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**Title:** Analysis of the effect size of overweight in muscular strength tests among adolescents.

Reference values according to sex, age and BMI

**Running head:** Muscular strength test according to BMI

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## **Competing interests**

None.

Analysis of the effect size of overweight in muscular strength tests among adolescents.  
Reference values according to sex, age and BMI

## INTRODUCTION

Muscular strength is a powerful marker of health during adolescence and for future adulthood (1). Muscular strength in young people has been reported to have a negative relationship with cardiovascular disease risk factors, such as triglycerides, total cholesterol, high/low-density lipoprotein cholesterol and blood pressure (2), or insulin resistance (3). Adolescents with low upper-body muscular strength also have a lower risk of reporting health risk behaviors such as alcohol consumption or getting drunk occasionally (4). Thus, muscular strength tests provide important health status information about young people.

The most common way to assess muscular strength in young people is through field tests due to their validity, ease of execution, lack of sophisticated technical equipment, the little time needed to perform them and the possibility of assessing a large number of participants simultaneously (5). Among the muscular strength tests most used are the standing long jump (6, 7), grip strength assessed with a manual dynamometer (6) and 30 s of sit-ups (7-9). Furthermore, there are now many valid and reliable batteries for these tests (5, 10-11). From these batteries, normative reference values are shown based on the sex and age parameters as it has been widely demonstrated that boys regularly obtain greater strength scores than girls and that strength increases significantly in both sexes as age advances (5, 12-13).

However, during the last 20 years, young people have increased the amount of daily time they are sedentary, spending 8–9 h/day on behaviors related to the use of new technologies –watching television, playing videogames and using smartphones, tablets

1 or computers– (14). In addition, currently 81% of young people aged 11–17 do not  
2 engage in the recommended daily minimum of 60 min of moderate to vigorous physical  
3 activity [MVPA] (15). The consequence has been a progressive increase in the  
4 prevalence of overweight/obesity (16). Overweight young people –including those with  
5 overweight+obesity– show lower power in their legs (6) and lower resistance in the  
6 flexor musculature of the trunk than their normal-weight counterparts (7-8), but greater  
7 hand grip strength (8, 17). Thus, body mass index (BMI), a measure more standardized  
8 globally and clinically equal to or even more reliable than other measures of weight  
9 status (18), could significantly influence strength test results in overweight adolescents,  
10 who will exhibit inferior performance compared to their normal-weight peers. To the  
11 best of our knowledge, no study has yet quantified the magnitude of the difference in  
12 previous measures, analysing the effect size of a high BMI on adolescent muscular  
13 strength.

14 Because overweight is affecting a greater number of young people, this study aimed  
15 to establish whether it is necessary to take account of BMI in assessing muscular  
16 strength in addition to sex and age. We hypothesize that the effect size obtained from  
17 the difference between normal-weight and overweight young people could exceed the  
18 result obtained from the differences between sexes within the same age group. These  
19 data would allow physical education (PE) teachers and coaches to adapt the level of  
20 muscular strength tests to consider BMI in addition to the sex and age of adolescents.  
21 Therefore, the purpose of this study was to quantify the effect size of overweight on the  
22 results of three muscular strength tests (upper limb, trunk and lower limb) in  
23 adolescents. It was also intended to report percentile tables adapted to sex, age and BMI  
24 in a relatively large sample of Spanish girls and boys aged 12 to 16 years.

## METHODS

### Experimental Approach to the Problem

This cross-sectional study aimed to quantify the effect size of overweight on the muscular strength of adolescents. It also provides percentile values for three different muscular strength tests according to sex (girl, boy), age (12-16 years) and BMI (normal-weight, overweight). In all, 861 secondary schools from Andalusia (Spain) were invited to participate in the study. Data were obtained from 42 secondary schools (4.87%) which were selected for convenience among the 165 (19.2%) schools that expressed interest in this study. The data were collected during 2013/14 and 2014/15. Data recording was carried out anonymously and informed consent was obtained from the parents or legal guardians of the participants. This study was approved by the Bioethics Committee of the University of XXX (omitted for anonymity). The design complies with the Spanish regulations for clinical research involving humans (*Law 14/2007, 3 July, on Biomedical Research*), with the regulations for private data protection (*Organic Law 15/1999*) and with the principles of the Declaration of Helsinki (2013 version, Brasil).

### Participants

A total of 11044 Spanish adolescents (48.5% girls) with an average age of  $14.39 \pm 1.21$  years took part in this study. They had a BMI of  $21.87 \pm 4.10$  kg/m<sup>2</sup> and were categorized as normal-weight and overweight according to the International Obesity Taskforce criteria (19) and the specific cutoffs for each sex and age proposed by Cole & Lobstein (20). Thus, 72.2% and 27.8% of the participants were found to be normal-weight and overweight+obesity respectively. The anthropometric and physical fitness

1 features of the study sample are detailed in Table 1. Participation was voluntary,  
2 authorized and unrewarded.  
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## 7 **Procedure**

