



# Flexibility and Abdominal Strength among Macedonian children and adolescents: Eurofit Protocol

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## Abstract

*The performance level of young people is often used to define the well-being. Indeed, several studies and correlations with health conditions (e.g. obesity and growth) are combined. In Macedonia there is lack of investigation in order to define the physical level of children and adolescents. Over 9241 subjects (6–14) grouped according to ages were tested during the Physical Education (PE) lessons by experts from the area of kinesiology and medicine, previously trained to perform tests and to take anthropometric measures. All instructions about testing phases were selected within Eurofit battery test. In particular, Sit and Up's (SUP) and Sit and Reach (SAR) were assessed to evaluate endurance of abdominal muscles and flexibility of the lower back. The results are processed with statistical parametric methods of relevance. On the basis of the obtained results it can be concluded that boys unlike the girls in all age categories showed better results in fitness test "Sit-ups 30 sec.", and these differences increase with age increasing. Girls in all age categories show better results in the test "Sit and Reach". Comparing the international studies with the results obtained in our research can be concluded that students of both sexes from Macedonia achieve an average lower scores in the tests "Sit-ups 30 sec." and "Sit and Reach" at the age of 11 and 14 years compared to the peers from Serbia, Belgium, Italy, Spain, Lithuania, Estonia. Critical performance suggests improvement in PE lessons both from a qualitative and a quantitative point of view.*

**Keywords:** Eurofit battery test, Abdominal Strength, Flexibility.

## Introduction

The physical fitness is powerful marker of the health condition during the childhood and adolescence. Even among the children and adolescents the fitness is inversely associated with cardiovascular risk factors for chronic disease, such as high blood pressure total fatness hyperinsulinemia, abdominal adiposity, atherogenic lipid profile insulin resistance, and clustering of metabolic risk factors.

Several studies have correlated the performance level with different lifespan condition leading researchers to assess a shared protocol for testing physical performance. Indeed, since 1988 within Council of Europe (CE) the Eurofit battery test (EBT) was accepted by numerous European countries as a uniformed procedure for the assessment of health-related, functional and motor status of people.

Differences within gender and manhood, intellectual disability, living areas influence (urban or rural) or sport practice have been investigated in different country (not only in Europe). In Macedonia this kind of investigation is lacking (at least for wide subject samples): status favors the spread of a general thought on a decrease in physical performance. Thus, the aim of this study was to establish the normative value for physical fitness among Macedonian children and adolescents. So a performance database could be used as a baseline for further health-correlated investigations and for between countries comparison.

## Materials and methods

**Sample of respondents:** The research was realized on a sample of 9241 subjects, the population of students from the primary and secondary schools of Republic of Macedonia. The sample is divided into two subsamples by gender, out of which 4176 male and 4525 female respondents. Each of the subsamples is also divided according to the chronological age in 9 age groups in the span of one calendar year. The sample is proportionally defined on state allocation of students in urban and rural environments.

The study included students for whom their parents had given consent to take part in the research, who were psychically and physically healthy and who regularly attended the classes of physical and health education. The respondents were treated in accordance with the Helsinki Declaration. Measurements were realized in March, April and May 2012 in standard school conditions at regular classes of physical and health education. The measurements were realized by experts from the area of kinesiology and medicine, previously trained to perform tests and to take anthropometric measures.

**Anthropometric measures and Evaluation of Physical Fitness:** Measuring of the anthropometric measurements was realized at the recommendations given by IBP-International Biology Program. For estimation of the morphologic characteristics, the following anthropometric measures have

been applied: body height in standing position (cm), body weight (kg), as well as the body mass index (BMI).

Prior to starting the study, the researchers involved in the project undertook training sessions in order to guarantee the standardization, validation, and reliability of the measurements, two tests, forming part of the eurofit battery, validated and standardized by the European Council, were applied in the following order: i. Sit-ups 30 sec. Maximum number of sit ups achieved in 30 seconds. This test measures the endurance of the abdominal muscles. ii. Sit and Reach test. With the subject seated on the floor using a standardized support, the maximum distance reached with the tip of the fingers by forward flexion of the trunk is measured. Test indicative of amplitude of movement or flexibility.

