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**Physical fitness levels of adolescents in the Ile de France region: comparisons
with Europeans standards and relevance for future cardiovascular risk**

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Short title: Physical fitness in French youth

ABSTRACT

The aim was to assess physical fitness in French schoolchildren in the region of Ile de France and to compare the results with European countries. The relationship between physical fitness and future health profile was of particular interest. Participants were 1851 French youth in the Ile-de-France region. Cardiorespiratory fitness, muscular endurance, speed, flexibility and speed agility were tested. Independent t-tests were used to compare differences between different variables. Spearman's rho correlation coefficients assessed the relationship between Body Mass Index, socioeconomic status and physical fitness. Boys were physically fitter than girls with the most significant difference being in agility. Subjects of normal weight have significantly better results than overweight or obese adolescents (+10.9 to 56.1%) ($p < 0.05$). Subjects with high socio economic status had better physical fitness than those with low socioeconomic status (+ 0.5 to 9.4%) ($p < 0.05$). Results also showed that the percentage of adolescents at increased future cardiovascular risk was 15.3 and 10.2% for boys and girls, respectively. Physical fitness in French schoolchildren living in the region of Ile de France is relatively low and unfavourable, especially in girls, when compared with existing European test results. In contrast, the adolescents' boys are generally fitter and also above the average of the European data. Introducing a health promotion curriculum in the schools of Ile de France is suggested to improve health and physical fitness.

Keywords: Assessment, Youth, Aerobic fitness, Muscular strength, Speed, Flexibility, Health

Introduction

Physical fitness is an important determinant of health in children and adolescents (Ortega *et al.*, 2008). Health-related physical fitness includes muscular strength, flexibility, speed/agility, and cardiorespiratory fitness (Heyward, 1991). Physically fit children and adolescents have fewer mental, nutritional, gastroenterological, cardiac, and respiratory diseases (Ortega *et al.*, 2008). Poor physical fitness is a strong risk factor for cardiovascular disease, even more powerful than dyslipidemia, hypertension or obesity (Myers *et al.*, 2002).

Cardiorespiratory fitness is the most significant health-related fitness measure in youth and has been well studied in European, American, African, Asian and Australian adolescents (Heyward, 1991; Olds *et al.*, 2006; Ortega *et al.*, 2011). Olds *et al.* (2006) reported on more than 100 studies of cardiorespiratory fitness in children and adolescents in 37 countries. However, other components of physical fitness are related to bone health, cardiovascular diseases, chronic musculoskeletal injuries and back problems in youth (Sjolie, 2004; Vicente-Rodriguez *et al.*, 2004; Vicente-Rodriguez *et al.*, 2008; Gale *et al.*, 2007; Malina *et al.*, 2004; Ruiz *et al.*, 2009). Improvement in muscular strength from childhood to adolescence was negatively associated with changes in adiposity, a predictor of improved cardiovascular profile later in life (Ruiz *et al.*, 2009).

The main objective of this study was to measure physical fitness levels in a large sample of French schoolchildren in the region of Ile de France and to compare the findings to other European countries. Cardiorespiratory fitness, as an important risk factor for cardiovascular disease, was of particular interest.

Methods

Study design

The current study was based on data from the French health promotion program “Move... A priority for your health” (<http://www.bougetasante.fr/>). The main aim of this program was to promote the benefits of physical activity and physical fitness on the health of French youth, ages 11 to 15 years. Data were collected between 2009 and 2013 in the Ile de France region (Paris Suburban, France). The program has been adopted in 23 schools throughout the region. The study was approved by the Research Ethical Committee (CPP Nord-Ouest IV, Lille, France). All procedures were performed in accordance with the ethical standards of the Helsinki Declaration of 1975 as revised in 2008 and the European Good Clinical Practices and with the ethical standards of the sport and exercise science research (Béghin *et al.*, 2008; Harriss & Atkinson, 2011).

A manual of operations was developed for the physical education teachers and study subjects in order to match tests across schools and improve homogeneity. Included in the manual was: rationale of the study, procedures of tests, and how data were recorded.

Measurements

Physical Measures

Height and weight were measured by a school nurse. Weight was measured in shorts and T shirts without shoes to the nearest 0.1 kg using an electronic scale. Height was measured without shoes to the nearest 0.1 cm using a standard physician’s scale. The body mass index (BMI) of the subjects was calculated from their measured height and weight (BMI = weight divided by height squared, kg/m²).

