

RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND HEALTH-RELATED PHYSICAL FITNESS IN 16-YEAR-OLD BOYS

Renata Rutkauskaitė, Arūnas Emeljanovas, Vida Volbekienė, Rita Sadzevičienė,
Edita Maciulevičienė, Olegas Batutis, Rita Gruodytė
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. It is well established that regular physical activity (PA) has many short- and long-term benefits for children's health. Physically active children are more physically fit than their physically inactive counterparts. Insufficient physical fitness of adolescents is one of the risk factors for chronic diseases and has a tendency to be carried over into adulthood.

Research aim was to examine health-related physical fitness in low, moderate and vigorous physical activity categories among 16-year-old schoolboys.

Research methods. The participants were 155 healthy schoolboys of the 10th grade from secondary schools of Kaunas (Lithuania). Their physical activity was measured by a modified short form of the International PA Questionnaire (IPAQ) (Craig et al., 2003). The respondents were divided in three PA categories: high (vigorous) (VPA) (n = 43), moderate (MPA) (n = 63), and low (LPA) (n = 49). Physical fitness tests were performed to measure participants' flexibility (by sit-and-reach test) (Eurofit, 1993), power (by vertical jump test), and muscular strength and endurance (by modified push-up test) (Sunı et al., 1994).

Research results. There were no significant differences between the boys in different PA groups in respect of anthropometrical and body composition parameters ($p > 0.05$). The results of health-related physical fitness tests were significantly better of the VPA group boys ($p < 0.05$). The total volume of PA correlated with all health-related physical fitness components that were measured ($r = 0.23\text{--}0.38$, $p < 0.01$).

Discussion and conclusions. We may conclude that health-related physical fitness is positively related to the total amount of physical activity in 16-year-old schoolboys.

Keywords: frequency, duration, intensity, volume, physical activity, physical fitness.

INTRODUCTION

Every organism is a complex, dynamic, and self-regulating system the functioning of which depends on the efficiency of numerous components (Kauffman, 2000). Similarly, people's health depends on a complex of many factors of which physical activity (PA) is playing its own important role. Physical activity is

suggested to be an essential part of everyday life, especially during growth and rapid development of school-aged children. The benefits of PA are numerous: it has a positive effect on the prevention of various diseases in schoolchildren (Dencker, Andersen, 2008), improves numerous aspects of emotional well-being (Burdette, Whitaker, 2005),

has influence on their cognitive development (Dencker et al., 2006), increases self-esteem and controls the levels of anxiety and stress, and certainly it affects the level of physical fitness (PF) (Malina, Katzmarzyk, 2006). F. B. Ortega et al. (2008 b) confirm the significant correlations between the level of physical fitness and morbidity and mortality rates caused by chronic diseases. PF is an important factor of health (Lohman et al., 2008). It has been suggested that physical fitness is an integrated dimension of most, if not all, functions of organism related with physical activity (Ortega et al., 2008 b). Indeed, the majority of physiological functions are estimated during physical fitness tests. The level of physical activity and physical fitness in childhood and adolescence has an influence on health status in adulthood (Gordon-Larsen et al., 2004; Matton et al., 2006). Components of physical fitness such as agility, balance, coordination, speed or reaction time are directly related with sport results and achievements rather than the state of health. Health-related physical fitness (HRPF) components are cardiovascular endurance, muscular strength and endurance, flexibility and body composition (Ortega et al., 2008). Recently, explosive power has been attributed to it as well.

The level of HRPF of schoolchildren in Lithuania and all over the world is decreasing and the tendencies of its change are negative. The number of children with overweight in Europe and USA is increasing (Currie et al., 2004). Although overweight or obesity are not common among Lithuanian children yet (Currie et al., 2004), evidence exists that overweight in children prevails when acceleration rate has stabilized or even decreased. As well schoolchildren' cardiovascular and muscular capacity is unsatisfactory and has a tendency to decrease. Our previous study has indicated a significant decrease of HRPF level in Lithuanian adolescents over the years 1992–2002, especially

in cardiovascular endurance and flexibility (Volbekiene, Gričiute, 2007).