**Statistical analysis:** Statistical analysis, anthropometric and physical fitness characteristics of the study samples are presented as means (SD), unless otherwise indicated. We analysed sex- and age-group differences in the anthropometric and physical fitness variables by two-way analysis of variance.

Paired t-test was used to compare means of distances performed in Sit-ups 30 sec. and Sit and Reach test between boys and girls at the same age. A significance level of 5% was used for statistical testing.

**Results:** The results of the anthropometric indicators and the tests Sit-ups 30 sec and Sit and Reach in terms of gender and age are presented in the Table 1.

Form the review of the Table 1. can be seen that the boys are in average heavier, taller, have higher body mass index (BMI) and achieve better results in the test "Sit and Reach". In general, the anthropometric characteristics increase with ages increasing.

From the review of Tables - 2 and 3 in which are shown the values of the anthropometric means and the level of statistical significance of the t-tests, it can be seen that there are statistically significant differences between male and female respondents in all age groups in the fitness test „Sit-ups 30 sec.” and „Sit and Reach”. From the reviews of the obtained results, it can be concluded that boys in all age categories show better results in the fitness test „Sit-ups 30 sec.”, while the girls in all age groups achieve better results in the fitness test „Sit and Reach”.

Statistical differences in fitness test “Sit-ups 30 sec.” are obtained in all adjacent age groups of both sexes except for females between 8 and 9, 9 and 10, 12 and 13, 13 and 14 adjacent age group and males between 13 and 14 adjacent age group. For both sexes in the fitness test “Sit and Reach” in all adjacent age group do not exist statistically significant differences in the arithmetical means. For both sexes in any adjacent age group do not exist statistically significant differences in the arithmetical means in the test “Sit and Reach”.

**Table-1**  
**Characteristics of the study sample by sex**

	All (n=9241)		Boys (n=4176)		Girls (n=4525)		Sex difference	Age trend
Age (years)	10,02	2,43	10,06	2,41	9,98	2,45	=	-
Height (cm)	143,72	15,36	144,38	15,84	143,03	14,81	>	>
Weight (kg)	41,46	14,89	42,18	15,53	40,70	14,14	>	>
Body mass index (kg/m <sup>2</sup> )	19,53	4,00	19,66	4,02	19,40	3,97	>	>
Sit-ups 30 sek (n)	14,01	5,75	15,26	5,80	12,71	5,40	>	>
Sit and Reach (cm)	15,76	6,59	14,45	6,33	17,12	6,57	<	=

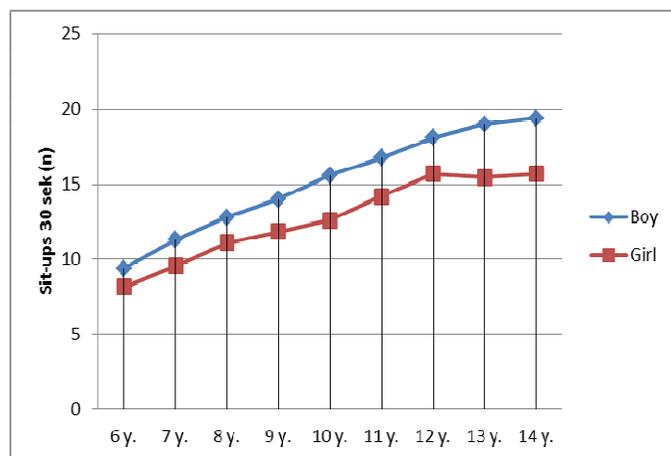
Data are shown as mean (SD), unless otherwise indicated. Sex and age differences were analysed by two-way analysis of variance, with sex and age group as fixed factors, and anthropometric or physical fitness measurements as dependent variables.

The symbol > in the “sex difference” column, the variable is significantly (p<0.05) higher for boys than for girls; <, the opposite; =, the non-significant differences.

Likewise, the symbol > in the “age trend” column, the variable tends to increase by increases in age; <, opposite; =, non-significant differences, -, not applicable.