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9 A detailed operating manual was designed to carry out all data collection processes. The  
10 members of the research team practised for two weeks before beginning the fieldwork  
11 (21). The data were registered during PE classes. All children in a standard class group  
12 were included in the study, except those with muscle or joint pathologies or any other  
13 physical impairment that militated against PA practice. The age range considered valid  
14 to participate in this study was 12-16 years.  
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24 Although there are several procedures for estimating effect size, such as the  
25 coefficient of determination,  $\eta^2$ ,  $\omega^2$ , or  $\phi$  (22), this study used the standardized  
26 difference of means obtained by the adjusted Hedges'  $g$  (23). Hedges'  $g$  estimates the  
27 difference between the means of the groups and expresses a typified value that makes it  
28 possible to infer from the normal curve the proportion of cases indicating that one group  
29 is below the average of the other group. This decision was based on three favourable  
30 criteria: (1) accurate and unbiased estimation, (2) simplicity of calculation and (3) ease  
31 of interpretation of the results (24).  
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## 46 **Instruments**

47 *Anthropometric measures.* Weight was measured in underwear and without shoes using  
48 an electronic scale (Type ASIMED® Elegant type B – class III) to the nearest 0.1 kg.  
49 Height was measured barefoot on the Frankfort horizontal plane with a telescopic height  
50 measuring instrument (Type SECA® 214) to the nearest 0.1 cm. BMI was calculated as  
51 body weight in kg divided by the square of height in m.  
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2 *Muscular strength fitness test.* To assess muscular strength, we selected one lower limb  
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4 test, one upper limb test and one core zone test from the ALPHA-Fitness (25) and  
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6 EUROFIT batteries (26): standing long jump, grip strength (manual dynamometer), and  
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8 sit-ups (30 s), respectively (see Figure 1). The reliability of these tests has previously  
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10 been demonstrated (1, 5, 12). The standing long jump and hand grip tests were  
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12 performed twice and the mean value was registered. The standing long jump, hand grip  
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14 test and sit-ups showed excellent intra-class correlations (ICC = 0.911, 95% CI: 0.906–  
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16 0.919; ICC = 0.892, 95% CI: 0.883–0.901; ICC = 0.923, 95% CI: 0.921–0.926 [applied  
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18 only to n=190], respectively).  
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27 [Insert Figure 1 about here]  
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32 The tests were as follows: The standing long jump test assesses leg power. The  
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34 participant stands behind the starting line and is instructed to push off vigorously and  
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36 jump as far as possible. The participant has to land with the feet together and stay  
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38 upright. The distance is measured from the take-off line to the point where the back of  
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40 the heel nearest to the take-off line lands on the mat. A further attempt was allowed if  
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42 the subject fell backwards or touched the mat with another part of the body (17, 27).  
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46 The maximum grip strength of each hand was assessed using a digital manual  
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48 dynamometer (Takei TKK 5101; range, 5–100 kg), obtaining the average of the two  
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50 measurements (8, 14).  
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54 Sit-ups assess abdominal muscular endurance. The participant lies supine on a mat,  
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56 with hands on shoulders and the knees flexed at an angle of 90°. A classmate holds the  
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58 subject's ankles firmly for support and to keep count. With each sit-up, the subject's  
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elbows have to touch the knees (on the same side, not twisting). After each upward movement, the shoulder blades have to return to touch the floor (mat). The participant repeats this movement as many times as possible in 30 s. The number of sit-ups performed in this time was recorded (6, 8, 27).

### **Statistical analysis**

The anthropometric and physical fitness characteristics of the study sample are presented as means (SD), unless otherwise indicated. The normality and homoscedasticity of the data were verified using the Kolmogorov–Smirnov and Levene tests, respectively. Percentile values were identified and smoothed using the Lambda-Mu-Sigma (LMS) method, which adjusts for the asymmetry of the percentile distribution (L = symmetry coefficient, M = median, and S = variation coefficient) ( 28). For this, the software TLMSchartmaker Light (version 2.54) was used (29). We analysed sex and age-group differences in the anthropometric and physical fitness variables through two-way analysis of variance. To analyse the differences in each strength test according to sex (male and female) and weight status (normal-weight and overweight+obesity) in each age group, we used Student’s t-test. Due to the practical interest of this kind of work, the effect size was calculated using the adjusted Hedges’  $\bar{g}$  because it maintains a greater independence of statistical significance with regard to the sample size (30). In addition, we calculated the value of the probability of each difference using the standardized normal distribution table (31). To make maximum use of the data, all valid data were included in the statistical analyses and therefore the sample sizes vary according to the physical test used. Analyses were performed separately for each physical test. The accepted level of significance was  $p < 0.05$ . The data were analysed in the Statistical Package for the Social Sciences (SPSS, version

22.0), except for the adjusted Hedges'  $\bar{g}$ , which was carried out in the Excel spreadsheet provided by Microsoft.

## RESULTS

The anthropometric characteristics and physical strength parameters of the study sample are shown by sex in Table 1. The results show that boys had a higher weight and height than girls ( $p < 0.05$ ). In all three tests and at all ages strength is greater in boys than in girls in both normal-weight and overweight populations (all  $p < 0.001$ ). All anthropometric variables and muscular strength test results tend to increase in both sexes when age advances.

