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THE ASSOCIATION BETWEEN THE LEVEL OF PHYSICAL ACTIVITY WITH SPINAL POSTURE AND PHYSICAL FITNESS PARAMETERS IN EARLY ADOLESCENCE

Aurelija Sidlauskiene*, Birute Strukcinskiene§, Juozas Raistenskis*, Rimantas Stukas*, Vaiva Strukcinskaite*, Raimondas Buckus*

*Faculty of Medicine, Vilnius University, Vilnius, Lithuania
§Faculty of Health Sciences, Klaipeda University, Klaipeda, Lithuania

**Correspondence to:** Birute Strukcinskiene, Faculty of Health Sciences, Klaipeda University,
H. Manto str. 84, Klaipeda, LT-92294, Lithuania.
Phone: +370 698 03097. E-mail: birutedoctor@hotmail.com
ABSTRACT

Background/Aim. To assess the association 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 consisted of 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-minute walking test (6 MWT) and by calculating maximum oxygen consumption (VO₂max). Other physical fitness such as general balance, flexibility, explosive leg power and abdominal muscle endurance were evaluated by applying The European Fitness Test (Eurofit). Correlations between the duration of moderate-vigorous physical activity, spinal posture evaluation results and physical fitness parameters were analyzed. According to time spent doing moderate to vigorous intensity physical activities (MVPA) the sample was divided into 2 groups – a low activity level and moderate-vigorous level of physical activity. We compared spinal posture evaluation results and physical fitness parameters between groups as well as correlations between the duration of moderate-vigorous physical activity, spinal posture evaluation results and physical fitness parameters. Results. The study showed that 22.2% of teenagers had low physical activity level and 16% of teenagers had incorrect posture. Teenagers of low physical activity group were less physically fit and had poorer posture than teenagers in the moderate-vigorous physical activity group. During the 6-minute walking test, teenagers in the low physical activity group walked on average 63.2 meters less (p = 0.002), and their maximum oxygen consumption (VO₂max) was 0.8 ml.kg.min⁻¹ lower (p = 0.006) than that of teenagers in the moderate-vigorous activity group. 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 moderate-vigorous physical activity group. Correlations between the duration of moderate to vigorous intensity physical activity (MVPA) and spinal posture evaluation results as well as some physical fitness parameters were very weak. Conclusion. Teenagers of low physical activity were less physically capable and had poorer posture than teenagers in the moderate to vigorous physical activity group.

Keywords: physical activity, spinal posture, physical fitness, adolescence.
INTRODUCTION

Physical activity in youth is associated with many health benefits in school-aged children and youth\(^1\),\(^2\). Despite the known importance and associated benefits of regular physical activity in promoting lifelong health and well-being, studies suggest that levels of physical activity decline dramatically during adolescence\(^3\),\(^4\). The World Health Organization (WHO) recommends for children and teenagers to accumulate at least 60 minutes of moderate to vigorous intensity physical activity daily\(^5\). However, data suggest that the majority of youth do not meet these guidelines, with approximately 80% of 13–15 year olds worldwide insufficiently physically active\(^6\).

Childhood and adolescence is a period of rapid growth and development, since 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 adolescence\(^9\). 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 fitness\(^10\). 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, not enough is known about the relationship between physical activity level and spinal posture as well as 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).

Subjects were examined during the first half of the day during 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.
Subject’s selection criteria: 11-14 year old teenagers; written parental permission. Subject’s rejection criteria: 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). Informed consent was obtained in written form from the parents of each participating child.

Assessment of physical activity

The study used the Youth Physical Activity Questionnaire (YPAQ)\(^1\). The questionnaire lists various physical activities, and participants must 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 is 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 time\(^\text{14}\).