Physical fitness

Physical fitness was assessed from the Eurofit and FitnessGram battery. The test battery assesses cardiorespiratory fitness, muscular endurance, flexibility, and speed/agility. Flexibility and speed/agility tests were performed twice and the best score was recorded. Cardiorespiratory fitness and muscular endurance tests were measured one time because they are exhausting and require considerable time to administer. Physical education teachers who had undergone special training to correctly administer tests performed all physical fitness tests.

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed with a 20 meter shuttle run test (Leger *et al.*, 1988). Subjects were required to run between two lines 20 m apart, while keeping pace with audio signals from a pre-recorded CD. The initial speed was 8.5 km.h⁻¹, which was increased by 0.5 km.h⁻¹.min⁻¹ (1 min equals one stage). Subjects were instructed to run in a straight line, to pivot on completing a shuttle, and to pace themselves in accordance with the audio signals. The test was terminated when the subject failed to reach the end lines concurrent with the audio signals on two consecutive occasions or if the subject stops because of fatigue. All measurements were carried out under standardized conditions on an indoor rubber-floored gymnasium. Subjects were encouraged to keep running throughout the test. The last completed stage or half-stage was recorded for use in a formula to obtain VO_{2max} easily and quickly (Leger *et al.*, 1988).

Muscular endurance

Muscular endurance was assessed by the curl ups test (Castro-Pinero *et al.*, 2009). The subject lies in a supine position on the mat, knees bent at an angle of approximately 90°, feet flat on the floor, legs slightly apart, arms behind the head. From this starting position, the subject curls up slowly, leading the elbows up to the knees and returns to the starting position completing as many repetitions as possible with a cadence of 1 curl every 3 seconds. The heels must maintain contact with the mat, and the elbows must touch the knees during the flexion movement and touch the mat during the extension movement. The test is terminated when the subject is not able to maintain the cadence, or to complete the flexion-extension movement correctly. Subjects were encouraged to breathe easily during the test.

Speed

The 50-meter sprint test was used to assess speed (Castro-Pinero *et al.*, 2010). The subjects stood still in a comfortable position, feet behind the starting line, with no rocking movements. The test began on the whistle and was concluded when the runner crossed the finish line.

Flexibility

Flexibility was assessed by the back-saver sit and reach test (Ortega *et al.*, 2011). The subject flexes the trunk and reaches forward as far as possible from a seated position, with one leg straight and the other bent at the knee. The test is performed once again with the opposite leg. The farthest position of the bar reached by each leg was scored in centimetres and the average of the distances reached by both legs was used in the analysis.

Speed/Agility

Speed and agility were assessed using the 5 x 10 m shuttle run test (Council of Europe, 1983). Two parallel lines were drawn on the floor 5 m apart. The subject was instructed to run as fast as possible from the starting line to the second line and returns, crossing each line with at least one foot every time. The test was performed twice, covering a distance of 50 m (10 x 5 m). The stopwatch was stopped when the subject crosses the end line with one foot.

Characteristics data

Nutritional status was assessed using international age- and gender specific cut-off points (Cole *et al.*, 2000). Socioeconomic status was assessed by the Human Development Index (HDI), developed by the United Nations Development Program (<http://hdr.undp.org/en>). The HDI combines three dimensions: (i) A long and healthy life: Life expectancy at birth; (ii) Education index: Mean years of schooling and Expected years of schooling; (iii) A decent standard of living: Gross National Income per capita. Low and high socio-economic status were determined using the thresholds of 0.5 (<http://hdr.undp.org/en>).

Cardiovascular Risk

Cardiovascular risk was categorized by sex-specific cut-offs for a healthy cardiorespiratory fitness level in adolescents proposed by FITNESSGRAM (Cureton & Warren, 1990; The Cooper Institute, 2004). These cut-off points were extrapolated from the thresholds for adult population related with a higher risk of morbidity and mortality established by Blair *et al.* (1989). In addition, they recently showed to be

valid for discriminating between adolescents with a more favourable cardiovascular profile and those with a less favourable profile (Lobelo *et al.*, 2009).

Statistical analysis

The data were analysed using the Statistical Package for the Social Sciences, Windows v. 11.5 (SPSS Inc., Chicago, IL) and Excel 2003 (Microsoft Inc., Redmond, WA). Data are expressed as mean (standard deviation).

