

**Associations Between Cardiorespiratory Fitness and Overweight With Academic Performance in 12-Year-Old Brazilian Children.**

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1 Associations between cardiorespiratory fitness and overweight with academic  
2 performance in 12-year old Brazilian children.

3 **Running title:** Obesity, aerobic fitness and academic performance.

4

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25

## 26 Abstract

27 Obesity has been associated with poor academic achievement, while  
28 cardiorespiratory fitness (CRF) has been linked to academic success. **Purpose:**  
29 To investigate whether CRF is associated with academic performance in  
30 Brazilian students, independently of body mass index (BMI), fatness and  
31 socioeconomic status (SES). **Methods:** Three hundred and nine two 5<sup>th</sup> and 6<sup>th</sup>  
32 grade students (193 girls) (12.11±0.75 years old) were evaluated in 2012.  
33 Skinfold thickness measures were performed, and students were classified  
34 according to BMI-percentile. CRF was estimated by a 20-meter shuttle run test,  
35 and academic achievement by standardized math and Portuguese tests.  
36 Multiple linear regression analyses were conducted to explore the association  
37 between academic performance and CRF, adjusted for SES, skinfold thickness  
38 or BMI-percentile. **Results:** Among girls CRF was associated with higher  
39 academic achievement in math ( $\beta=0.146$ ;  $p=0.003$ ) and Portuguese  
40 ( $\beta=0.129$ ;  $p=0.004$ ) in crude and adjusted analyses. No significant association  
41 was found among boys. BMI was not associated with overall academic  
42 performance. There was a weak negative association between skinfold  
43 thickness and performance in mathematics in boys ( $\beta=-0.030$ ;  $p=0.04$ ), but not in  
44 girls. **Conclusion:** The results highlight the importance of maintaining high  
45 fitness levels in girls throughout adolescence a period commonly associated  
46 with reductions in physical activity levels and CRF.

47 Key words: Aerobic Fitness, Obesity, Academic Achievement, Physical  
48 Education, Students.

49

50

## 51 **1. Introduction**

52 The deleterious effects of obesity on physical health are well  
53 appreciated (39). It is also known that cardiorespiratory fitness (CRF) is an  
54 independent variable associated with a broad range of health outcomes  
55 including blood pressure and clustering of cardio-metabolic risk factors (32).

56 An inverse relationship between adiposity and academic performance  
57 in children has been reported (9, 45). Poor academic performance might be  
58 associated with excess body fatness, but could be mediated by other  
59 variables such as anxiety, depression, low self-esteem, teasing and social  
60 rejection, and low cardiorespiratory fitness (CRF) (5, 18, 46).

61 CRF is a general term often used to characterize an individual's  
62 performance during a standardized exercise test or protocol (41). School-  
63 based fitness test batteries traditionally include endurance performance  
64 (such as the 1-mile [1.6-km] or 20-meter shuttle run) as a field indicator of  
65 CRF described as maximum oxygen consumption ( $VO_{2max}$ ) (40).

66 While some studies report an inverse association between obesity and  
67 CRF (11, 37), others suggest that due to growth and maturation the  
68 relationship between these two variables might be more complex in children  
69 and adolescents (41). It is reported that CRF and body fat contribute equally  
70 to endurance performance in field tests (40).

71 There is some evidence CRF may modulate cognition and academic  
72 performance (19), by contributing to structural changes in the brain, such as  
73 higher volume in specific regions of the basal ganglia and hippocampus (6),  
74 increased recruitment of neurons, and also by contributing to increases in the

75 blood vasculature in the region of the cerebral cortex, stimulating the growth  
76 of new neurons and synapses (22).

77 Due to the bidirectional nature of the association between CRF and  
78 obesity, it is hard to determine the contribution of each individual factor to  
79 academic performance. Another important issue to consider is the  
80 association of socioeconomic status (SES) with academic performance due  
81 its relationship with both CRF and obesity (21, 23).

82 Thus, we hypothesized that CRF would be independently associated  
83 with child academic performance even when controlling for body mass index  
84 (BMI), body fat and SES. The aim of this study was to determine the  
85 relationship between CRF and academic performance in elementary school  
86 students.