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

Time spent doing medium to vigorous intensity physical activities (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 moderate to vigorous intensity activities over the course of one week. The MET (metabolic equivalent) minutes of physical activity were calculated by using the following formula: duration \(\times\) frequency \(\times\) MET intensity\(^\text{16}\). Based on modified recommendations for the evaluation of physical activity\(^\text{17}\) , participants were categorized according to their total MVPA into physical activity levels:

I. Low physical activity \(<\ 1260\ \text{MET-min/week};

II. Moderate-vigorous physical activity \(>1260\ \text{MET-min/week}.

The questionnaire was translated into the Lithuanian language. 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\(^\text{18}\) 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

A 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 children 19, 20, 21. During the test, participants were separated into groups of 8. The participants were instructed to walk for 6 minutes along the boundary lines of a standard volleyball court (54 m). The test results were registered as the distance travelled in 6 minutes, expressed in meters.

Physical capacity was also assessed by maximum oxygen consumption (VO$_2$max), which was calculated with the results of the 6-minute walking test and data about body mass index (BMI) entered into a formula developed by Vanhelst et al. (2013) 22: VO$_2$max (ml.kg.min$^{-1}$) = 26.9 + 0.014 × distance travelled during the 6-minute walking test (in meters) – 0.38 × BMI (kg/m2).

Physical fitness was also evaluated by applying The European Fitness Test (Eurofit) 23 in the following order:

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

2. Sit-and-Reach Test. A 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 centimeters. For the result to be accurate, the participant must maintain this position for about 2 seconds. The test is slowly carried out twice (the second time after a brief resting period). The better result is recorded (measured in centimeters reached on the centimeter ruler on top of the measurement box).

3. 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 centimeters.
4. **Sit-ups Test.** The test evaluates abdominal muscle endurance. Participants must complete as many sit-ups as possible in 30 seconds. 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. Participants must do a preparatory sit-up before the test begins. The recorded result is the number of correctly completed sit-ups in 30 seconds.

**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 and maximum data limits (min-max) and frequency distributions of qualitative data.

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

Pearson and Spearman correlation coefficients (r) were used to determine correlations (with the Pearson coefficient for normally distributed interval variables and the Spearman 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. Differences considered statistically significant if p is less than 0.05 (p < 0.05).

**RESULTS**

The analysis of physical activity data demonstrated that teenagers spent from 7.1 minutes to 408.6 minutes doing moderate to vigorous intensity activities (MVPA) every day (91.4 ± 66.8 min on average). On weekends, teenagers spent more time (16.2 min on average) doing moderate to vigorous intensity activities (MVPA) than on school days. Based on the modified data processing and analysis guidelines presented by the International Physical Activity Questionnaire (IPAQ), test subjects were classified into low-activity and moderate-vigorous physical activity groups (Table 1).
Table 1. Groups according to physical activity

<table>
<thead>
<tr>
<th>Groups according to physical activity</th>
<th>n (%)</th>
<th>Age (years)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low physical activity group</td>
<td>118 (22.2 %)</td>
<td>12.89 ± 1.09</td>
<td>Girls, n (%)</td>
</tr>
<tr>
<td>Moderate-vigorous physical activity group</td>
<td>414 (77.8 %)</td>
<td>13.02 ± 0.93</td>
<td>Girls, n (%)</td>
</tr>
</tbody>
</table>

Teenagers in the low physical activity group made up 22.2% of the sample population, with teenagers in the moderate-vigorous physical activity group taking up the remaining 77.8%.

The analysis of posture evaluation in 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 moderate-vigorous physical activity group: the average sum of Hoeger points received by teenagers in the low physical activity group reached 36.7 ± 7.7 points, whereas teenagers in the moderate to high physical activity group were evaluated with an average of 39.1 ± 7.2 (p = 0.008) (Figure 1).
Figure 1. Spinal posture evaluation in different physical activity groups

