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Motor Abilities in Physically Active and Inactive School Adolescents Aged 13-15 Years: A Comparative Study

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Abstract

Accumulating at least 60 min of physical activity every day is health-beneficial and will contribute to development of motor abilities. The objective was to compare some motor abilities of physically active [N=42; (24 boys & 18 girls)] and inactive [N=55; (24 boys & 31 girls)] school adolescents at the age of 13-15 years: (1) abdominal muscle strength; (2) lower back muscle strength; (3) upper limbs muscle strength; (4) lower limbs muscle strength; and (5) explosive leg power. The PAQ-C questionnaire was applied to evaluate the level of physical (in)activity. A cut-off value of 2.73 was set to categorize children as inactive (<2.73) and physically active (≥2.73), as suggested by Benitez-Porres et al. (2016). Student's t-test was applied in order to compare motor abilities between physically active and inactive adolescents. Findings of the present study indicate that physically active adolescents have higher upper limbs muscle strength and explosive leg power than inactive adolescents. No significant differences were observed in abdominal muscle strength, lower back muscle strength and lower limbs muscle strength, between physically active and inactive school adolescents aged 13-15 years. We believe that specifically tailored exercise interventions with an appropriate frequency, intensity, and volume might be necessary in order to induce higher and more significant changes in all segments of the motor abilities spectrum.

Keywords: *adolescents, explosive leg power, muscle strength, physical activity*

Introduction

Physical activity (PA) is any bodily movement that is raising the energy expenditure and is produced by the skeletal muscles (Piggin, 2020). PA is beneficial for the overall health (Wu et al., 2017). More active adolescents display healthier cardio-metabolic profiles and develop higher peak bone masses than their less active counterparts (Boreham & Riddoch, 2001; Brown & Summerbell, 2009; Janssen & LeBlanc, 2010). Also, physically active adolescents have better mental health and psychosocial well-being than those that are inactive (Iannotti, Janssen, et al., 2009; Iannotti, Kogan, et al., 2009). On the other hand, physical inactivity and sedentary behavior are associated with various negative health consequences such as obesity or increased risk for cardio-metabolic diseases (Leung et al., 2012), and may also contribute to a delay of the motor development (Tremblay et al., 2011).

Daily life PA can be categorized into occupational, sports, conditioning, household, or other activities (Dasso, 2019). Nowadays, adolescents have become less physically active with an approximate energy expenditure of 600 kcal per day,

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which is far less than the approximate energy expenditure few years ago (Boreham & Riddoch, 2001). Since PA among children and adolescents has been demonstrated to benefit a number of health issues and diseases through life (Boreham & Riddoch, 2001; Tremblay et al., 2011), assessment and monitoring of the physical (in)activity status is very important. It may contribute to early detection, as well as prevention of the trend of inactivity among children and adolescents by developing and implementing effective interventions that will increase their PA levels. It is generally recommended by the World Health Organization to accumulate at least 60 min of PA with moderate-to-vigorous intensity every day (World Health Organization, 2023).

Promoting PA in early childhood may also contribute to healthier motor development in children, as well as to the development of motor abilities and skills in school adolescents (Timmons et al., 2007; Herodek et al., 2024). Motor abilities are specific abilities that allow performing motor skills, affect performance, and are also very important for the activities of the daily living (Fairclough & Stratton, 2005). Especially strength and explosive leg power, which are essential for the motor tasks during everyday life such as: jumping, running, sprinting and change of direction (Suchomel et al., 2016). Previous evidence reported significant differences in the motor abilities of active adolescents compared to inactive, favoring the active ones (Ahmed et al., 2017; Keiner et al., 2013). Recent systematic reviews have also reported that appropriate levels of motor abilities and skills were distinguishing active from inactive adolescents (Martins et al., 2021; Mateo-Orcajada et al., 2022). However, there are some studies that did not observe significant differences in the motor abilities between active and inactive children and adolescents (Malina & Katzmarzyk, 2006; Martínez-Vizcaíno & Sánchez-López, 2008).

