The Journal of Sports Medicine and Physical Fitness
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Title: Physical fitness for sedentary students: a common trend from six European countries
Paper code: J Sports Med Phys Fitness-8926
Submission Date: 2018-05-02 17:04:30
Article Type: Original Article

Files:
1): Manuscript
    Version: 2
    Description: full text
    File format: application/msword

2): Figures 1
    Version: 1
    Description: figure
    File format: application/pdf

Physical fitness for sedentary students: a common trend from six European countries

ABSTRACT

Background. Several studies have assessed the fitness level of students to evaluate physical condition, compare groups with differences in social disadvantage and to define indexes for post training programs. Often, these large surveys compared groups without normative value that could define the real, practical gaps. Thus, the aim of this study was the definition of baseline values describing the fitness level of sedentary European students.

Methods. Standing Broad Jump (SBJ), Sit Up (SUP) and Sit and Reach (SAR) physical fitness tests were assessed on 31,476 students (age=11-13) from six European countries were collected and analysed.

Results. The effect size for multiple groups ANOVA was obtained to verify the biological consistence of differences. Then, weighted-means were calculated and stratified for age and gender.

Overall, boys obtained SAR scores close to zero, while girls obtained results between 2 and 7 cm. The SUP test revealed similar results between boys and girls (about 20). SBJ performances were similar among countries (over 160 cm for boys and 150 for girls).

Conclusion. Our results were aligned to others studies performed in other Continents or Countries and can contribute to the establishment of a large and objective reference to readily evaluate the physical fitness and health-related status of young students.

Keywords: Student, Physical Education, Eurofit test, Performance, Physical Activity

Introduction

Physical activity plays a crucial role in determining mental and social behavior. It has been proven that regular physical activity leads to improvements in physiological and psychological health and in disease prevention.[1]

Several investigations analysed the fitness level of children, pre-adolescents and adolescents to evaluate the influence of new lifestyles based on electronic games, urban transportation habits, build environment,[2-3] that reduced the opportunities to practice outdoor activities. Factors like the economic development,[4] the socio-economic status, the urban/rural context,[5] the availability of facilities,[6] and the cultural habits or parent education level[7] necessarily influence the comparison of fitness level among different countries. That is particularly true if pre-adolescent students are assessed: as explained in a Spanish study,[8] the increased dropout rates of physical activity among school children begin during adolescence. For instance, Collins et al.[9] showed that young people belonging to suburban and rural context tend to spend more time in physical activities than matched urban students. At the same time, in a recent study assessing students from two countries with different level of development, Lovecchio et al.[6] did not detect significant differences between rural and urban populations.

Tomkinson et al.[7] found that north-east European students outperformed their southern counterparts in general physical fitness tests, apart from strength scores.[8, 10]

In practical terms should be take into account various factors (context, economical status, parental education, etc.).

Global values properly describing the youth population of different countries are difficult to obtain or are referred to a restricted area: Scandinavia[11], Spain[12] and Belgium/Flemish region.[13]

Thus, it became necessary to obtain large-scale, updated values describing a baseline physical fitness level reducing, at the best, the influence of different external factor. The

aim of this study was the definition of inter-area baseline values concerning the fitness level of young sedentary European students according to sex and age.

In particular, students from six European countries along a geographic longitudinal axis (North to South) were assessed. The scores of sedentary individuals could be assumed as a "baseline" value, i.e. an objective starting point in the evaluation of students in the examined age range, since it is not influenced by confounding factors as the exposure to different sport disciplines. The results of this study could represent a useful tool to evaluate the physical fitness and health-related status of young students. Indeed, assuming the sedentary level as the baseline value further consideration could be based on objective data: more than this level technicians could consider the results for sport evaluations while under as a critical condition for health status or fitness outcomes.