Independent t-tests were used to compare differences between different genders, BMI categories and levels of cardiovascular risk. To assess the relationship between BMI, HDI and the different components of physical fitness, Spearman's rho correlation coefficients were calculated.

A *P* value of 0.05 was chosen for significance.

Results

Physical characteristics of subjects according to gender are presented in Table 1. One thousand eight hundred fifty-one volunteers, 946 male and 905 female, participated in the study. Mean age was 12.3 ± 3.6 years. The mean of height and weight were 1.54 ± 0.8 m and 45.9 ± 10.6 kg, respectively. Among the subjects sample, 14% were overweight (17% and 11% for boys and girls, respectively) and 4% were obese (5 and 2% for boys and girls, respectively).

Fitness results according to genders are presented in Table 2. Generally, boys performed better than girls. Significant differences were found between boys and girls in speed and cardiorespiratory fitness tests (Table 2).

Fitness results according to BMI categories are presented in Table 3. Normal weight subjects had significantly better results than those who were overweight or obese for each physical fitness component ($p < 0.05$).

Fitness results according to socioeconomic status are presented in Table 4. Subjects of high socioeconomic status performed significantly better than those of low socioeconomic status in speed/agility and cardiorespiratory fitness tests ($p < 0.05$).

Correlations between BMI, socioeconomic status and physical fitness are provided in Table 5. Negative correlations were found between BMI and speed ($r = -0.134$, $p = 0.001$), speed/agility ($r = -0.089$, $p = 0.001$), muscular endurance ($r = -0.087$, $p = 0.001$) and cardiorespiratory fitness test ($r = -0.204$, $p = 0.001$). Positive correlations were found between socioeconomic status and speed ($r = 0.640$, $p = 0.004$), speed/agility ($r = 0.243$, $p = 0.001$), muscular endurance ($r = 0.179$, $p = 0.001$), flexibility ($r = 0.590$, $p = 0.009$) and cardiorespiratory fitness ($r = 0.510$, $p = 0.022$).

Cardiovascular Risk

The percentage of French schoolchildren at future risk of cardiovascular disease is presented in Figure 1. The percentage of subjects with low cardiorespiratory fitness and increased cardiovascular risk was higher in boys than girls. In general, subjects at increased cardiovascular risk performed more poorly on physical fitness tests than those not at risk (Figure 2) ($p < 0.05$).

Discussion

Physical fitness in childhood and adolescence is a potent predictor of health, not only over the further years but also at the adult age (Ortega *et al.*, 2008). Cardiorespiratory fitness but also muscular fitness have been increasingly recognized in the prevention of chronic disease and inversely associated with established and emerging cardiovascular risk factors in adolescents (Wolfe, 2006; Benson *et al.*, 2006; Steene-Johannessen *et al.*, 2009; Magnussen *et al.*, 2012). The purpose of this study was to measure physical fitness in a large sample of French schoolchildren in the Region of Ile de France, to compare our findings with other European countries, and, based on the measurement of fitness in the present sample, to estimate the percentage of adolescents at increased cardiovascular risk.

Our findings, that adolescent boys are physically fitter than adolescent girls, agrees with previous studies assessing health-related physical fitness (Ortega *et al.*, 2011; Ortega *et al.*, 2005; Secchi *et al.*, 2014). Our results, that adolescents of higher socio economic status are more physically fit than adolescents of low socio economic status, also agrees with previous findings which showed a significant difference between socioeconomic groups in aerobic fitness of female high school students (Fahlman *et al.*, 2006; Welk *et al.*, 2010). Authors examined the relationship between demographic and geographic variability in aggregated school-level data on aerobic fitness and concluded that school-level attainment of fitness was consistently higher in schools categorized as high socioeconomic status (Welk *et al.*, 2010).