**Table-2**  
**Basic statistical parameters and statistically significant differences between sex in fitness test “Sit-ups 30 sec (n)” with students from 6 to 14 years**

Years	Boy		Girl		p
	Mean	SD	Mean	SD	
6 y.	9,38	4,84	8,13	4,72	0,000
7 y.	11,29	4,98	9,53	5,22	0,000
8 y.	12,77	4,68	11,08	4,90	0,000
9 y.	13,98	4,88	11,82	4,98	0,000
10 y.	15,58	4,93	12,57	5,39	0,000
11 y.	16,74	5,14	14,17	4,58	0,000
12 y.	18,07	5,20	15,68	4,30	0,000
13 y.	18,98	4,67	15,46	4,29	0,000
14 y.	19,39	4,80	15,70	4,52	0,000

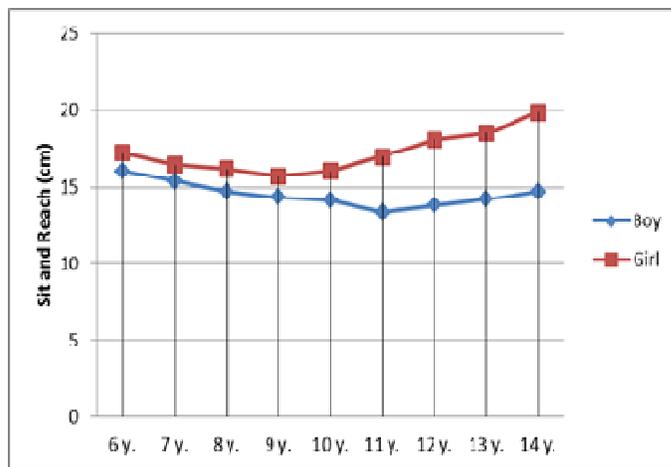


**Figure - 1**

**Development trend in fitness test Sit-ups 30 sec (n) with students from 6 to 14 years**

**Table-3**  
**Basic statistical parameters and statistically significant differences between sex in fitness test “Sit and Reach (cm)” with students from 6 to 14 years**

Years	Boy		Girl		P
	Mean	SD	Mean	SD	
6 y.	16,05	5,39	17,23	5,58	0,010
7 y.	15,40	5,78	16,45	5,58	0,040
8 y.	14,70	5,72	16,18	5,60	0,000
9 y.	14,35	5,97	15,73	6,03	0,000
10 y.	14,16	5,70	16,04	6,12	0,000
11 y.	13,39	6,24	16,99	6,65	0,000
12 y.	13,81	6,65	18,09	7,11	0,000
13 y.	14,21	6,91	18,47	7,39	0,000
14 y.	14,72	8,11	19,86	7,93	0,000



**Figure - 2**

**Development trend in fitness test Sit and Reach (cm) with students from 6 to 14 years**

**Discussion:** Several studies reported results about children’s and adolescent’s performance relating to different countries and within different health condition correlations. Rural or urban living areas<sup>1</sup>, growth<sup>2</sup>, biological manhood<sup>3,4</sup>, socio-economic status<sup>5</sup>, overweight and obesity<sup>6,7</sup>, PA level<sup>8</sup> have been related to physical performance. Indeed, the original idea of CE was the physical performance like a predictor of wellbeing status or health growth. In this way the EBT has easily applied and the instruction provided by the CE was found extremely useful.

As like suggested by Serbescu<sup>9</sup> the secular trend in motor performance of children and adolescents shows a decline but longitudinal studies are still not widespread (at least in Europe)<sup>10,11,12</sup>. In this European situation, the present study try to define the Italian performance baseline relating to children.

On the basis of the obtained results of our research can be concluded that boys unlike the girls in all age categories show better results in the fitness test “Sit-ups 30 sec.” and these differences are increasing with increasing the ages. The most expressed are the differences at the age of 14 (boys in average make 3,69 more repetition unlike the girls), the lowest results are observed at the age of 6 and 7 (the boys in average make 1,25 more repetition compared to girls). Gender differences in adolescence in combination with the effects of endocrine adaptation (influence of gonadal steroid hormones and the growth hormon) typical for sexual maturation, morphological difference, initially in the body composition (for boys is increasing the content of minerals in the bones and muscle mass and decreases fat deposition around hips), functional differences and physical activity are the main factors for the differences in the level of muscular fitness during adolescence among boys and girls<sup>13,14</sup>.

In all age categories girls show better results in the test “Sit and Reach”. The obtained results are similar with the research realized in Greece and France<sup>14,15</sup>. The reason can be in the

differences in the extent of growth and development of connective muscle and bone tissue, and because of the difference in the anatomy of the hip joint and pelvis between boys and girls<sup>16,17,18</sup>.