87

## 88 **2. Material and Methods**

### 89 **Participants**

90 This cross-sectional study was conducted with 450 elementary school  
91 students between the ages of 10 and 13 years (5<sup>th</sup> and 6<sup>th</sup> grade), enrolled in  
92 public schools in Recife, an urban city in northeast Brazil. Subjects (n= 9120)  
93 came from 31 of 34 public elementary schools. Two schools with full day  
94 programs and one school without facilities for conducting CRF testing were  
95 not eligible to participate. Children were randomly (randomizer.org) selected  
96 using a 2-stage cluster sampling where the 31 schools and the  
97 corresponding 9120 students were separated as units at the first and second  
98 stages of sampling, respectively. Nine schools were selected and the  
99 principal of each selected school provided a list of the students, thereafter,

100 fifty children from each school were selected, and invited to take part in the  
101 study (N=450).

102 This study was carried out with the principles of the declaration of  
103 Helsinki and was formally approved by the Ethics Committee of the  
104 University of Pernambuco (#192/11). Informed consent and assent were  
105 obtained from the parents or legal guardians and the children respectively.

### 106 **Study design**

107 During the first visit to the school, the principle investigator explained  
108 the aims and the study protocol, and invited the children to participate. Those  
109 who agreed received an informed consent form to be signed by their parents.  
110 During the second visit, participants were asked to complete a SES  
111 questionnaire. At the third and fourth visits, CRF, anthropometry, body  
112 composition and academic performance were assessed. Due to the well-  
113 known negative effects of underweight on the outcomes variables (49)  
114 twenty-five underweight children (BMI < 5<sup>th</sup> percentile) were not included in  
115 the analyses. The final sample consisted of 392 students (193 girls) enrolled  
116 in 5<sup>th</sup> (n=230) and 6<sup>th</sup> (n=162) grade (Figure 1).

117

118 **\*\*\*INSERT FIGURE I\*\*\***

119

### 120 **Measurements**

121 Measurements were conducted in 2012 at the schools during school  
122 hours by a trained research staff member.

123 Socioeconomic Status

124           We used the questionnaire from the Associação Brasileira de  
125   Empresas de Pesquisa (Brazilian Association of Research Companies), as a  
126   valided instrument developed to measure SES in the Brazilian population (2).  
127   The instrument contains 9 questions (answers ranging from 0 to 5 points).  
128   The questions relate to the possession of electrical appliances, a bathroom in  
129   the home, automobile, housekeeper, washing machine, refrigerator and  
130   freezer, and information about parental education. Based on the sum of the  
131   scores, the individual was classified into socioeconomic class A, B, C or D,  
132   where class A had the highest purchasing power and highest educational  
133   level and class D had the lowest purchasing power and educational level.

134

#### 135   Academic performance

136           To measure academic performance, tests were developed by an  
137   education specialist to assess students' knowledge of Portuguese and  
138   mathematics. The content of the test was based on the reference standards  
139   of the Prova Brasil, which is the preferential test from the Brazilian  
140   educational system to assess skills and abilities in Portuguese and Math  
141   (35). This multiple choice instrument had 10 questions to assess Portuguese  
142   reading comprehension and grammar and 10 mathematics questions  
143   focusing on logic, geometric design, mathematical operations, fractions, and  
144   decimals. Each question had four alternative responses, with only one being  
145   the correct one. The students had one hour to complete the tests  
146   (Portuguese and math).

147 For each correct answer, the student scored one point; thus the score  
148 for both Portuguese and math tests, ranged from 0 to 10. An overall score  
149 was calculated from the arithmetic average of both tests.

150

#### 151 Anthropometry and body composition

152 Participants were weighed wearing light clothing and no shoes on a  
153 Filizola scale (model 160/300, Brazil) to the nearest 0.1 kg. Height was  
154 measured to nearest 0.5 cm using a wall-mounted stadiometer (Welmy®,  
155 Brazil). Body weight and height were measured in triplicate and the average  
156 values were used to calculate BMI by dividing body weight by height squared  
157 ( $\text{kg}/\text{m}^2$ ). BMI-percentile was classified according to the age- and sex-growth  
158 charts from the Centers for Disease Control and Prevention (CDC) (29). BMI  
159 values between the 5<sup>th</sup> and 84.9<sup>th</sup> percentile were classified as normal weight  
160 and percentiles above 85<sup>th</sup> were categorized as overweight. Triceps and calf  
161 skinfolds on the right side were determined in triplicate (the average value is  
162 reported) to the nearest 0.1 mm using standard techniques. Adiposity was  
163 estimated by sum of skinfolds (triceps and calf).