Findings of the present study showed that physical fitness of French schoolchildren living in the Ile de France region was lower compared to European norms. European normative values are available for the cardiorespiratory fitness, speed and flexibility tests (Ortega *et al.*, 2011; Castro-Pinero *et al.*, 2009; Castro-Pinero *et al.*, 2010). Compared to European adolescent boys our male subjects were

at the 50th percentile while adolescent girls were well below the European mean, i.e., 20th to 30th percentile for the flexibility (Ortega *et al.*, 2011). For the cardiorespiratory fitness, French adolescent boys from our study were slightly above the European mean in cardiorespiratory fitness, between the 50th and 70th percentiles while our adolescent girls were at the 40th percentile of the European mean (Ortega *et al.*, 2011). Results from the 50 meter sprint test showed that our subjects, both boys and girls, performed poorly compared to Spanish adolescents, falling between the 20th and 30th percentile for boys and the 30th and 40th percentile for girls (Castro-Pinero *et al.*, 2010). Our findings concur with studies of physical fitness levels in children and adolescents of different European countries, which showed that French adolescents were classified relatively poorly, 14th of 22 countries (Tomkinson *et al.*, 2007).

To our knowledge, no data are available assessing cardiorespiratory fitness and cardiovascular risk in French adolescents. Using cardiorespiratory thresholds associated with increased cardiovascular risk, we estimated the percentage of adolescent boys and girls at cardiovascular risk in adulthood as 15.3% and 10.2% (The Cooper Institute for Aerobics research, 2004). Thresholds fixed to discriminate no risk or future cardiovascular risk are 42 and 38 ml.kg⁻¹.min⁻¹ for adolescent boys and girls, respectively. Based on these thresholds more than one in ten French adolescents are at risk to develop cardiovascular disease in adulthood. Moreover, adolescents at risk for cardiovascular disease likely would be even greater when taking low results in other physical fitness tests, e.g. muscular endurance, speed, agility and flexibility into consideration. Cardiorespiratory, speed/agility and muscular fitness were all shown to be associated with established and emerging cardiovascular disease risk factors (Ortega *et al.*, 2008). Physical fitness in childhood

and adolescence is a powerful marker of health (Ortega *et al.*, 2008). Based on findings from the present study, the authors recommend promoting school-based intervention programs for this age group that increase vigorous physical activity and improve physical fitness. Furthermore, it was observed that health-related fitness testing required minimal time and equipment, was easily administered by a physical education teacher, was safe, inexpensive, and easily adapted according to age.

In summary, physical fitness in adolescents' girls living in the Ile de France region is generally low when compared with existing European values. In contrast, the adolescents' boys are generally fitter and also above the average of the European data. Low physical fitness levels were related to obesity and low socioeconomic status. Implementing a physical education curriculum to promote positive health related physical fitness in the schools of the region would help to promote better health and fitness.

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Conflict of Interest statement

The authors declared no conflict of interest.

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Legends

Figure 1. Percentages of French adolescents with a cardiovascular risk associated with a low cardiorespiratory fitness (The Cooper Institute for Aerobics research, 2004).

Figure 2. Difference between the two groups (no and future cardiovascular risk) in adolescents for the different health-related physical fitness components. All tests were significantly different ($p < 0.05$) (The Cooper Institute for Aerobics research, 2004).

Table 1. Physical characteristics of subjects (n = 1851)

Table 2. Physical fitness results (mean \pm SD) according to gender

Table 3. Physical fitness results (mean \pm SD) according to BMI categories

Table 4. Physical fitness (mean \pm SD) according to socioeconomic status

Table 5. Spearman's rho correlations (p) with BMI and HDI

Table 1. Physical characteristics of subjects (n = 1851)

	Boys	Girls	All
N	946	905	1851
Age (<i>yr</i>)	12.3 ± 5	12.4 ± 0.9	12.3 ± 3.6
Height (<i>m</i>)	1.54 ± 0.1	1.54 ± 0.1	1.54 ± 0.8
Weight (<i>kg</i>)	46.1 ± 10.8	45.9 ± 10.4	45.9 ± 10.6
Overweight/Obese (<i>n</i>)	157/46	102/23	259/69

Table 2. Physical fitness results (mean \pm SD) according to gender

	Boys (n=946)	Girls (n=905)
Speed (<i>sec</i>)	9.36 \pm 1.59	9.58 \pm 1.98*
Speed/Agility (<i>sec</i>)	19.96 \pm 3.1	19.77 \pm 3.04
Muscular endurance (<i>n</i>)	32 \pm 19	31 \pm 19
Flexibility (<i>cm</i>)	19.9 \pm 8.6	19.8 \pm 8.6
Cardiorespiratory fitness (VO ₂ ml.kg.min ⁻¹)	49.7 \pm 7.3	45.9 \pm 6.5*

