correlation between the moderate-vigorous physical activity (MVPA) and posture of teenagers ($r = 0.186$; $p < 0.001$).

Table 4**Physical fitness parameters in the low group and moderate-vigorous physical activity (MVPA) group**

Physical fitness parameters	Low physical activity group	MVPA group	<i>p</i> -value
	(n = 118)	(n = 414)	
	mean ± SD	mean ± SD	
6 MWT distance (meters)	571.8 ± 117.1	635.0 ± 149.2	0.002*
VO ₂ max (mL/kg/min)	27.7 ± 1.7	28.5 ± 2.8	0.006*
Balance (n/min)	13.4 ± 6.1	13.8 ± 7.1	0.582
Explosive leg power (cm)	153.3 ± 25.4	158.8 ± 25.7	0.05*
Flexibility (cm)	23.2 ± 7.2	22.0 ± 7.9	0.174
Abdominal muscle endurance (n ₁ /30s)	25.4 ± 4.7	27.0 ± 6.2	0.005*

6 MWT – 6-minute walk test; VO₂max – maximal oxygen consumption; SD – standard deviation; n – number of attempts (non falls) to maintain balance; n₁ – number of correctly completed sit-ups.

***statistically significant.**

The results of the physical fitness tests indicate that, during 6MWT, the teenagers in the low physical activity group walked on average 63.2 m less ($p = 0.002$), and their VO₂max was 0.8 mL/kg/min lower ($p = 0.006$) than that of teenagers in the MVPA group.

The teenagers in the low physical activity group did not perform as well in the explosive leg power and the abdominal muscle endurance tests compared to the teenagers in the MVPA group. On average, the low physical activity teenagers jumped a distance 5.5 cm shorter ($p = 0.005$) and completed 1.6 fewer sit-ups ($p = 0.050$) than the teenagers in the MVPA group. No statistically significant differences were found in the results of the balance and flexibility tests. The results of the assessment of physical fitness parameters are presented in Table 4.

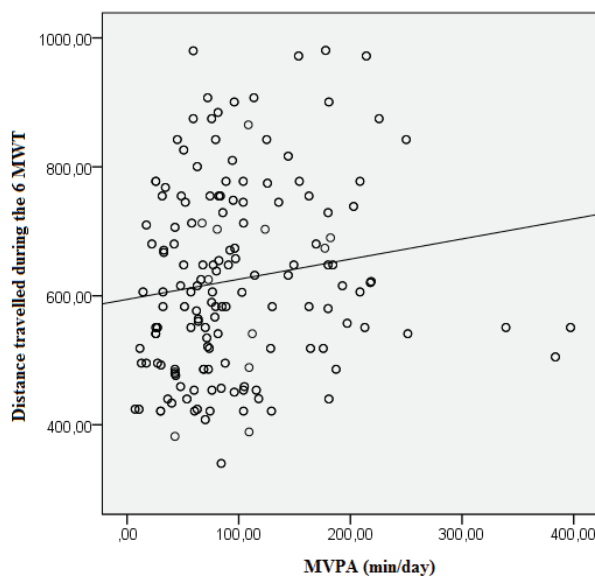


Fig. 2 – Correlation between the moderate-vigorous physical activity (MVPA) and the distance travelled during the 6-min walking test (6 MWT) of teenagers ($r = 0.148$; $p = 0.010$).

MVPA of teenagers had a statistically significant and positive but very weak link with the distance travelled during 6MWT ($r = 0.148$, $p = 0.010$) (Figure 2) and VO₂max ($r = 0.155$; $p = 0.009$) (Figure 3), which demonstrates that the teenagers who were more physically active achieved better results in the physical capacity test.

The correlation analysis of the other teenagers' physical fitness parameters and MVPA revealed a very weak positive correlation between the duration of MVPA and explosive leg power ($r = 0.101$; $p = 0.040$).

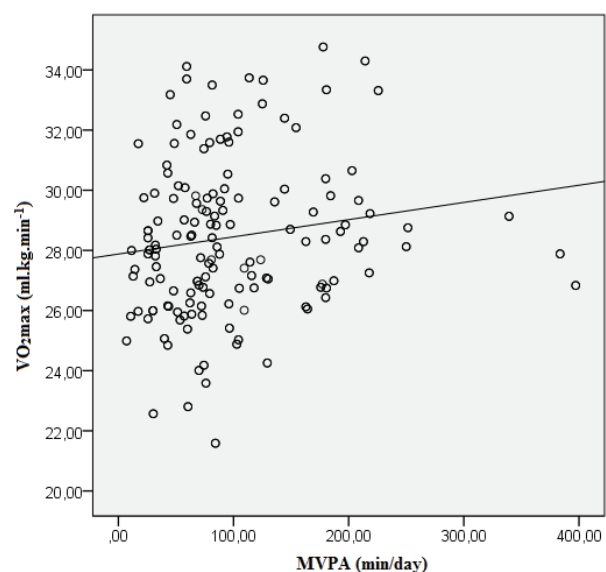


Fig. 3 – Correlation between the moderate-vigorous physical activity (MVPA) and maximum oxygen consumption (VO₂max) of teenagers ($r = 0.155$; $p = 0.009$).