Studies justify the relationships between physical activity and health, but research on the relationship between physical activity and health-related physical fitness remains problematic. The most important studies are focusing on the dose-response relationship between physical activity and various health components (Rankinen, Boucard, 2002; Lee, 2007). Moderate PA is recommended for adult population, while children and youth should experience moderate-to vigorous PA. However, the evidence, based on longitudinal studies justifying the benefit of vigorous PA on health and physical fitness of children and adolescents, is still lacking. Furthermore, the steadily decreasing levels of PA of children and adolescents are a matter of great concern for their health and physical fitness in the future. **The aim** of the study was to investigate the relationship between physical activity and health-related physical fitness of 16-year-old boys.

RESEARCH METHODS

The study was performed in March–April 2009 in seven secondary schools of Kaunas (Lithuania) with the following restrictions, i. e. schools for national minorities and schools situated in the periphery of the city were not included. The convenient sample of this study consisted of 191 schoolboys of the 10th grade (about of 16 years old). All of the participants were of the regular Physical Education group according to their health status. Schoolboys (n = 155) who fulfilled all requirements of the study (e. g. they voluntarily agreed to take part in the tests; their parents or foster parents gave written informed consent; they provided all necessary data for calculating the total amount of physical activity in the questionnaire and performed all of the given physical fitness tests) were selected for the statistical analysis. The study was carried out in two stages: 1) physical

Groups	n	Age, years	Height, cm	Body mass, kg	BMI
Low PA	49	16.2 ± 0.5	178.9 ± 6.6	65.6 ± 10.1	20.5 ± 2.5
Moderate PA	63	16.2 ± 0.5	181.5 ± 7.0	71.2 ± 13.0	21.6 ± 3.2
High PA	43	16.3 ± 0.5	181.6 ± 5.1	70.2 ± 8.9	21.0 ± 2.6
Total	155	16.2 ± 0.5	180.7 ± 6.5	69.1 ± 11.3	21.1 ± 2.9
F		0.66	2.81	3.79	2.05
p		> 0.05	> 0.05	< 0.05	> 0.05

Table 1. Characteristics of the study population (mean ± SD)

Note. PA – physical activity; BMI – body mass index.

activity measurements in March, and 2) health-related physical fitness testing in April.

Physical activity of schoolboys was measured using the Short Form of International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). The data of intensity (METs), frequency (days / week) and duration (minutes / day) of vigorous, moderate and low (walking) physical activity that lasted for at least 10 minutes at a time was used to calculate the total amount of PA during one week (MET-minutes / week). According to the level of the total amount of PA and following the “*Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) Short and Long Forms*” (2005), all of the participants were divided into 3 groups: low PA (≤ 1387 MET-minutes / week), moderate PA ($> 1387 < 3001$ MET-minutes / week) and high PA (≥ 3001 MET-minutes / week). Characteristics of the study population are presented in Table 1.

Health-related physical fitness was estimated by measuring the following components:

1) body composition by calculating BMI (kg / m^2) from height (cm) and body mass (kg) data;

2) explosive power of leg muscles by performing vertical maximal jump (cm) with countermovement on *Kistler* contact platform, analyzing results with BioWare Performance Software Version 3.0, and registering the best result from three attempts;

3) muscular strength and endurance of arms and trunk by modified push-up test (n / 40 seconds) (Sunni et al., 1994).

4) flexibility by sit-and-reach test (cm) (Eurofit, 1993).

All participants were informed about the aim of the study, the content of the questionnaire as well as process of filling it in, and the methodology of HRPF test performance. The interview for IPAQ and the HRPF tests were conducted by a specially trained team of qualified testers. The research was carried out under the mutual agreements between the Lithuanian Academy of Physical Education and secondary schools aiming at investigating the levels of physical activity and physical fitness of schoolchildren.