[Insert Table 1 about here]

The results obtained in the standing long jump test are presented in Table 2. At all ages, boys and girls in the overweight sample had lower values for the standing long jump than their normal-weight peers (all  $p < 0.001$ ). The analysis of effect size showed that 75.4% of boys and 69.8% of girls aged 12 years in the overweight group had standing long jump scores equal to or lower than the average for their normal-weight peers ( $143.3 \pm 24.1$  vs.  $159.9 \pm 24.3$  cm,  $\bar{g} = 0.689$ , effect magnitude [M] = 0.754 and  $121.4 \pm 22.4$  vs.  $133 \pm 21.6$  cm,  $\bar{g} = 0.529$ , M = 0.698, respectively). Similar effect sizes were obtained for the other ages ( $\bar{g} = 0.874$ , M = 0.807 and  $\bar{g} = 0.512$ , M = 0.695 for the highest and the lowest, respectively). Regarding sex, between 95.6% and 98.2% (highest and lowest values, respectively) of normal-weight girls had standing long jump scores equal to or lower than the average for boys ( $\bar{g} = 1.172$ , M = 0.956 and  $\bar{g} = 2.149$ , M = 0.982). Similarly, the standing long jump scores for overweight girls were between

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83.1% and 98.8% (lowest and highest values, respectively), equal to or lower than the boys' average ( $\bar{g} = 0.961$ ,  $M = 0.831$  and  $\bar{g} = 2.271$ ,  $M = 0.988$ ).

[Insert Table 2 about here]

The results obtained in the manual dynamometer test are presented in Table 3. At all ages, overweight boys and girls exhibited higher manual strength than their normal-weight peers (all  $p < 0.01$ ). The analysis of effect size shows that 69.8% of boys and 71.2% of girls aged 12 years in the overweight group had manual strength equal to or higher than the average for normal-weight peers ( $25.2 \pm 6.3$  vs.  $22.2 \pm 5.5$  kg,  $\bar{g} = 0.520$ ,  $M = 0.698$  and  $20.7 \pm 4.4$  vs.  $18.3 \pm 4.2$  kg,  $\bar{g} = 0.560$ ,  $M = 0.712$ , respectively). Similar effect sizes were obtained for the remaining ages ( $\bar{g} = 0.516$ ,  $M = 0.698$  and  $\bar{g} = 0.376$ ,  $M = 0.643$  for the highest and the lowest, respectively). Regarding sex, between 76.5% and 98.8% (lowest and highest values, respectively) of normal-weight girls exhibited manual strength equal to or lower than the boys' average (range  $\bar{g} = 0.794$ ,  $M = 0.765$  and  $\bar{g} = 2.261$ ,  $M = 0.998$ ). Similarly, the manual strength scores for overweight girls were between 68.4% and 99.4% (lowest and highest value, respectively), equal to or lower than the boys' average ( $\bar{g} = 0.848$ ,  $M = 0.684$  and  $\bar{g} = 2.561$ ,  $M = 0.994$ ).

[Insert Table 3 about here]

The results obtained in the 30 s sit-ups test are presented in Table 4. At all ages, overweight boys and girls had lower core strength than their normal-weight peers (all  $p < 0.05$ ). Analysis of the effect size shows that 65.5% of boys and 65.9% of girls aged 12 years in the overweight category obtained scores for 30 s of sit-ups equal to or lower than the average of their normal-weight peers ( $24.10 \pm 5.58$  vs.  $26.16 \pm 5.11$  cm,  $\bar{g} = 0.401$ ,  $M = 0.655$  and  $19.81 \pm 4.65$  vs.  $21.79 \pm 5.07$  cm,  $\bar{g} = 0.407$ ,  $M = 0.659$ ,

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respectively). Similar effect sizes were obtained for the other ages ( $\bar{g} = 0.598$ ,  $M = 0.722$  and  $\bar{g} = 0.351$ ,  $M = 0.636$  for the highest and lowest, respectively).

Regarding sex, 80.2% and 84.3% (lowest and highest values, respectively) of normal-weight girls obtained scores for 30 s sit-ups equal to or lower than the average for boys ( $\bar{g} = 0.574$ ,  $M = 0.802$  and  $\bar{g} = 1.075$ ,  $M = 0.843$ ). Similarly, among overweight girls, 79.9% and 86.4% (lowest and highest values, respectively) attained scores for sit-ups equal to or lower than the average for boys ( $\bar{g} = 0.838$ ,  $M = 0.799$  and  $\bar{g} = 1.032$ ,  $M = 0.864$ ).

[Insert Table 4 about here]

Figure 2 shows the average of the magnitudes of means obtained for those aged 12–16 years in the three muscular strength tests. The results show higher percentages for effect magnitude between boys and girls than between the normal-weight and overweight groups in all three muscular strength tests. In all, 96.4% and 91.2% of normal-weight and overweight girls, respectively, performed a standing long jump equal to or less than boys with similar weight status. However, only 76.30% and 72.80% of the overweight boys and girls, respectively, attained a jump equal to or less than normal-weight boys and girls. Similar results were observed in the hand grip and sit-up tests.