From the review of the curve (Figure 1) can be seen consistently moderate improvement of the results of the test „Sit-ups 30 sec.” from year to year in both sexes but between 12 and 13 year for girls when there is fall in the results of the test for 0.22 repetitions. The increase of the test result is not linear in all age categories, but shows periods of faster and slower intensity. The average increase of the motor test ”rasing the trunk in 30 sec” for boys between 6 and 14 year is 1.25 repetitions, and for girls 0.95 repetitions, and the same in both sexes annually increase from 0.24 to 1.61 repetitions. For girls the greatest acceleration of the test it is seen between 10<sup>th</sup> and 11<sup>th</sup> year, while for boys between 6<sup>th</sup> and 7<sup>th</sup>, and 9<sup>th</sup> and 10<sup>th</sup> year. The greatest variability of the motor test, „ Sit-ups 30 sek” it is indicated in 6th year for both sexes.

The flexibility shows oscillatory changes with the ages in both sexes. For girls from 6<sup>th</sup> to 9<sup>th</sup> years comes to a slight decline of the flexibility in the hip joint and lower spine then a slight acceleration (slight improvement) in the test results up to 14<sup>th</sup> year. For boys between 6<sup>th</sup> and 11<sup>th</sup> year come to a slight decline of the flexibility, then a slight acceleration of the test results from 12<sup>th</sup> to 14<sup>th</sup> year. The greatest improvement of the flexibility for both sexes is between 12<sup>th</sup> and 14<sup>th</sup> year in average for 1,39 cm for girls and 0,50 cm for boys. The greatest variability for both sexes in the fitness test “Sit and Reach” is at the age of 14<sup>th</sup>.

Comparing the international studies with the results obtained in our research can be concluded that students of both sexes from Macedonia achieve in average lower scores in tests “Sit-ups 30 sec.” and “Sit and Reach” at the age of 11 and 14 compared to the peers from Serbia, Belgium, Italy, Spain, Lithuania, Estonia<sup>4,7,8,19,20,21</sup>.

*Why is the flexibility important for young population?* There are many studies that prove the connection of the flexibility with better physical skills, reduced risk of injury, prevention or reduction of pain after exercise, improvement of the coordination<sup>41</sup>. A certain number of studies point that reduced flexibility in the reverse loge is a risk for development of tendinopathy and patelofemoral pain<sup>23,24</sup>, injuries of the tendons and muscles performing eccentric exercise. The poor flexibility can be the reason of subsequent injuries of tendons, including the Achilles tendon<sup>23</sup> and the plantar fascia<sup>24</sup>. The results of a recent finnished study showed that flexibility of the back loge (estimated by the test “Sit and Reach”) is one of the best indicators of the level of health and fitness in adult man. Many evidences suggest that maintenance of the flexibility in the joints prevent or greatly removes the pain and difficulties that occur with aging.

*Why is important the strength of abdominal muscles for young population?* The abdominal muscles are located in the front of the trunk from the chests to the groin. Along with the back muscles make so called natural corset that helps maintain normal, correct positions and preserving the stability and health of the spine and prevent injuries of the spine, the accompanying abdominal organs (organs located in the abdominal cavity), help with deep breathing or participate in performing many everyday movements<sup>25</sup>. From all above stated it can be concluded that the strength of the muscles of the front stomach wall is particularly important from functional and health reasons, and there may be added and esthetical, which is important for people of both sexes.

## Conclusions

In conclusion the performance scored by Macedonian boys and girls has shown a poor condition, the level of abdominal strength and low back flexibility is inferior than among other European countries’ students and improvements are desirable. Cultural disinclination to stretching training are in particular the most significant poor cause of results in SAR test.

From this point of view, the present study could represent the first Macedonian performance baseline useful to assess further physical condition study (urban and rural differences), PA correlations (sport practice influence), growing related modification and new inter-countries comparison (trend between different state).

Improvements of PE course in schools, definition of close program in content and cultural diffusion of benefits resulting from constant stretching and strength training are, in our opinion, the possible Italian solutions. Indeed, according to these result the Ministry of Education, recently, have radiated the new indication to improve the PE contents and to define the sports activity in school environment.

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