Materials and methods

Participants

31,476 students (15,328 females and 16,148 males) were recruited from six European countries and aged between 11 to 13 years during Physical Education (PE) classes. After the explanation of all procedures and the involved risks, an informed consent was obtained from all parents or legal guardians. The study was carried out in the same period (September-October 2016 during the first two month of the scholastic year) in several scholastic institutes in Italy, Croatia, Hungary, Serbia, Slovakia and Lithuania. In all these countries, the compulsory hours of PE are two and the physical practice is organised by school, sportive clubs (associated to the national Olympic committees) and recreational associations. In particular, the PE classes followed similar ministerial guidelines focusing on coordination skills, conditional improvement and team sport activity.[15-16]

All students were considered healthy and were not affected by neurological, orthopaedic or cardio-vascular diseases. The selection criteria were: (i) active participation to PE

classes; (ii) absence of injuries and possession of a valid medical certificate; (iii) not being involved in sport or other organized physical activities outside school. The latter allowed to considering them as sedentary, as not implicated in activities that do not increase energy expenditure above the resting level.[15]

Measures

The data collection consisted of physical fitness testing and anthropometric characterization. Physical tests were selected within the widespread Eurofit Battery Test.[17-18] Indeed, the Eurofit tests are a reliable and valid instrument to measure physical fitness in children;[18-23] since they are strictly defined, free from operators' influence,[23-24] simple to administrate, cheap, and can easily be organized in the school setting.[7, 18]

Other information about maturation and growth (for example the Tanner's self-assessment[25] were avoided because of practical issues in obtaining parental approval by parents and full compliance with students.

The Standing Broad Jump (SBJ), Sit and Reach (SAR) and Sit Up (SUP) tests were choose because their results are considered independent one to the other[11]. A brief explanation is reported below:[17]

SBJ: Each subject performed distance jumps from a standing start. While performing the jumps, the subjects were asked to bend their knees with their arms in front of them, parallel to the ground, then to swing both arms, push off vigorously and jump forward as far as possible, trying to land with their feet together and stay upright. The best out of two attempts was taken as the final score (expressed in centimeters).

SAR: from a seated position, children had to place their feet flat against one prepared box with a slide ruler between their feet. They were to gradually push the ruler with hands stretched, without jerking, and bend their trunk trying to reach forward as far as possible, always keeping the knees straight. Fingers of both hands had to reach the same

distance, and bouncing movements were not allowed. The test was done twice, and the better result counted as the score (in centimeters).

SUP: Trunk strength was assessed as the maximum number of sit-ups achieved in half a minute. Children were seated on the floor, backs straight, hands clasped behind their neck, knees bent at 90° with heels and feet flat on the mat. They then lay down on their backs, shoulders touching the mat, and returned to the sitting position with their elbows out in front to touch their knees, keeping the hands clasped behind their neck the whole time. The total amount of correctly performed sit-ups in 30 seconds was the score.

Procedures

First, each school was contacted through the local Physical Education teacher to obtain the approval of the director and the general school board. Subsequently, a specific newsletter explained to the parents the purpose of the study in order to obtain the written consent for students' participation.

The study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Data were collected by PE teachers (employed in middle school) provided with previous specific training in order to guarantee the standardization, validation and reliability of the measurements.[11, 17-18] The choice of middle-school students as a reference sample relied on the high motivation in participating in PE classes and in limited dropout rates, compared to adolescent students;[8] and because this class of age guarantee to meet the compulsory PE classes (two our/week) in all Countries of Europe.[15, 26]

All trials were performed during PE classes in three distinct sessions (one test per week to avoid fatigue effects[5] and following the SBJ-SAR-SUP order). One week before the first assessment a specific session was used to demonstrate the execution of all tests and permit to all students a tentative trial.[5, 27] At this stage, the height and weight were

measured with a fixed stadiometer (Seca Stadiometer or similar) and with a beam balance (Seca Beam Balance or similar) with accuracy nearest to 0.5 cm and 0.2 kg as already used in other studies administrated in school context and with children/preadolescent.[29] In particular, the anthropometric measurements of height and weight were taken according to the standard procedures described by the International Society for the Advancement of Kinanthropometry[30] and recorded anonymously.

Statistical analysis

Descriptive statistics (mean and standard deviation, SD) were calculated within sex, age and country for all anthropometric characteristics and tests scores.

The score of Physical fitness tests were compared among countries, sex and age categories using a 2x3x3 Multivariate Analysis of variance (MANOVA). Factors sex (male and female), age (11, 12 and 13 years) and country (Italy, Croatia, Hunghery, Serbia, Slovakia and Lithuania) were tested, as well as the reciprocal interaction.