[Insert Figure 2 about here]

## DISCUSSION

This paper quantifies the effect size of overweight status on the results of three different muscular strength tests in adolescents. It also reports percentile tables related to sex, age

1 and BMI in a relatively large sample of Spanish girls and boys aged 12 to 16 years. The  
2 results show a total prevalence of overweight-obesity of 27.8%. At all ages, boys attain  
3 greater standing long jumps, more 30 s sit-ups and greater hand grip strength than girls,  
4 both in the normal-weight and overweight categories. Overweight boys and girls obtain  
5 lower values for the standing long jump and 30 s sit-ups, but higher scores for hand grip  
6 strength than those in the normal-weight group. Nevertheless, contrary to our  
7 hypothesis, the magnitude of the differential effect size between boys and girls is higher  
8 than that between normal-weight and overweight adolescents in all three muscular  
9 strength tests. Despite the above, 76.3% and 72.8% of boys and girls respectively in the  
10 overweight category attain a standing long jump equal to or lower than the average  
11 scores for normal-weight boys and girls.  
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26 In all, 67.4% and 67.1% of overweight boys and girls respectively show a hand grip  
27 strength equal to or lower than the average scores for the normal-weight participants.  
28 Finally, 68.7% and 65.9% of overweight boys and girls, respectively, attain scores for  
29 30 s sit-ups equal to or lower than the average for their normal-weight peers. These  
30 results suggest that it is necessary to take BMI into account when assessing muscular  
31 strength during adolescence, in addition to sex and age.  
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41 Our findings are similar to those of other international studies examining muscular  
42 strength in adolescents from the United States, Australia (10), Norway (32), Portugal  
43 (33), Greece (13), Poland (21), Germany (11), France (34) or Spain (35). Most of the  
44 studies consulted show muscular strength classifications according to the sex and age of  
45 the participants and they only consider BMI as a possible modulating element of test  
46 results. Similar to this study, the weight status (with a focus on overweight+obesity) has  
47 tended to be determined applying the criteria of the International Obesity Task Force  
48 (20). Other studies have used the criteria of the Center for Disease and Control and  
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1 Prevention (36), the criteria of the World Health Organization (17), or their own  
2 classifications based on the percentiles of national scale samples (37). In spite of this, to  
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4 the best of the authors knowledge, there are not other research that use BMI to create  
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6 muscular strength scales adapted to overweight adolescents, or that has quantified and  
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8 compared the effect size of BMI with regard to sex.  
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11 Our results reveal that the relationship between overweight and muscular strength is  
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13 sensitive to the strength test employed. Indeed, seven out of ten overweight adolescents  
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15 perform a standing long jump equal to or less than the average for their normal-weight  
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17 peers. These results verify those of other studies that have used all kinds of jumps,  
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19 although not quantifying the effect size (1, 6, 7, 17). Also, seven out of ten overweight  
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21 adolescents attained values for 30 s sit-ups equal to or lower than the average for their  
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23 normal-weight peers. Again, these results verify those of investigations analysing sit-up  
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25 tests to assess muscular strength in adolescents, although not quantified. Therefore,  
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27 overweight negatively affects the results of tests which require bearing or mobilizing  
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29 body weight. This evidence has also been shown in the majority of cross-sectional and  
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31 longitudinal studies carried out among adolescents, which point out that overweight is  
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33 accompanied by a lower performance in motor fitness (1, 5, 8, 17).  
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41 On the other hand, 67% of the overweight adolescents obtained better scores in the  
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43 hand grip test than their normal-weight peers. Previous studies have shown this  
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45 evidence (8, 38). However, other research has questioned this relationship (9, 17), some  
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47 studies suggesting that the association between overweight and muscular fitness  
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49 disappears if absolute muscular strength is relativized with regard to corporal weight (9,  
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51 39). The above suggests that being overweight is a variable that conditions muscular  
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53 strength in adolescents and the degree of conditioning will increase as the degree of  
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55 obesity increases (1). The fact that normal-weight individuals have both less body fat  
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1 and higher relative muscular strength than their overweight-obese counterparts may  
2 explain these findings (5), but this warrants further investigation.  
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## 6 **PRACTICAL APPLICATIONS**

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9 The data presented are related to the sex, age and BMI of Spanish adolescents and can  
10 be used as standard values for the estimation of muscular strength and comparison  
11 among adolescents from other similar countries. Schools must strive to improve  
12 students' muscular physical fitness levels through PE programmes to improve health  
13 and prevent diseases. Determining the influence of BMI in assessing muscular strength  
14 can be helpful in ensuring the equity of the effort made by overweight youth and  
15 preventing future problems with frustration. Finally, the presentation of tables of  
16 percentiles 10–100 (Annexed Tables 5, 6 and 7) can facilitate the evaluation of  
17 muscular strength within PE programmes. This classification allows an intuitive  
18 assessment of student's muscular strength using a Likert scale: very poor physical  
19 fitness ( $X < P20$ ), poor ( $P20 \leq X < P40$ ), intermediate ( $P40 \leq X < P60$ ), good ( $P60 \leq X$   
20  $< P80$ ) and very good ( $X \geq P80$ ) (21). In addition, these references contribute to the  
21 diagnosis and prevention of possible muscular deterioration (i.e.  $< 30$ th percentile) and  
22 contribute to checking specific muscular programme improvements (18). Also, young  
23 people who achieve values above the 90th percentile could be considered potential  
24 talent for sports in which muscular strength is relevant (21).  
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48 This research has some limitations. The cross-sectional design does not allow causal  
49 relationships to be determined. In addition, the normative values of muscular strength  
50 status should be obtained from longitudinal studies that provide the possibility of  
51 evaluating natural changes in individual growth and development. However, in the  
52 absence of these data, the cross-sectional information in this study was accurately  
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evaluated through harmonized and standardized procedures and using appropriate statistical methods.