Since there is inconsistency among the scientific literature between the studies that compare motor abilities of active and inactive individuals, this topic requires further research. Therefore, objective of the present study was to compare the motor abilities of physically active and inactive school adolescents at the age of 13-15 years: (1) abdominal muscle strength; (2) lower back muscle strength; (3) upper limbs muscle strength; (4) lower limbs muscle strength; and (5) explosive leg power.

Methods

Participants and procedures

The present study is realized on a sample of 97 participants (52 boys and 45 girls) at the age of 13-15 years, school adolescents from the Elementary School Dimkata Angelov Gaberot-Vatasha, Kavadarci (Macedonia).

All measurements and evaluations were performed during the academic year 2020/2021 at the Elementary School Dimkata Angelov Gaberot-Vatasha, with respect to all prevention and protection protocols due to COVID-19. The study was approved by the principal of the school and realized in accordance with the principles of the Helsinki Declaration. Parents of all adolescents included in the study gave consent for participation.

Instruments

Physical activity

In order to realize the particular aim of the study, the PAQ-C questionnaire was applied during PE class to all participants. The PE teacher was in charge of clarifying concepts and explaining questions if necessary. PAQ-C is a self-reported 7-day recall questionnaire that assesses participation in different types of PA (e.g., walking, bicycling, running, swimming, dancing), as well as the frequency of participation after school and during the weekends (e.g., none; 1; 2 or 3; 4; 5 or more times) (Benítez-Porres et al., 2016). It uses a five-point Likert scale ranging from 1 (low PA level) to 5 (high PA level). The total score of the PAQ-C is calculated as a mean of the scores for the 9 items that form part of the questionnaire. In order to allocate adolescents in the inactive or physically active group, a cut-off value of 2.73 was established as suggested by Benitez-Porres et al., (2016). Finally, two groups were created: (1) inactive adolescents: PAQ-C <2.73 [N=55; (24 boys & 31 girls)]; and (2) physically active adolescents: PAQ-C ≥2.73 [N=42; (24 boys & 18 girls)].

Anthropometric characteristics

Anthropometric characteristics of the adolescents such as body mass, height and BMI were measured barefoot and wearing light clothes, according to the World Health Organization manual (World Health Organization, 2007). Body mass was measured with a calibrated digital scale (TANITA TBF 300; TANITA, Middlesex, UK). Height was measured using a wall mounted stadiometer (SECA SE206, Hamburg, Germany). BMI was calculated from height and body mass as follows: body mass in kg devided by height in m2.

Motor abilities

Motor abilities of the adolescents were assessed by applying the modified EUROFIT (1993) testing battery proposed by Jovanovski (1998), which is cost-effective, practical and easy to apply in school environment (EUROFIT, 1993; Jovanovski, 1998): (1) Abdominal muscle strength test (AMST): abdominal crunches in 1 min; (2) Lower back muscle strength test (LBMST): back extensions in 1 min; (3) Upper limbs muscle strength test (ULMST): push-ups in 1 min; (4) Lower limbs muscle strength test (LLMST): squats in 1 min; (5) Standing long jump (SLJ): standing long jump (cm).

Data analysis

Kolmogorov-Smirnov test was applied to test the normality of the distribution. Appropriate statistical methods were used to calculate descriptive statistical parameters. Student's t-test was applied to compare: abdominal muscle strength, lower back muscle strength, upper limbs muscle strength, lower limbs muscle strength, and explosive leg power, between physically active and inactive adolescents. Statistical analysis was performed with the SPSS 23 statistical package (SPSS Inc, Chicago, IL, United States). Significance level was set to $p<0.05$.

Results

According to what is presented in Table 1, data of adolescents that are physically active are normally distributed, with a normal asymmetry considered when values for Skewness are in range between -1.00 to 1.00, and Kurtosis values that are in range between -3.00 to 3.00 (Kallner, 2013). Exception is the Skewness value for LLMS that indicates on a left-oriented distribution, meaning that more adolescents have shown a higher repetition score in the squat test than the calculated average that is 34 repetitions.