164

#### 165 Cardiorespiratory fitness

166 The 20-meter shuttle run test was used to assess CRF as proposed  
167 by Léger et al. (31). Students were instructed to run 20 meters marked by a  
168 cone in time with an audible signal. The test was performed in groups of 10  
169 students. The test started at 8.5 km/h and increased by 0.5 km/h for each  
170 level until the participant failed twice to keep up with the beep intervals or

171 reached exhaustion. The  $VO_{2max}$  were estimated using the equation provided  
172 by Barnett et al. (3) below:

$$173 \quad VO_{2max} = 24.2 - 5.0 * S - 0.8*A + 3.4*SP$$

174 Whereas S is sex (male =0, female =1); A is age; SP is final speed

175

176 This equation provides a high agreement (Mean difference: 1.3 ml.kg<sup>-1</sup>.min<sup>-1</sup>, 95% CI: -0.3 to 2.9) with directly measured  $VO_{2max}$  in children (42).

178

### 179 Statistical Analysis

180 Data normality was examined by the Kolmogorov-Smirnov test.

181 Continuous variables are presented as means  $\pm$  standard deviations;

182 categorical variables are presented as absolute and relative frequency and

183 95% confidence intervals (95%CI). Differences between different variables

184 according to sex were calculated by Student's t test for independent samples

185 or chi-squared, when appropriate. Univariate analysis associating 1) the

186 number of shuttles completed, 2) BMI, and 3) the sum of skinfolds to

187 academic performance were conducted. Crude and adjusted multiple linear

188 regression analyses, stratified by sex, were conducted to examine the

189 association between academic performance and CRF. Analysis between

190 depended and independent variables was adjusted by sum of skinfolds and

191 SES in a first model and by BMI-percentile and SES in a second model. A

192 residual analysis was performed and the assumption of homoscedasticity

193 and adherence to the normal distribution was followed for both models.

194 Considering alpha = 0.05 and power = 0.80, the sample size in this study

195 was sufficiently large to detect R-squared values greater than 0.05 in the

196 regression analyses even when including independent variables (BMI-  
197 percentiles, body fat and SES) in the adjusted model. The level of  
198 significance was set as  $p < 0.05$ . Data were analyzed using SPSS v.10.0.

199

### 200 **3. Results**

201 From the total of 392 students analyzed, ninety-seven were stratified  
202 into socioeconomic class B (24.7%; CI 95%: 20.5-29.3), two hundred and  
203 forty-seven into class C (63.0%; CI 95%: 58.0-67.8) and forty-eight into class  
204 D (12.2%; CI 95%: 9.1-15.9). None of the students were classified as  
205 socioeconomic class A.

206 Table 1 shows anthropometry, sum of skinfolds, number of shuttles  
207 completed, CRF and academic performance of the students according to  
208 sex. The results revealed that boys had a lower sum of skinfolds ( $p < 0.001$ ), a  
209 higher number of shuttles completed and higher CRF ( $p < 0.001$ ) compared to  
210 girls.

211

212 **\*\*\*INSERT TABLE 1\*\*\***

213

214 One hundred forty-two girls were classified as normal weight (73.5%;  
215 CI 95%: 66.7-79.6) and 51 as overweight (26.5%; CI 95%: 20.3-33.2).  
216 Among boys, 142 had normal weight (71.4%; CI 95%: 64.5-77.5) and 57  
217 were overweight (28.6%; CI 95%: 22.4-35.4). There were no sex differences  
218 ( $\chi^2 = 0.24$ ,  $p = 0.62$ ).

219

220 CRF and number of shuttles completed was significantly higher in  
normal weight girls compared to overweight girls (normal weight =  $42.79 \pm$

221 2.26 ml.kg<sup>-1</sup>.min<sup>-1</sup>; 23.66±10.74 and overweight= 41.24±1.50 ml.kg<sup>-1</sup>.min<sup>-1</sup>;  
222 16.41±5.42; t= 5.48, p =<0.001). Lower CRF and a lesser number of shuttles  
223 completed was also seen in overweight boys compared to normal weight  
224 boys (normal weight = 50.07±2.75 ml.kg<sup>-1</sup>.min<sup>-1</sup>; 35.40±13.71 and  
225 overweight= 47.77±2.37 ml.kg<sup>-1</sup>.min<sup>-1</sup>; 24.98±13.83; t= 5.74, p =<0.001).  
226 However, no statistical differences were noted between weight status and  
227 academic performance in Portuguese (normal weight= 4.54±2.12 and  
228 overweight = 4.44±1.82; t= 0.45, p=0.65), Math (normal weight= 3.92±2.28  
229 and overweight= 3.68±1.98; t= 1.02, p=0.30) and overall average (normal  
230 weight= 4.22±1.94 and overweight= 4.06±1.55; t= 0.89, p= 0.37) in both  
231 sexes combined or separated.