## CONCLUSION

The study concludes that the performance of approximately 70% of overweight adolescents in a standing long jump and 30 s sit-ups is equal to or lower than that of normal-weight peers, but their hand grip strength is equal to or higher. In the three tests studied (standing long jump, hand grip strength and 30 s sit-ups), the differential effect size magnitude is higher between boys and girls (approximately 90%) than between normal-weight and overweight adolescents. Despite the above, the findings suggest that taking BMI into account when assessing muscular strength in adolescents, in addition to sex and age is of value. The percentile values by sex, age and BMI are also reported for the three muscular strength tests in a large random sample of Spanish adolescents. These values will allow accurate and equitable assessment of muscular strength during adolescence.

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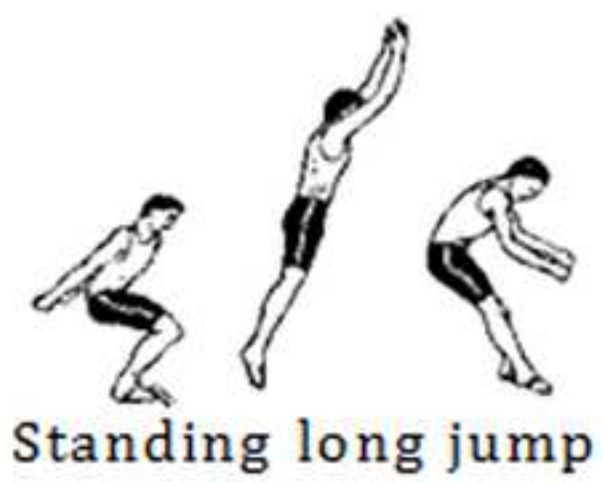
## FIGURE LEGENDS

Figure 1. Muscular strength tests.

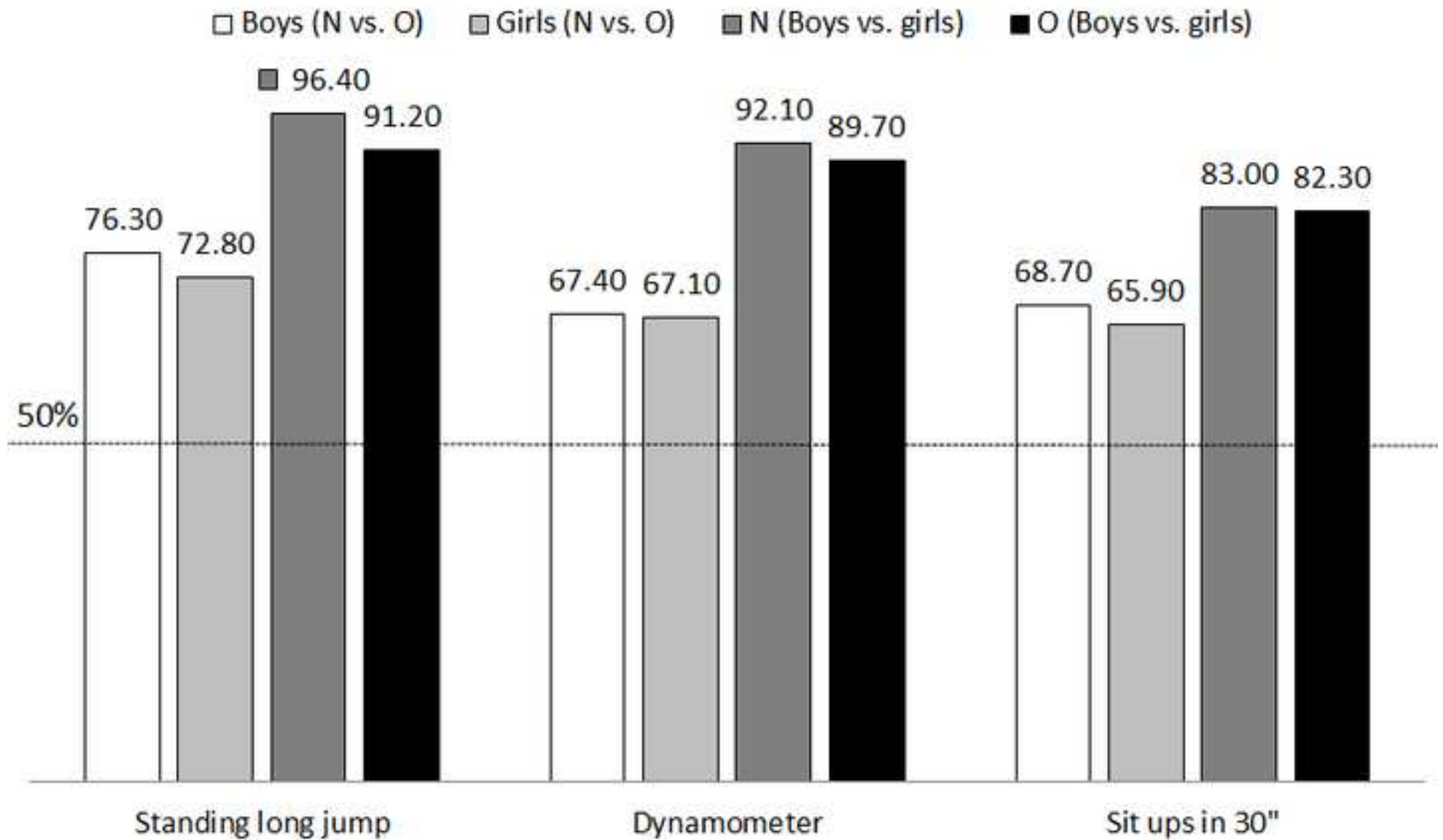
Figure 2. Average magnitude of effect size obtained for boys and girls aged 12–16 years in muscular strength tests. The values for boys and girls in the standing long jump and sit-up tests indicate the percentage of overweight young with results equal to or lower than the average for their normal-weight peers (50%) [in the manual dynamometer test, the values were inverted]. The values for normal-weight (N) and overweight (O) groups indicate the percentage of girls with scores equal to or lower than the boys' average (50%).