Table 1. Descriptive statistical parameters of physically active school adolescents

	N	Min	Max	X	SD	Skewness	Kurtosis	K-S
Body mass (kg)	42	49	90	65.25	13.46	0.66	0.29	p > 0.20
Height (m)	42	1.58	1.82	1.70	0.07	-0.42	-0.52	p > 0.20
BMI	42	18	29	22.73	4.24	0.34	-1.62	p > 0.20
AMST (rep)	42	35	45	38.75	3.69	0.47	-0.78	p > 0.20
LBMST (rep)	42	11	20	14.75	3.85	0.52	-1.68	p > 0.20
ULMST (rep)	42	8	15	11.38	2.33	0.30	-0.67	p > 0.20
LLMST (rep)	42	25	40	34.25	4.68	-1.18	1.41	p > 0.20
SLJ (cm)	42	165	240	204.38	26.78	0.22	-0.99	p > 0.20

Note. AMST - Abdominal muscle strength test; LBMST - Lower back muscle strength test; ULMST - upper limbs muscle strength test; LLMST - Lower limbs muscle strength test; SLJ - Standing long jump.

Based on Table 2, data of inactive adolescents are normally distributed, except Skewness values for: body mass, height, BMI and LBMST that are above the accepted value, indicating on a right-oriented distribution and meaning that more adolescents have shown lower values for the previously mentioned variables than the calculated average. In addition to this, Skewness values for ULMST and SLJ indicate to a left-oriented distribution, meaning that more adolescents have shown higher repetition score in the push-up test and higher jumping distance than the calculated averages. Furthermore, Kurtosis values for height and LBMST are also higher than the acceptable range, but if in addition to these values we take in consideration standard deviations for the same variables, it is considered as acceptable (Kallner, 2013).

Table 2. Descriptive statistical parameters of inactive school adolescents

	N	Min	Max	X	SD	Skewness	Kurtosis	K-S
Body mass (kg)	55	41	73	52.89	11.48	1.04	-0.21	p > 0.20
Height (m)	55	1.55	1.82	1.68	0.07	2.18	5.72	p > 0.20
BMI	55	15	27	18.8	3.68	1.40	2.13	p > 0.20
AMST (rep)	55	25	47	35.22	7.22	0.07	-0.92	p > 0.20
LBMST (rep)	55	10	22	14.33	3.28	1.64	4.28	p > 0.20
ULMST (rep)	55	0	12	7.22	4.41	-1.08	-0.21	p > 0.20
LLMS (rep)	55	20	45	32.00	8.2	0.17	-0.94	p > 0.20
SLJ (cm)	55	105	210	167.78	36.50	-1.09	0.06	p > 0 .20

Notes. AMST - Abdominal muscle strength test; LBMST - Lower back muscle strength test; ULMST - upper limbs muscle strength test; LLMST - Lower limbs muscle strength test; SLJ - Standing long jump.

Based on what is presented in Figure 1, physically active adolescents have shown better results than inactive adolescents in: abdominal muscle strength, lower back muscle strength, upper limbs muscle strength, lower limbs muscle strength and explosive leg power.

However, according to what is presented in Table 3, we can conclude that there is a significant difference between physically active and inactive adolescents in upper limbs muscle strength and explosive leg power, and no significant difference between them in abdominal muscle strength, lower back muscle strength and lower limbs muscle strength.

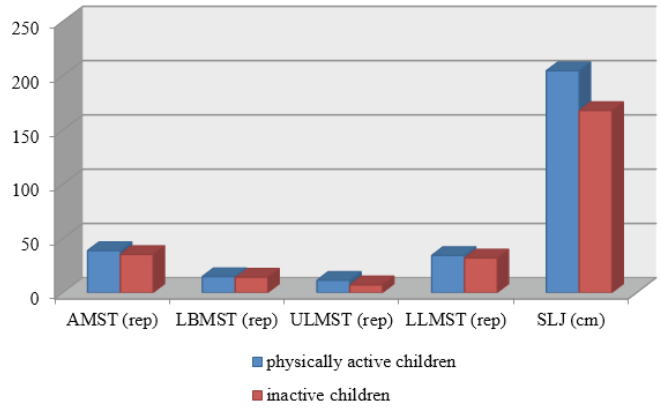

FIGURE 1. Comparison between physically active and inactive school adolescents
Notes. AMST - Abdominal muscle strength test; LBMST - Lower back muscle strength test;
ULMST - Upper limbs muscle strength test; LLMST - Lower limbs muscle strength test; SLJ - Standing long jump; rep: repetitions.