The Cohen's d effect size for multiple-groups analysis of variance (ANOVA)[32] was computed to verify the biological consistence of differences. Then, weighted-means and standard deviations were calculated pooling the value of countries: stratification was kept for age and gender. All calculations were performed using SPSS v 14.0 and the significance level was set at $p<0.05$.

RESULTS

The minimum average values of weight ranged between 39 kg (11 years) and 48 kg (13 years) for girls and between 39 kg and 49 kg for boys, while maximum values were 45-54 kg and 44-56 kg for girls and boys, respectively (Table 1). In the female group, the average gain in weight was 5 kg between 11 to 12 years and 4.5 kg between 12 to 13

years, while boys gained 6.5 and 5 kg in the same age categories. Croatian students were the heaviest (both boys and girls) while Slovakian and Lithuanian students were the lightest.

The height increase was similar in both sexes (6 cm), both between 11 and 12 years and between 12 and 13 years. In general, Serbian students seemed to be the shortest. For girls, standing height ranged between 146 cm (Serbia; 11 years) and 162 cm (Slovakia, Crotian, Lithuania; 13 years); for boys, between 145 cm (Serbia; 11 years) and 164 cm (Croatia, 13 years).

Slovakia showed the lowest BMI values both for boys and girls while Croatia and Italy the largest. No BMI mean values were below 17 or over 21.5 kg/m^2.

In general, in SAR tests boys obtained scores that were negative. In particular, no male group (countries x age stratification) reached 2 cm. The highest mean value (1.4 cm) was found in the Croatian group. On the contrary, girls obtained results ~~comprised~~ between 2 and 7 cm. Italian girls showed the highest mean value (7 cm), while Lithuanian girls had the lowest (close to 2 cm). Slovakian and Hungarian participants' scores were similar: about 4.5 cm.

The SUP test revealed similar results between boys and girls. On average, boys performed 21 complete crunch cycles while girls about 19. Slovakia and Lithuania showed the best performance both for boys and girls: on average, 23.7 and 21 cycles respectively.

SBJ performances were over 160 cm for boys and about 150 for girls. SBJ scores were very similar among countries: Italian students scored 149 (girls) and 163 (boys); Slovakian 154 (girls) and 159 (boys); Hungheryn 151 (girls) and 167 (boys); Croatian 147 (girls) and 169 (boys), Serbian (140) girls and 153 (boys); Lithuanian 152 (girls) and 168 (boys).

The 3-way Anova showed significant differences for all variables and interactions except for height (sex factor, p=0.26) and BMI (Sex x Age x Countries, p=0.62) but the effect

sizes were less than one or very close for all variables (Table 2). Therefore, pooled means among countries were computed, maintaining the stratification by sex and age.

Considering the whole sample, we observed that children weight (boys and girls) during growth (11 to 13 years) increased from 41 to 51 kg (SD pooled between ages and sexes equal to 4 kg). The height growth was similar in both sexes: the stature ranged (female/male) from 150/149 cm (11 years) to 160/162 cm (13 years). The pooled SD between ages were 2.9 and 3.5 cm). The weighted means of BMI were, ordered by age (11-12-13 years), 18.46±0.76 kg/m^2, 19.09±0.53 kg/m^2 and 19.83±0.47 kg/m^2 for girls, and 19.01±1.37 kg/m^2, 19.68±1.13 kg/m^2 and 19.84±0.90 kg/m^2 for boys.

When considering all countries together, physical fitness trials revealed low values in SAR test (Figure 1). Girls reached, on average, 4.7±1.3 cm while boys reached negative scores up to -1.4 cm±SD 1.1. On average, in SBJ test girls jumped less than boys, and scores increased with age. On average, during the SUP test children performed about 20 crunch cycles (Figure 1).

DISCUSSION

The health status is a crucial issue for all governments[16] and its evaluation it is indirectly committed to physical tests.[17, 31-33] However, its practical assessment is difficult because many factors can invalidate or influence the performance: the cultural context, the personal habits/life styles, the rural/urban origin, the socio-economic status, the country economic level and parent cultural traditions.[3-6, 9, 34-36]

Thus, the aim of this research was the assembly of a baseline fitness level among different European countries based on a wide sample population, in order to minimize and alleviate the impact of all the previously cited factors.[37]

Only sedentary students were taken into account to exclude all occasional physical activity and/or sport practice-related differences.