## ANNEXES

[Insert Tables 5, 6 and 7 about here]



## Average magnitude of the effect on teenagers



**TABLE 1.** Anthropometric characteristics and physical fitness parameters of the study sample according to the sex.

	All (n= 11044)	Boys (n= 5684)	Girls (n= 5360)	Sex differences	Age trend
Age	14.39 (1.21)	14.21 (1.31)	14.56 (1.66)	=	-
Weight (kg)	58.65 (13.34)	61.77 (14.76)	55.88 (11.23)	>	>
Height (m)	1.63 (0.08)	1.77 (0.9)	1.60 (0.06)	>	>
BMI	21.87 (4.10)	21.99 (4.5)	21.76 (3.87)	=	>
Standing long jump (cm)	150.99 (32.70)	170.20 (31.04)	133.53 (22.92)	>	>
Handgrip strength (Kg) <sup>a</sup>	24.71 (6.44)	28.75 (8.02)	21.02 (4.32)	>	>
Sit ups in 30''	24.90 (6.47)	27.50 (6.40)	22.55 (5.57)	>	>

Data are expressed as mean and standard deviation (SD). Differences between sex and age were analyzed by analysis of variance with two factors, including sex and age as fixed factors and anthropometric measures or physical tests as dependent variables. <sup>a</sup>Average value of left and right hands. The symbol > in the sex differences column, means that the variable is significantly higher in boys than in girls ( $p < 0.05$ ). The same symbol, in the age trend column, refers to the variable tends to increase as the age increases. The = symbol means that there are no significant differences, and the - symbol means that it is not applicable.

**TABLE 2.** Results for standing long jump test according to age (12–16 years), sex (boys vs. girls) and weight status (normalweight and overweight [overweight+obesity]).  $\bar{g}$  = adjusted Hedges' g. Effect magnitude (M), shown in brackets, represents the probability for each of the typified differences using the standardized normal distribution table. This value is also expressed in the text as a percentage.

Standing long jump test												
Age	Boys ( n= 5420)				Girls ( n= 5212 )				Normalweight (Boys vs. girls)		Overweight (Boys vs. girls)	
	Normalweight		Overweight		Normalweight		Overweight		p	$\bar{g}$ (M)	p	$\bar{g}$ (M)
	n=3972	n=1448	p	$\bar{g}$	n=3720	n=1492	p	$\bar{g}$				
	Mean (SD)	Mean (SD)		(M)	Mean (SD)	Mean (SD)		(M)				
n	N			n	n							
12	159.9 (24.3)	143.3 (24.1)	<.001	0.689	133.0 (21.6)	121.4 (22.4)	<.001	0.529	<.001	1.172	<.001	0.961
	1008	464		(0.754)	968	620		(0.698)		(0.956)		(0.831)
13	175.2 (26.9)	150.9 (27.5)	<.001	0.549	134.1 (24.1)	122.1 (21.6)	<.001	0.512	<.001	1.595	<.001	1.165
	788	312		(0.708)	644	272		(0.695)		(0.944)		(0.868)
14	185.3 (26.5)	162.4 (26.6)	<.001	0.874	138.0 (22.5)	124.5 (21.6)	<.001	0.602	<.001	1.922	<.001	1.529
	744	304		(0.807)	852	196		(0.723)		(0.971)		(0.935)
15	192.2 (29.9)	166.6 (32.5)	<.001	0.852	140.6 (22.0)	126.6 (17.0)	<.001	0.666	<.001	1.88	<.001	1.543
	708	216		(0.802)	712	200		(0.748)		(0.969)		(0.938)
16	195.0 (27.1)	176.9 (25.4)	<.001	0.674	142.5 (20.4)	127.5 (18.7)	<.001	0.760	<.001	2.149	<.001	2.271
	724	152		(0.748)	544	208		(0.776)		(0.982)		(0.988)

**TABLE 3.** Results for Handgrip strength test (Kg) according to age (12–16 years), sex (boys vs. girls) and weight status (normalweight and overweight [overweight+obesity]).  $\check{g}$  = adjusted Hedges' g. Effect magnitude (M), shown in brackets, represents the probability for each of the typified differences using the standardized normal distribution table. This value is also expressed in the text as a percentage.