Statistical analysis of the results was performed using computer programs *MS Excell* and *SPSS*. Appropriate statistical methods were used to calculate means and standard deviations (\pm SD), one-way analysis of variance (ANOVA) and Tukey

post hoc test were used to establish the differences among the groups. The relationships between physical activity and HRPF components were identified using Pearson’s correlation analysis. A significance level of 0.05 was used.

RESEARCH RESULTS

Physical activity. The total amount of physical activity (i. e. energy expenditure during one week) of 16-year-old boys on average was 959.0 MET-minutes / week in low PA group, 2056.7 MET-minutes / week in moderate PA group and 3548.8 MET-minutes / week in high PA group. The frequency, duration and total amount of vigorous physical activity (VPA) of the whole group are presented in Table 2. The dominant frequency of VPA is 2–3 days / week. The duration of PA ranged from 28.6 minutes per 1 day to 42.4 minutes per 3 days. The greatest energy expenditure (809 kcal / week) was when VPA frequency was seven days per week.

The significant differences were found between the boys of high and low PA groups in respect of vigorous PA: the mean frequency and duration of VPA were 4 days / week and 46 minutes / day vs. 1.5 days/week and 14 minutes/day, respectively ($p < 0.001$).

The frequency, duration and total amount of moderate physical activity (MPA) of the whole group are presented in Table 3.

The dominant frequency of MPA is 2–3 days / week. The duration of PA ranged from 25.5 minutes per 7 days to 45.8 minutes per 6 days. The greatest energy expenditure (700 and 908 kcal / week) was when MPA frequency was five and six days per week.

The dominant frequency and duration of walking in the whole group were seven days per week and 40.8 minutes per day, respectively (Table 4). Everyday walking with energy expenditure of 943 kcal / day was experienced by 56.1% of schoolboys. The mean frequency and duration of walking activities were the greatest of the boys of the high PA group (6.6 days / week and 52.8 minutes / day, respectively; $p < 0.05$). The greatest amount of time spent for sitting activities was of the boys of the low PA group (approximately 9.3 hours / day, $p < 0.05$).

Health-related physical fitness in different physical activity groups. There were significant differences in HRPF tests results among the different physical activity groups, i. e. in all cases

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	18.1	28
1	28.6 ± 15.9	94 ± 53	7.1	11
2	29.7 ± 13.8	196 ± 91	18.7	29
3	42.4 ± 21.3	420 ± 209	20.0	31
4	37.0 ± 20.5	488 ± 271	16.1	25
5	37.1 ± 16.4	612 ± 270	12.3	19
6	33.5 ± 12.9	663 ± 256	6.5	10
7	35.0 ± 7.1	809 ± 163	1.3	2
Total			100	155

Table 2. Frequency, duration and total amount of vigorous physical activity

Note. Data presented as mean ± SD.

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	2.6	4
1	35.0 ± 32.0	116 ± 106	5.8	9
2	42.1 ± 24.6	278 ± 163	22.6	35
3	42.1 ± 28.8	417 ± 285	21.3	33
4	37.6 ± 20.2	497 ± 267	13.5	21
5	42.4 ± 21.8	700 ± 360	17.4	27
6	45.8 ± 23.6	908 ± 468	7.7	12
7	25.5 ± 17.9	649 ± 418	9.0	14
Total			100	155

Table 3. Frequency, duration and total amount of moderate physical activity

Note. Data presented as mean ± SD.

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	0.6	1
1	30.0 ± 20.0	99 ± 66	1.9	3
2	59.1 ± 48.8	390 ± 322	7.1	11
3	47.8 ± 28.2	473 ± 279	5.8	9
4	22.9 ± 10.8	302 ± 142	4.5	7
5	33.2 ± 23.3	548 ± 385	14.2	22
6	34.3 ± 19.2	680 ± 380	9.7	15
7	40.8 ± 23.7	943 ± 547	56.1	87
Total			100	155

Table 4. Frequency, duration and total amount of walking

Note. Data presented as mean ± SD.