The absence of significant differences from a practical point of view (effect size far less than one) among the countries allows a general interpretation of the data considering the same baseline about the variables. Despite these average values were not linked to a health outcome, they are useful for health and fitness screening, profiling and monitoring by identifying the mean rank of children/adolescents.

The weighted mean of BMI did not indicate cases of underweight or overweight,[38-39] although individual examinations are often preferable on this issue.

Physical Tests outcomes

SAR test indicates a critical condition in back motion and hamstring flexibility.[40-41] According to our data, the baseline value for girls is 5 cm while for boys at least the "zero" position should be obtained (Fig. 1). Indeed, this flexibility test returned poor results, already observed in similar populations, as reported by Ekblom et al.[28] as consequence of scantly habit/adherence to stretching practice.

Other studies found higher values, even in countries similar for socio-economic status or sport tradition.[31, 36, 42-43] These large differences should be taken with caution: the administration of SAR test could have been conducted according to the American College of Sport Medicine protocol (V leg position SAR test), that use a different procedure with respect to the Eurofit protocol,[17] or using a bouncing action. In general, the low hamstring flexibility assessed using European protocol suggests important education and promotion of stretching exercise. Other considerations considering maturation/growth are difficult to sustain based on the data collected. Indeed, Gouvea et al.[44] affirmed that late-maturation subjects may show less flexibility than typically developing peers, while Volver et al.[45] found better results according to the sexual

maturation during trunk forward flexion (stages II and III of Tanner's scale). These controversial results are emphasized by Kanbur et al.[46] who did not find correlations among sit-and-reach and sexual maturation (Tanner's stage), height, weight and BMI.

The SBJ that is an easily reproducible test both in clinical contexts and in school/gym environments provides interesting information about explosive force and coordination:[17] the range of this performance observed in the present analysis was 142-154 cm for girls and 154-173 cm for boys. In general, girls, as previously reported by other studies,[5, 10] had their mean distance very similar to their stature or 10-20 cm less, while boys were about 10-20 cm above their own stature.

Secular trends or other surveys assessing this performance in young people found similar results. For boys, in particular, Sauka et al.[11] and Catley and Tomkinson[47] reported similar results from Northern European Countries and Australia, respectively. Additionally, other studies showed values that matched our observations: Flemish region;[13, 48] Spain[12, 31] and Belgium[49]. Concurrently, Australian girls performed SBJ very similarly to our observations (143-157 cm),[47] or even equal if considering a Latvian survey.[11] In point of this, the personal stature could be considered as a personal reference value to reach (at least) during explosive strength performance. So, if the general question is "How long should my jump be to be adequate?"; the answer would be very easy and immediate: "A span around your standing!"

Considering the SUP test, many studies over the world assessed the performance of crunch. In particular, our global mean values are in line with other data collections: large surveys in Spain,[8, 43] Turkey,[50] Flemish region,[48] Sweden,[41] Madeira island[4] and Latvia[11] found results between 20-23 crunches for boys aged 10-13 years old. Also for girls, similar results were observed worldwide.[8, 11, 4, 13]

Thus, within our results, we propose that a score around 19-21 cycles (the SD is very low: 1.5) is the baseline among sedentary middle school population.

Limitations

The main limitation of the current study consists in the absence of information about the actual prepubertal/pubertal stage of the children, which are very arduous to obtain in the school context: in particular when the general purpose was not a clinical target. Further, no endurance run test was administered because its organization and correct implementation depends on the availability of gardens or adequate outdoor area: our scope was the easy, practible and large engagement of a lot schools.

In addition, the current data could be used within school programs for physical activity as baseline values and are not meant to identify pathological conditions.

CONCLUSION

In summary, we provided baseline values for physical fitness in sedentary European pre-adolescent children. Our result were very similar to that found in other European countries or in other continents. Waiting for the collection of a world-scale database including populations from other continents, this baseline of European students represents an objective normogram to evaluate physical fitness in school or gym context for scholastic academic results or performance assessment (by PE teacher/trainer). Further, physician/physiotherapist could use this baseline to assess the rehabilitation process and estimate the end of clinical activity. In sum, this large and wide geographical database is representative of sex- and age- specific evaluation of adolescent with outcomes for health, fitness screening, profiling and monitoring.