Handgrip strength test												
Boys ( n= 5480 )					Girls ( n= 5268 )				Normalweight (Boys vs. girls)		Overweight (Boys vs. girls)	
Age	Normalweight n=4020	Overweight n=1460	p	$\check{g}$ (M)	Normalweight n=3756	Overweight n=1512	p	$\check{g}$ (M)	p	$\check{g}$ (M)	p	$\check{g}$ (M)
	Mean (SD) n	Mean (SD) n			Mean (SD) n	Mean (SD) n						
12	22.2 (5.5) 1024	25.2 (6.3) 472	<.001	0.520 (0.698)	18.3 (4.2) 972	20.7 (4.4) 624	<.001	0.560 (0.712)	<.001	0.794 (0.765)	<.001	0.848 (0.684)
13	27.7 (6.4) 792	31.4 (8.8) 316	<.001	0.516 (0.698)	20.2 (3.7) 648	21.9 (4.4) 272	<.001	0.433 (0.666)	<.001	1.399 (0.917)	<.001	1.335 (0.872)
14	30.7 (6.3) 768	33.5 (7.5) 308	<.001	0.421 (0.662)	21.0 (3.8) 860	22.6 (3.8) 204	<.001	0.420 (0.662)	<.001	1.889 (0.969)	<.001	1.731 (0.958)
15	33.2 (7.1) 716	35.9 (7.4) 212	.003	0.376 (0.643)	22.1 (4.4) 720	23.8 (4.0) 200	.009	0.393 (0.651)	<.001	1.88 (0.969)	<.001	2.016 (0.977)
16	35.8 (6.7) 720	38.8 (6.4) 152	<.001	0.451 (0.673)	22.8 (4.2) 556	24.6 (4.1) 212	<.001	0.431 (0.666)	<.001	2.261 (0.988)	<.001	2.561 (0.994)

**TABLE 4.** Results for sit-ups (30 s) according to age (12–16 years), sex (boys vs. girls) and weight status (normalweight and overweight [overweight+obesity]).  $\check{g}$  = adjusted Hedges' g. Effect magnitude (M), shown in brackets, represents the probability for each of the typified differences using the standardized normal distribution table. This value is also expressed in the text as a percentage.

Sit - ups ( 30 s )												
Age	Boys ( n= 5260 )				Girls ( n= 5052 )				Normalweight (Boys vs. girls)		Overweight (Boys vs. girls)	
	Normalweight n=3844	Overweight n=1460	p	$\check{g}$ (M)	Normalweight n=3580	Overweight n=1472	p	$\check{g}$ (M)	p	$\check{g}$ (M)	p	$\check{g}$ (M)
	Mean (SD) n	Mean (SD) n			Mean (SD) n	Mean (SD) n						
12	26.16 (5.11) 1004	24.10 (5.58) 460	<.001	0.401 (0.655)	21.79 (5.07) 948	19.81 (4.65) 620	<.001	0.407 (0.659)	<.001	0.854 (0.802)	<.001	0.842 (0.799)
13	28.39 (5.94) 780	26.10 (5.83) 316	<.003	0.386 (0.648)	22.45 (5.74) 644	20.57 (4.68) 268	.025	0.351 (0.636)	<.001	1.005 (0.841)	<.001	1.032 (0.864)
14	29.93 (6.52) 748	27.04 (5.52) 292	<.001	0.598 (0.722)	23.59 (5.37) 824	21.49 (5.28) 200	.008	0.464 (0.667)	<.001	1.075 (0.843)	<.001	1.014 (0.864)
15	31.21 (6.57) 632	27.72 (7.14) 200	<.001	0.520 (0.698)	24.67 (5.86) 660	22.51 (5.65) 188	.011	0.387 (0.648)	<.001	1.039 (0.841)	<.001	0.809 (0.791)
16	32.20 (6.72) 680	28.41 (6.21) 148	<.001	0.559 (0.712)	26.21 (6.33) 504	23.19 (6.21) 196	<.001	0.478 (0.684)	<.001	0.933 (0.823)	<.001	0.838 (0.799)

**TABLE 5.** Standing long jump test percentiles in adolescents based on sex, age and weight status (with focus in overweight).

	<b>P<sub>10</sub></b>	<b>P<sub>20</sub></b>	<b>P<sub>30</sub></b>	<b>P<sub>40</sub></b>	<b>P<sub>50</sub></b>	<b>P<sub>60</sub></b>	<b>P<sub>70</sub></b>	<b>P<sub>80</sub></b>	<b>P<sub>90</sub></b>	<b>P<sub>100</sub></b>
<b>Normalweight girls</b>										
<b>12</b>	108	118	121	125	134	137	142	151	162	202
<b>13</b>	105	115	121	128	134	139	146	153	168	200
<b>14</b>	108	120	126	135	139	144	151	157	168	198
<b>15</b>	116	122	128	132	141	145	152	157	170	210
<b>16</b>	120	127	131	137	142	144	151	160	172	200
<b>Overweight girls</b>										
<b>12</b>	95	103	111	113	121	125	133	139	150	185
<b>13</b>	100	110	115	120	123	130	140	146	152	177
<b>14</b>	100	106	116	120	125	132	141	148	153	190
<b>15</b>	110	114	118	125	126	134	137	138	154	172
<b>16</b>	100	104	110	120	128	125	133	141	149	166
<b>Normalweight boys</b>										
<b>12</b>	130	140	148	153	159	166	172	180	191	238
<b>13</b>	140	153	165	171	176	182	191	199	205	245
<b>14</b>	148	162	175	184	186	191	197	205	220	270
<b>15</b>	155	165	176	184	193	204	210	220	231	255
<b>16</b>	159	176	181	190	196	205	210	216	228	255
<b>Overweight boys</b>										
<b>12</b>	116	124	130	135	143	149	154	160	176	206
<b>13</b>	115	126	136	143	150	157	161	170	187	229
<b>14</b>	137	145	152	161	162	173	182	193	201	226
<b>15</b>	120	131	143	155	167	174	180	190	199	245
<b>16</b>	144	152	164	174	177	176	185	195	215	240

**TABLE 6.** Manual dynamometer test percentiles in adolescents based on sex, age, and weight status (with focus in overweight).