* p<0.05

Table 3. Physical fitness results (mean \pm SD) according to BMI categories

	Normal Weight (n=1523)	Overweight + Obese (n=328)
Speed (<i>sec</i>)	8.32 \pm 1.62	10.23 \pm 3.24*
Speed/Agility (<i>sec</i>)	19.82 \pm 3.12	22.24 \pm 4.01*
Muscular endurance (<i>n</i>)	41 \pm 22	18 \pm 7*
Flexibility (<i>cm</i>)	24.8 \pm 7.6	13.7 \pm 6.7*
Cardiorespiratory fitness (<i>ml.kg.min⁻¹</i>)	44.3 \pm 8.9	25.6 \pm 6.9*

* p<0.05

Table 4. Physical fitness (mean \pm SD) according to socioeconomic status

	Low	High
Speed (<i>sec</i>)	9.51 \pm 1.64	9.46 \pm 1.85
Speed/Agility (<i>sec</i>)	20.57 \pm 3.57	19.61 \pm 2.81*
Muscular endurance (<i>n</i>)	29 \pm 18	32 \pm 19
Flexibility (<i>cm</i>)	19.6 \pm 8.8	20.1 \pm 8.5
Cardiorespiratory fitness (<i>ml.kg.min⁻¹</i>)	38.1 \pm 6.2	39.3 \pm 3.8*

* p<0.05

Table 5. Spearman's rho correlations (*p*) with BMI and HDI

	BMI	HDI
Speed (<i>sec</i>)	- 0.134 (0.001)	0.640 (0.004)
Speed/Agility (<i>sec</i>)	- 0.089 (0.001)	0.243 (0.001)
Muscular endurance (<i>n</i>)	- 0.087 (0.001)	0.179 (0.001)
Flexibility (<i>cm</i>)	- 0.005 (0.842)	0.590 (0.009)
Cardiorespiratory fitness (<i>ml.kg.min⁻¹</i>)	- 0.204 (0.001)	0.510 (0.022)

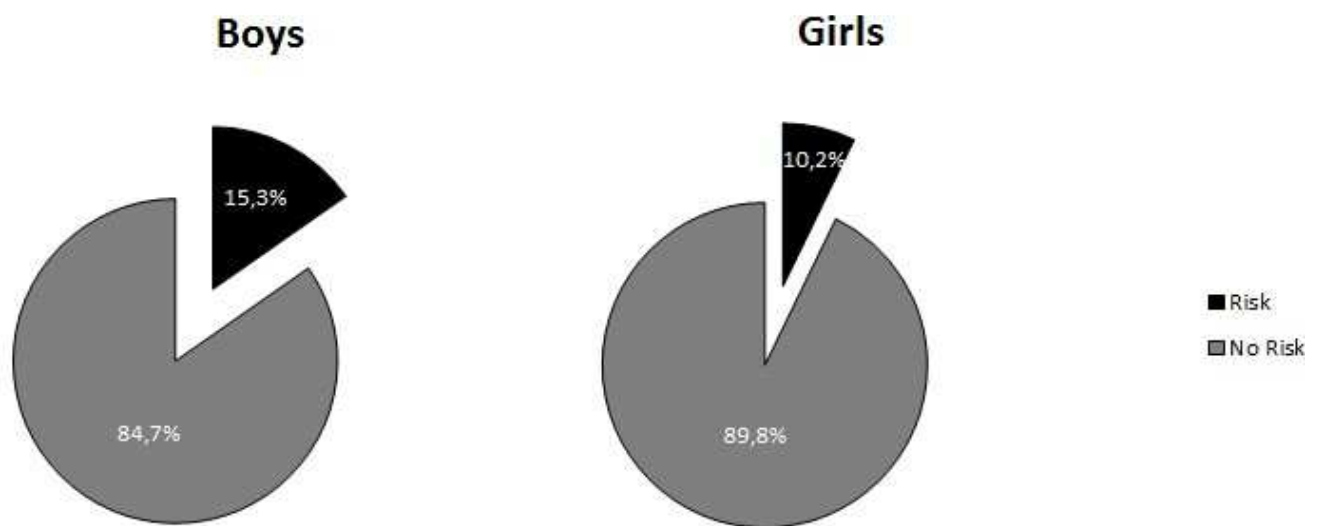


Figure 1. Percentages of French adolescents with a cardiovascular risk associated with a low cardiorespiratory fitness (The Cooper Institute for Aerobics research, 2004).