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

<table>
<thead>
<tr>
<th>Body segments</th>
<th>Poor (%)</th>
<th>Average (%)</th>
<th>Good (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal plane:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>3.6</td>
<td>30.8</td>
<td>65.6</td>
</tr>
<tr>
<td>Shoulders</td>
<td>8.7</td>
<td>66.1</td>
<td>25.2</td>
</tr>
<tr>
<td>Spine</td>
<td>3.6</td>
<td>66.1</td>
<td>30.3</td>
</tr>
<tr>
<td>Hips</td>
<td>2.9</td>
<td>45.8</td>
<td>51.3</td>
</tr>
<tr>
<td>Knees and ankles</td>
<td>4.4</td>
<td>33.9</td>
<td>61.7</td>
</tr>
<tr>
<td>Sagittal plane:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck and upper back</td>
<td>2.9</td>
<td>32.9</td>
<td>64.2</td>
</tr>
<tr>
<td>Trunk</td>
<td>3.9</td>
<td>37.2</td>
<td>58.9</td>
</tr>
<tr>
<td>Abdomen</td>
<td>2.9</td>
<td>38.3</td>
<td>58.8</td>
</tr>
<tr>
<td>Lower back</td>
<td>7.7</td>
<td>51.6</td>
<td>40.7</td>
</tr>
<tr>
<td>Legs</td>
<td>2.2</td>
<td>20.8</td>
<td>77.0</td>
</tr>
</tbody>
</table>

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. Analysis of distribution according to 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.

A statistically significant and positive but very weak link was identified between spinal posture results and the duration of moderate to vigorous intensity physical activity (MVPA) \( r = 0.186, p < 0.001 \) (Figure 2). This indicates that the posture of teenagers who are more physically active received higher evaluations.
Figure 2. Correlation between teenagers moderate-vigorous physical activity (MVPA) and posture ($r=0.186; p < 0.001$)

The analysis of physical fitness parameters revealed that the distance travelled during the 6-minute walk ranged from 340.0 to 980.6 meters. Teenager’s VO$_2$max ranged from 21.6 ml.kg.min$^{-1}$ to 34.8 ml.kg.min$^{-1}$. The results of the other physical fitness parameters (balance, flexibility, explosive leg power, abdominal muscle endurance) are presented in Table 3.
The results of the physical fitness tests indicate that, during the 6-minute walking test, teenagers in the low physical activity group walked on average 63.2 meters less (p = 0.002), and their maximum oxygen consumption (VO₂max) was 0.8 ml.kg.min⁻¹ lower (p = 0.006) than that of teenagers in the moderate-vigorous activity group.

Teenagers in the low physical activity group did not perform as well in the explosive leg power and abdominal muscle endurance tests compared to teenagers in the moderate-vigorous physical activity group. On average, 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 teenagers in the moderate-vigorous physical activity 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.
### Table 4. Physical fitness parameters in the low and moderate-vigorous physical activity groups

<table>
<thead>
<tr>
<th>Physical fitness parameters</th>
<th>Low physical activity group <em>(n=118)</em></th>
<th>Moderate-vigorous physical activity group <em>(n=414)</em></th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 MWT distance (meters)</td>
<td>571.8±117.1</td>
<td>635.0±149.2</td>
<td>0.002*</td>
</tr>
<tr>
<td>VO₂max (ml.kg.min⁻¹)</td>
<td>27.7±1.7</td>
<td>28.5±2.8</td>
<td>0.006*</td>
</tr>
<tr>
<td>Balance (n/min)</td>
<td>13.4±6.1</td>
<td>13.8±7.1</td>
<td>0.582</td>
</tr>
<tr>
<td>Explosive leg power (cm)</td>
<td>153.3±25.4</td>
<td>158.8±25.7</td>
<td>0.05*</td>
</tr>
<tr>
<td>Flexibility (cm)</td>
<td>23.2±7.2</td>
<td>22.0±7.9</td>
<td>0.174</td>
</tr>
<tr>
<td>Abdominal muscle endurance (n/30s)</td>
<td>25.4±4.7</td>
<td>27.0±6.2</td>
<td>0.005*</td>
</tr>
</tbody>
</table>

6 MWT – six-minute walk test; VO₂max – maximal oxygen consumption

* p ≤ 0.05

The moderate-vigorous physical activity (MVPA) of teenagers had a statistically significant and positive but very weak link with the distance travelled during the 6-minute walking test (r = 0.148, p = 0.010) (Figure 3) and maximum oxygen consumption (r = 0.155, p = 0.009) (Figure 4), which demonstrates that teenagers who are more physically active achieved better results in the physical capacity test.
Figure 3. Correlation between teenagers moderate-vigorous physical activity (MVPA) and the distance travelled during the 6-minute walking test ($r = 0.148; p = 0.010$)
Figure 4. Correlation between teenagers moderate-vigorous physical activity (MVPA) and maximum oxygen consumption ($r = 0.155; p = 0.009$)

A correlation analysis of the other teenagers' physical fitness parameters and moderate-vigorous physical activity (MVPA) revealed a very weak positive correlation between the duration of moderate-vigorous physical activity (MVPA) and explosive leg power ($r = 0.101, p = 0.040$).