	<b>P<sub>10</sub></b>	<b>P<sub>20</sub></b>	<b>P<sub>30</sub></b>	<b>P<sub>40</sub></b>	<b>P<sub>50</sub></b>	<b>P<sub>60</sub></b>	<b>P<sub>70</sub></b>	<b>P<sub>80</sub></b>	<b>P<sub>90</sub></b>	<b>P<sub>100</sub></b>
<b>Normalweight girls</b>										
<b>12</b>	14.2	15.6	16.7	18.0	19.0	19.9	20.6	21.7	23.6	25.1
<b>13</b>	15.1	16.6	17.9	19.3	20.5	21.2	22.2	23.4	25.0	29.2
<b>14</b>	16.2	17.9	18.8	19.9	20.9	21.8	22.8	24.2	26.3	34.7
<b>15</b>	16.8	18.4	19.8	21.1	21.8	22.8	23.9	25.6	27.9	43.3
<b>16</b>	16.5	17.6	19.3	20.9	22.6	23.7	25.7	29.6	34.3	45.0
<b>Overweight girls</b>										
<b>12</b>	15.6	17.2	18.8	19.9	21.0	22.3	23.5	24.4	26.7	30.7
<b>13</b>	15.8	18.5	20.4	21.8	22.4	23.3	24.1	24.9	26.6	32.4
<b>14</b>	17.4	19.2	20.7	22.0	23.1	24.0	24.7	25.5	27.1	34.1
<b>15</b>	18.3	19.9	21.4	23.0	23.7	24.8	26.2	27.4	28.7	34.4
<b>16</b>	19.1	20.3	22.9	23.4	24.2	26.0	28.2	30.5	32.1	39.6
<b>Normalweight boys</b>										
<b>12</b>	15.4	17.5	18.5	20.3	21.7	23.1	24.7	26.4	28.8	41.6
<b>13</b>	19.7	22.1	24.0	25.8	27.7	29.2	31.0	32.7	36.6	44.8
<b>14</b>	22.5	25.5	27.5	29.2	30.9	32.1	33.8	35.9	39.2	49.1
<b>15</b>	24.2	28.1	30.9	32.4	33.8	36.3	38.3	40.2	42.9	50.2
<b>16</b>	26.8	30.5	32.5	34.3	36.1	37.4	39.0	41.4	43.6	54.1
<b>Overweight boys</b>										
<b>12</b>	18.5	20.6	21.6	23.0	25.0	26.3	27.8	30.7	33.7	51.4
<b>13</b>	19.8	22.5	24.8	27.3	30.4	31.4	35.9	38.4	42.7	55.8
<b>14</b>	23.7	26.3	29.3	30.9	32.9	34.5	36.2	39.1	43.9	49.7
<b>15</b>	27.1	28.9	30.9	33.2	35.2	36.6	39.3	42.2	44.4	61.0
<b>16</b>	30.5	32.4	36.8	38.5	39.0	40.4	41.7	43.6	46.2	58.5

**TABLE 7.** Sit ups 30'' test percentiles in adolescents based on sex, age and weight status (with focus in overweight).

	<b>P<sub>10</sub></b>	<b>P<sub>20</sub></b>	<b>P<sub>30</sub></b>	<b>P<sub>40</sub></b>	<b>P<sub>50</sub></b>	<b>P<sub>60</sub></b>	<b>P<sub>70</sub></b>	<b>P<sub>80</sub></b>	<b>P<sub>90</sub></b>	<b>P<sub>100</sub></b>
<b>Normalweight girls</b>										
<b>12</b>	17	17	20	20	21	24	25	25	28	45
<b>13</b>	16	19	20	22	22	24	26	27	29	51
<b>14</b>	16	18	21	22	23	24	26	28	30	40
<b>15</b>	16	19	20	21	25	25	27	29	31	44
<b>16</b>	17	21	23	25	27	28	29	31	33	42
<b>Overweight girls</b>										
<b>12</b>	15	17	20	20	21	22	24	26	27	35
<b>13</b>	16	19	21	21	22	24	25	27	28	31
<b>14</b>	15	19	21	21	22	24	26	27	31	37
<b>15</b>	16	17	20	22	23	23	23	26	28	34
<b>16</b>	17	20	21	23	24	26	28	29	33	39
<b>Normalweight boys</b>										
<b>12</b>	19	21	23	25	25	27	28	31	35	39
<b>13</b>	22	24	26	28	29	31	31	32	37	42
<b>14</b>	24	26	28	29	30	32	34	35	39	46
<b>15</b>	23	26	29	30	32	33	35	37	41	49
<b>16</b>	24	27	29	31	33	33	36	37	41	52
<b>Overweight boys</b>										
<b>12</b>	18	19	20	23	25	27	27	29	32	41
<b>13</b>	18	20	25	25	27	27	30	33	34	42
<b>14</b>	21	24	24	27	28	29	31	33	36	43
<b>15</b>	18	21	23	25	27	29	30	34	38	43
<b>16</b>	22	24	27	29	28	31	32	34	38	39