Discussion

Scientific research demonstrates that the majority of adults and children across the entire world are not sufficiently physically active, and this level of physical activity keeps decreasing in all age groups^{23–25}. Aside from this, physical activity naturally decreases as children grow up^{26,27}. Scientific research has established that only 1 in 5 children in the European Union is sufficiently physically active to satisfy recommendations for physical activity²⁸. The results of our study also revealed that slightly more than a fifth of 11–14 year old teenagers could be classified in the low-level activity group. We also observed that there were more girls in the low-level activity group than boys.

Physical activity is a lifestyle factor that can determine an individual's physical capacity²⁹, which apart from being an important indicator of health in childhood and adulthood, is also a significant risk factor for cardiometabolic diseases³⁰. Scientific studies have provided evidence for the link between the aerobic capacity of children as well as teenagers and medium-high intensity physical activity³¹. Our study also showed that the teenagers in the low physical activity group travelled a shorter distance during the 6MWT and had lower VO_{2max} than the teenagers in the CMVPA group. The other authors analyzed differences in the health-related physical capabilities among 12, 14 and 16 year old Lithuanian teenagers from 1992 to 2002, and observed that the physical capacity of children and teenagers was decreasing. A comparison of data from 1992 and 2002 revealed a strong decrease in the boy's and girl's physical capacity. The authors attribute this change to a reduced level of daily physical activity³².

The correlation analysis between the physical activity and physical capacity indicators found a link between the duration of MVPA and the distance travelled during the 6MWT ($r = 0.148$) as well as VO_{2max} ($r = 0.155$), which means that the teenagers who are more physically active perform better on the physical capacity tests. An overview by Kristensen et al.¹¹ also indicates that studies of children's physical activity and physical capacity frequently find weak to moderate correlations between these two factors (with the r coefficient varying from 0.14 to 0.33). Thus, even though aerobic power in childhood is determined by genetic factors^{33,34}, physical activity is probably an important factor that influences the children's physical capacity.

Physical activity is also important for maintaining a correct posture. Studies have shown that moderate physical activity increases abdominal strength and reduces the risk of back pain³⁵. Mucha et al.³⁶ found that the young people aged 14–16 years characterized by increased physical activity had a more correct value of lumbar lordosis, the angle of the sacrum, the difference in the distance of the scapula's from the spine, and a greater spinal range of motion in the sagittal and frontal planes than their peers with the average and low physical activity level. Our study also revealed that the teenagers in the low physical activity group had poorer posture: the posture of teenagers in the lower physical activity group received on average 2.4 points less than the teenagers in the MVPA group.

The correlation analysis demonstrated that the duration of teenagers' MVPA had a very weak, positive correlation with the total sum of Hoeger points ($r = 0.186$), which also indicates that the more physically active teenagers had better posture. Latalski et al.⁷, who assessed the posture and physical activity of 14 year old teenagers in Poland and the Czech Republic, also found a link between the low levels of physical activity and incorrect posture⁷. The study performed by Wyszynska et al.³⁷ also revealed that the physical activity level determined the variability of the parameter characterizing the body posture. However, as an overview of scientific

literature indicates, even though it has long been established that the physical activity influences posture, this link has not been sufficiently studied³⁸.

The results of our study also revealed a link between the teenager's physical activity and their physical fitness. It was observed that the teenagers of low-level physical activity did not perform as well in the explosive leg power and abdominal muscle endurance tests as teenagers in the MVPA group. A positive very weak correlation was noticed between the duration of teenagers' MVPA and explosive leg power ($r = 0.101$). Martinez-Gomez et al.³⁹ also determined that the high intensity physical activity had a positive effect on teenagers' muscle power and strength. Given that the physical fitness components relate in different ways to the different health outcomes, physical activity programs should be designed to improve not only the levels of cardiorespiratory fitness but also the muscular fitness and speed/agility⁹. It is also important to emphasize that adolescence is characterized by some specificities of the metabolism and the reactions of the organism. Physiologically, early adolescence is dominated by puberty and sexual development⁴⁰. During normal puberty, height and body weight increase, bone mass and muscle mass increase, blood volume expands, and the heart, brain, lungs, liver, and kidney all increase in size⁴¹, so puberty affects almost all bodily systems. However, very few studies have been conducted to examine the association between the teenagers' physical activity and physical fitness parameters such as balance, flexibility, muscle power and endurance.

The main limitation of this study was that the sample is not large enough for regressive analysis and model construction, which would have allowed to establish causal links between physical activity and spinal posture as well as physical fitness parameters in early adolescence. The other limitation of the study was the indirect method for predicting VO_{2max} , which may be less accurate than the direct methods. Thus, it would be useful to continue research on this subject.

Conclusion

In the early stages of adolescence, the spinal posture and physical fitness parameters had very weak correlations with the physical activity level. On the other hand, the teenagers of low physical activity were less physically capable than the teenagers in the moderate to vigorous physical activity group. The incorrect posture, weak leg power and weak abdominal muscle endurance were more frequent among teenagers of low physical activity. The findings underline the need for interventions to increase physical activity level and improve the spinal posture as well as physical fitness in teenagers.

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