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 $^{24-26}$. Aside from this, physical activity naturally decreases as children grow up $^{27, 28}$. Scientific research has established that only 1 in 5 children in the European Union is sufficiently physically active to satisfy recommendations for physical activity $^{29}$. 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 capacity \(^{30}\), which apart from being an important indicator of health in childhood and adulthood, is also a significant risk factor for cardio-metabolic diseases \(^{31}\). Scientific studies have provided evidence for the link between the aerobic capacity of children as well as teenagers and medium-high intensity physical activity \(^{32}\). Our study also showed that teenagers in the low physical activity group travelled a shorter distance during the 6-minute walking test and had lower maximum oxygen consumption (VO\(_{2}\)max) than teenagers in the moderate-vigorous physical activity group. The other authors analyzed differences in 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 is decreasing. A comparison of data from 1992 and 2002 revealed a strong decrease in boy’s and girl’s physical capacity. The authors attribute this change to a reduced level of daily physical activity \(^{33}\).

A correlation analysis between physical activity and physical capacity indicators found a link between the duration of moderate-vigorous physical activity and the distance travelled during the 6-minute walking test (\(r = 0.148\)) as well as maximum oxygen consumption (VO\(_{2}\)max) (\(r = 0.155\)), which means that teenagers who are more physically active perform better on physical capacity tests. An overview by Kristensen et al. (2010) 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) \(^{11}\). Thus, even though aerobic power in childhood is determined by genetic factors \(^{34, 35}\), physical activity is probably an important factor that influences the children's physical capacity.

Physical activity is also important for maintaining correct posture. Studies have shown that moderate physical activity increases abdominal strength and reduces the risk of back pain \(^{36}\). Mucha et al. (2015) found that young people aged 14–16 characterized by increased physical activity have 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 greater spinal ROM in the sagittal and frontal planes than their peers with average and low physical activity level \(^{37}\). 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 teenagers in the moderate-vigorous activity group.

A correlation analysis demonstrated that the duration of teenagers' moderate to vigorous intensity activity 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. (2013), who assessed the posture and physical activity of 14 year old teenagers in Poland and the Czech Republic, also found a link between low levels of physical activity and incorrect posture. The study performed by Wyszyńska et al. (2016) also revealed that physical activity level determines 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 physical activity influences posture; this link has not been sufficiently studied.

The results of our study also revealed a link between teenager’s physical activity and their physical fitness. It was observed that teenagers of low-level physical activity did not perform as well in explosive leg power and abdominal muscle endurance tests as teenagers in the moderate-vigorous physical activity group. A positive very weak correlation was noticed between the duration of teenagers' moderate to vigorous intensity physical activity and explosive leg power (r = 0.101). Martinez-Gomez et al. (2011) also determined that high intensity physical activity has a positive effect on teenagers' muscle power and strength. Given that 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 muscular fitness and speed/agility. 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 development. 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 size, so puberty affects almost all bodily systems. However, very few studies have been conducted to examine the association between teenagers’ physical activity and physical fitness parameters such as balance, flexibility, muscle power and endurance.

All studies have limitations. 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_{2 max}, which may be less accurate than direct methods. Thus, it would be useful to continue research in this subject.

**CONCLUSION**

In the early stages of adolescence, spinal posture and physical fitness parameters had very weak correlations with physical activity level. On the other hand, teenagers of low physical activity
were less physically capable than teenagers in the moderate to vigorous physical activity group. 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 spinal posture as well as physical fitness in teenagers.

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