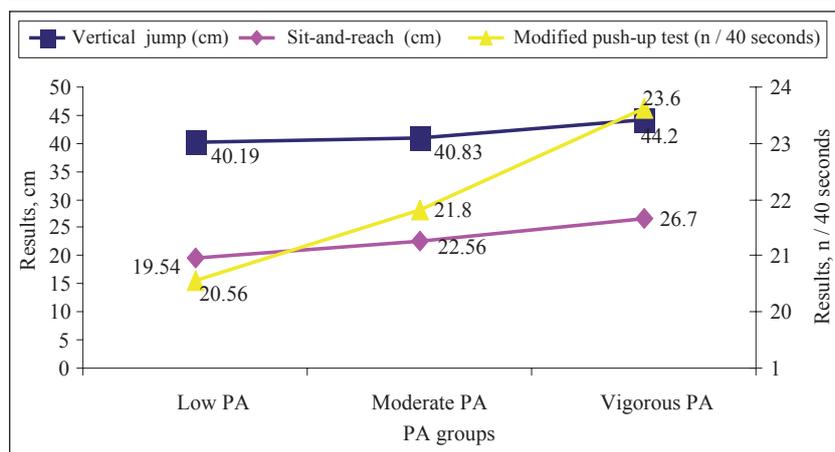


Figure. Health-related physical fitness results in low, moderate and high PA groups

Note. * – difference from high PA group, $p < 0.05$.

the better results were in higher physical activity groups ($F = 11.39$ – 5.56 ; $p < 0.05$) (Figure). The boys of high PA group demonstrated the best results in all measured components: explosive power (the mean of vertical maximal jump was 44.2 cm), flexibility (the mean sit-and-reach test result was 26.7 cm), and muscular strength and endurance of arms and trunk (the mean result was 23.6 push-ups in 40 seconds).

Relationship between physical activity and health-related physical fitness. There were weak to moderate significant correlations between physical activity and HRPF components. The total amount of physical activity (kcal/week) correlated to explosive power of leg muscles ($r = 0.23$; $p < 0.01$), muscular strength and endurance of arms and trunk ($r = 0.38$; $p < 0.01$), and flexibility ($r = 0.38$; $p < 0.01$).

DISCUSSION

It has been well established that regular physical activity (PA) has many short- and long-term benefits for children's health (Katzmarzyk, Craig, 2006). Despite these benefits many children and adolescents do not engage in recommended amounts of physical activity (Jago et al., 2005). Daily moderate-to-vigorous physical activity for at least 60 minutes is suggested to be health-enhancing and recommended by experts for children and adolescents (Oja et al., 2010).

The results of our study indicated that the dominant frequency of moderate physical activity was two to three days per week and only for 43.9% of 16-year-old schoolboys. Moderate PA on everyday basis was experienced by 9% of the respondents with mean duration of about 26 minutes / day only.

Physically active children are more physically fit than their physically inactive counterparts. Insufficient physical fitness of adolescents is one of the risk factors for chronic diseases and has a tendency to be carried over into adulthood (Gordon-Larsen et al., 2004; Matton et al., 2006). In our study, when comparing different physical activity groups, the results of all HRPF tests were significantly better in higher physical activity groups. Boys with higher levels of physical activity have greater explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility. The same tendency was found in our previous study (Volbekienė et al., 2008).

Although physical fitness is greatly dependant on genetical heredity, daily physical activity and health status are also related to it (Malina et al., 2004). Numerous epidemiological studies indicate positive influence of physical exercise on cardiovascular capacity and functional status (Myers et al., 2004; Macera et al., 2003). Many

studies emphasize positive effects of exercise on cardiovascular (Baquet et al., 2006; Dollman, Olds, 2007) and muscular fitness (Horst et al., 2007).