Table 3. Comparison of means between inactive and physically active school adolescents, t-test and significance level (p-value)

	Inactive Adolescents	Physically active adolescents	t – test	p level
AMST (rep)	35.22	38.75	1.29	0.22
LBMST (rep)	14.33	14.75	0.24	0.81
ULMST (rep)	7.22	11.38	2.47	0.03*
LLMS (rep)	32.00	34.25	0.70	0.50
SLJ (cm)	167.78	204.38	2.37	0.03*

Notes. AMST - Abdominal muscle strength test; LBMST - Lower back muscle strength test; ULMST - upper limbs muscle strength test; LLMST - Lower limbs muscle strength test; SLJ - Standing long jump; * - p<0.05

Discussion

Results obtained in this study indicate that adolescents that are physically active have higher upper limbs muscle strength and explosive leg power than adolescents that are not physically active. However, there are no differences between physically active and inactive adolescents in terms of abdominal muscle strength, lower back muscle strength and lower limbs muscle strength.

Differences in terms of motor abilities between physically active and inactive adolescents have been reported in the scientific literature so far (Martínez-Vizcaíno & Sánchez-López, 2008). Moreover, it has been suggested that these differences are causal effect of the regular PA (Martínez-Vizcaíno & Sánchez-López, 2008). In this line, there were differences in upper limbs muscle strength and explosive leg power between physically active and inactive adolescents at the present study, but there were no significant differences between them in abdominal muscle strength, lower back muscle strength and lower limbs muscle strength. In support to the present findings, previous evidence also suggested partial and moderate effects on muscle strength induced by PA (Ferreira et al., 2012; Malina & Katzmarzyk, 2006; Martínez-Vizcaíno & Sánchez-López, 2008). PA is usually in context of non-formal sport activities and active games whose primary goal is enjoyment and play, instead of improving motor abilities or specific skills (Coutinho et al., 2016; Ilic et al., 2024). Furthermore, PA seems unlikely to modify all motor abilities to a big extent because it is largely unpredictable and non-systematic, and may occur in relatively short bursts (Martínez-Vizcaíno & Sánchez-López, 2008). We believe that specifically tailored and structured physical exercise interventions with an appropriate frequency, intensity, and volume might be necessary in order to induce higher and more significant changes in all segments of the motor abilities spectrum. According to the concepts of training specificity, specifically tailored physical exercise targeting the specific motor ability will induce better improvement of that ability, rather than any other physical activity that does not directly target that ability (Zhao et al., 2021). In this line, previous study reported that PA based trials induced lower effects on muscle strength than specifically structured resistance exercise trials (Ferreira et al., 2012). Another study has shown that after applying a structured strength-oriented physical exercise intervention, there was a significant improvement in muscle strength after the intervention (Haskell et al., 2007).

However, taking in consideration the small sample size of the present study and the narrow spectrum of motor abilities assessed, larger studies are necessary for further generalization in terms of motor abilities in physically active and inactive adolescents. Inclusion of accelerometer in addition to the PA questionnaire can also be considered in future research, in order to assure that the self-reported PA is habitually maintained and complies with the real PA levels of the adolescents.

Conclusion

Physically active adolescents at the age of 13-15 years have higher upper limbs muscle strength and explosive leg power than the inactive adolescents, but there are no significant differences between them in abdominal muscle strength, lower back muscle strength and lower limbs muscle strength. We assume that structured and specifically designed exercise interventions with an appropriate frequency, intensity, and volume might be necessary to induce significant changes in all segments of the motor abilities spectrum.

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Conflicts of interest

Authors have no relevant financial or non-financial interests to disclose.

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