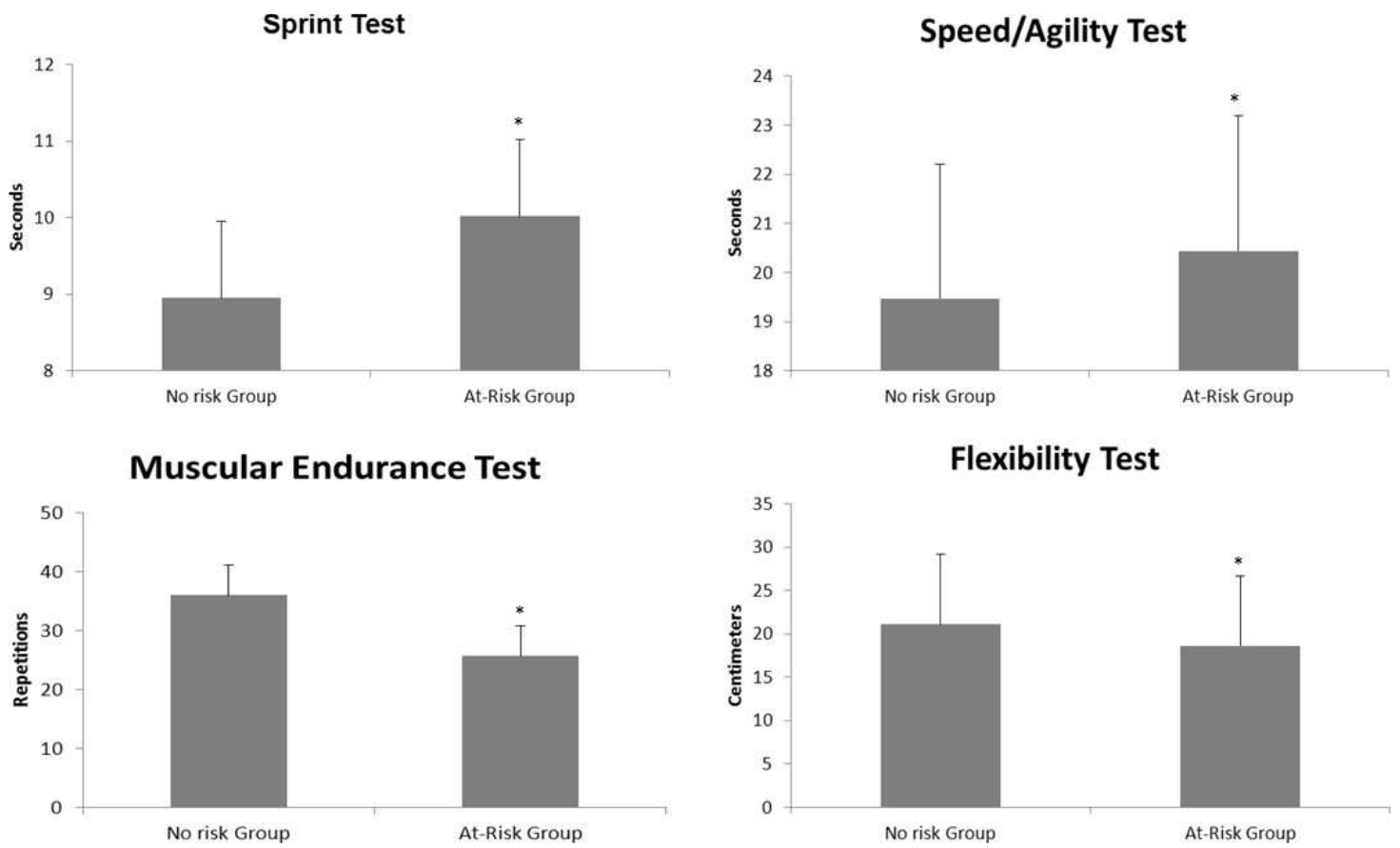


Figure 2. Difference between the two groups (no and future cardiovascular risk) in adolescents for the different health-related physical fitness components. All tests were significantly different ($p < 0.05$) (The Cooper Institute for Aerobics research, 2004).