Conflicts of interest

Nothing to declare.

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Table 1. Anthropometric characteristics and sample sizes (n). Units for weight, height and BMI are kg, cm and kg/m^2 respectively.

			Girls			Boys		
Age			11	12	13	11	12	13
Italy	n		951	892	857	905	965	941
	Weight	mean	43.24	47.93	51.32	42.98	47.88	53.49
		SD	10.01	10.09	9.44	9.25	11.71	11.51
	Height	mean	149.90	156.20	159.34	148.85	155.56	162.37
		SD	7.81	6.40	6.49	7.38	8.30	8.72
	BMI	mean	19.10	19.56	20.17	19.28	19.62	20.15
		SD	3.45	3.61	8.92	3.21	3.74	3.30
Slovakia	n		732	606	444	752	648	940
	Weight	mean	39.85	43.16	48.62	40.85	44.00	50.46
		SD	8.25	8.98	7.29	8.88	8.40	10.29
	Height	mean	151.43	155.35	162.30	150.43	154.90	163.10
		SD	8.26	9.29	7.97	6.79	7.64	9.23
	BMI	mean	17.38	17.88	18.46	18.05	18.34	18.97
		SD	8.26	9.14	7.63	7.84	8.02	9.76
Hungary	n		894	872	1002	880	900	1036
	Weight	mean	41.70	45.70	49.70	41.90	46.80	51.60
		SD	10.50	10.70	9.60	10.90	11.50	11.70
	Height	mean	150.90	156.40	160.00	149.70	156.40	162.10
		SD	8.30	7.80	7.70	8.90	8.90	9.00
	BMI	mean	18.31	18.68	19.41	18.70	19.13	19.64
		SD	9.40	9.25	8.65	9.90	10.20	10.35

Croatia	n		1002	1015	1161	970	1059	992
	Weight	mean	45.48	50.27	54.32	44.61	50.10	56.10
		SD	11.07	11.42	10.57	10.88	12.09	13.31
	Height	mean	152.06	157.88	162.45	150.50	156.37	164.15
		SD	7.88	6.98	6.59	7.49	8.18	8.73
	BMI	mean	19.77	20.12	20.61	21.18	21.63	21.51
		SD	3.74	3.70	3.45	3.49	3.66	3.96
Serbia	n		852	934	934	884	1066	916
	Weight	mean	39.28	46.07	51.26	39.87	46.26	50.73
		SD	9.04	11.67	21.19	9.42	17.44	12.77
	Height	mean	146.05	154.16	158.67	145.21	152.43	158.63
		SD	7.15	7.77	7.75	7.32	8.19	9.54
	BMI	mean	18.27	19.24	20.24	18.75	19.73	19.94
		SD	3.24	3.97	8.11	3.37	7.42	3.67
Lithuania	n		736	714	730	784	790	720
	Weight	mean	39.73	46.39	50.34	39.88	47.78	49.46
		SD	7.77	8.03	8.75	7.76	9.94	9.39
	Height	mean	150.91	158.69	162.40	150.26	159.11	163.14
		SD	7.23	6.78	6.60	7.17	7.99	8.70
	BMI	mean	17.35	18.38	19.04	17.58	18.78	18.45
		SD	2.62	2.77	2.80	2.66	3.10	2.30

Table 2. Effect sizes (Cohen's *d*) for Anova with multiple groups. Comparison among Countries (keeping the stratification for age and sex) about the anthropometric and physical test.

	Age	Height	Weight	SAR	SUP	SBJ
Girls	11	0.95	0.87	0.94	0.79	0.91
	12	0.94	1.02	0.94	0.85	0.94
	13	0.75	0.99	0.99	0.76	0.99
Boys	11	0.89	0.86	0.83	1.01	0.88
	12	1.04	1.03	0.89	0.96	0.92
	13	0.99	0.93	0.96	0.97	0.89

Figure I. Results (mean and SD) about Sit and reach (SAR, top), Standing Broad Jump (SBJ, middle) and Sit Up (SUP, bottom) tests. Data were pooled among countries. Sex and age division were kept.

Figure I. Results (mean and SD) about Sit and reach (SAR, top), Standing Broad Jump (SBJ, middle) and Sit Up (SUP, bottom) tests. Data were pooled among countries. Sex and age division were kept.