Physical activity correlates positively with physical fitness and negatively with fat mass and risk factors for cardiovascular system in children and adolescents (Ortega et al., 2008 b). As the boys of high physical activity group in our study demonstrated significantly better results in all of the HRPF tests and positive correlations of the total amount of physical activity were found with all HRPF components ($r = 0.23-0.38$), we may suggest that physical activity positively influences health-related physical fitness of 16-year-old boys. This corresponds well with the findings of other studies indicating that physical activity affects physical fitness (Emeljanovas, Poderys, 2010; Wilmore, Costill, 2001). The correlations between physical fitness and physical activity found in our study were weak to moderate. Other studies with children and adolescents report the same tendency (Malina et al., 2004; Oja et al., 2010).

CONCLUSIONS AND PERSPECTIVES

Adolescent boys with greater amounts of physical activity have significantly greater explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility. The total amount of physical activity positively correlates with health-related physical fitness components (such as explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility) in 16-year-old boys. Although the preliminary results of this study indicate the relationship between PA and HRPF in schoolboys, further investigation is required to test our findings.

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ŠEŠIOLIKAMEČIŲ BERNIUKŲ FIZINIO AKTYVUMO IR SU SVEIKATA SUSIJUSIO FIZINIO PAJĖGUMO RYŠIAI

Renata Rutkauskaitė, Arūnas Emeljanovas, Vida Volbekienė, Rita Sadzevičienė,
Edita Maciulevičienė, Olegas Batutis, Rita Gruodytė
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Tyrimais nustatyta, kad reguliarius fizinis aktyvumas (FA) turi trumpalaikį ir ilgalaikį teigiamą poveikį sveikatai. Vaikai, patiriantys didesnę fizinę aktyvumą, yra fiziškai pajėgesni (FPj) nei mažiau fiziškai aktyvūs jų bendraamžiai. Nepaisant to, vis dar labai daug vaikų yra nepakankamai fiziškai aktyvūs. O pasyvi gyvensena, nepakankamas FPj vaikystėje ir paauglystėje gali būti vienu iš rizikos veiksnių susirgti įvairiomis lėtinėmis ligomis suaugus.

Tikslas: nustatyti 16 metų berniukų su sveikata susijusį fizinį pajėgumą mažo, vidutinio ir didelio fizinio aktyvumo grupėse.

Metodai. 155 dešimtos klasės mokiniai, įvykdę visus būtinus tyrimo reikalavimus, buvo atrinkti iš Kauno miesto bendrojo lavinimo mokyklų. Fizinis aktyvumas (FA) nustatytas pagal modifikuotą tarptautinio FA (IPAQ) klausimyno trumpąją formą (Craig et al., 2003). Visi respondentai pagal bendrąją FA apimtį buvo suskirstyti į 3 grupes: mažo ($n = 49$), vidutinio ($n = 63$) ir didelio FA ($n = 43$). Fizinis pajėgumas nustatytas matuojant lankstumą (*Eurofit*, 1993), kojų raumenų staigiąją jėgą (matuokliu SBM-1), rankų ir liemens raumenų ištvėrmę (Suni et al., 1994).

Rezultatai. Tiriamųjų antropometriniai duomenys ir kūno kompozicija statistiškai reikšmingai nesiskyrė tarp skirtingo fizinio aktyvumo grupių ($p > 0,05$). Geresnių su sveikata susijusio fizinio pajėgumo rezultatų pasiekė mokiniai, priskirti didelio fizinio aktyvumo grupei ($p < 0,05$). Nustatyti teigiami silpni ryšiai tarp mokinių bendrosios fizinio aktyvumo apimties ir su sveikata susijusio fizinio pajėgumo rodiklių ($r = 0,23-0,38$; $p < 0,01$).

Aptarimas ir išvados. 16 metų amžiaus grupės berniukų su sveikata susijęs fizinis pajėgumas ir bendrojo fizinio aktyvumo apimtis yra susiję teigiamais koreliaciniais ryšiais.

Raktažodžiai: fizinio aktyvumo dažnumas, trukmė, intensyvumas, fizinis pajėgumas.

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Corresponding author **Renata Rutkauskaitė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 67409104
E-mail r.rutkauskaite@lkka.lt