232 The number of laps completed in the shuttle run test was not significantly  
233 associated with performance in Portuguese ( $\beta$ = 0.018; p= 0.21 – in girls;  $\beta$ = -  
234 0.015; p= 0.13 - in boys), mathematics ( $\beta$ = 0.019; p= 0.18 - in girls;  $\beta$ = -  
235 0.011; p= 0.34 - in boys) or with the overall average ( $\beta$ = 0.018, p= 0.13, girls;  
236  $\beta$ = -0.013, p= 0.17). Similarly, BMI was not significantly associated with  
237 performance in Portuguese ( $\beta$ = -0.019; p= 0.65 - girls;  $\beta$ = -0.051; p= 0.14 -  
238 boys), mathematics ( $\beta$ = -0.042; p= 0.33 and  $\beta$ = -0.073; p= 0.06 – for girls and  
239 boys) or overall average ( $\beta$ = -0.030; p= 0.40 for girls;  $\beta$ = -0.062; p= 0.06 for  
240 boys). There was not a significant association between the sum of skinfolds  
241 and performance in Portuguese ( $\beta$ = 0.006, p= 0.70 girls;  $\beta$ = -0.013, p= 0.33  
242 boys) or overall average ( $\beta$ = -0.005, p= 0.71 girls;  $\beta$ = -0.022, p= 0.08 boys).  
243 There was a weak inverse association between sum of skinfolds and  
244 performance in mathematics in boys ( $\beta$ = -0.030, p= 0.04), but not in girls ( $\beta$ =  
245 -0.016, p= 0.31).

246 Multiple linear regression in model 1 revealed that CRF was associated  
247 with academic performance among girls even after adjustments by the sum  
248 of skinfolds and SES. Similarly, multiple linear regression in model 2 showed  
249 that CRF was associated with academic performance among girls after  
250 adjustments for BMI-percentiles and SES. No associations were observed  
251 among boys on crude or adjusted analyses (Table 2).

252

253 **\*\*\*INSERT TABLE 2\*\*\***

254

#### 255 **4. Discussion**

256

257 To the best of our knowledge, this is the one of few studies examining  
258 the relationship between overweight, CRF and academic performance in  
259 elementary school students. The main finding was that CRF was positively  
260 associated with academic performance in girls regardless of BMI, body fat  
261 and SES, but not in boys.

262 Some previous studies found that CRF is positively associated with  
263 academic performance, independent of BMI (7, 38, 43). However, another  
264 study, which adjusted the analysis by sex and SES but not for BMI and body  
265 fat, did not find a significant association between academic performance and  
266 CRF (5).

267 Some studies also examined the association between physical activity  
268 and academic performance (30, 33). Similar to the present study Martínez-  
269 Gómez et al. (33) reported that active commuting to school was associated  
270 with better cognitive performance only in adolescent's girls, independent of

271 participation in extracurricular physical activities. The different results for  
272 boys and girls was also found in some other studies. Kwak et al. (30) found  
273 that CRF was associated with academic performance in boys but not in girls.  
274 Others reported in effects in both sexes (12, 20). These differences might be  
275 attributed to the age of the subjects (12, 20, 30), different measurement  
276 instruments (e.g. standardized vs cognitive tests) (12, 20, 30), and  
277 assessment of CRF.

278 A negative association between adiposity and academic performance  
279 has been shown in few studies in the USA, Europe and Asia (1, 36, 44).  
280 Some studies found adiposity to be significantly related to lower cognitive  
281 performance and academic results (25, 26), but other studies did not find  
282 such an association (4, 14). It is not clear if academic performance is directly  
283 mediated by fatness or if it is influenced by factors associated with excessive  
284 fatness, such as poor self-esteem, anxiety/depression (16), teasing and  
285 social rejection (18), impairment in motor skills (20) and poor physical fitness  
286 (44). Future studies should focus on identifying possible factors associated  
287 with adiposity (such as low self-esteem, body dissatisfaction, depression,  
288 psychological problems, eating disorders, physical inactivity, cardiovascular  
289 risks, motor impairment) that might be more strongly related to academic  
290 performance than just fatness by itself.

291 The mechanism of the association between academic performance  
292 and CRF remains unclear. It is hypothesized that improvements in CRF, as  
293 induced by changes in physical activity levels, may have a positive influence  
294 on cognition mediated by increased levels of brain-derived neurotrophic  
295 factor (BDNF) (22). In a systematic review, Knaepen et al. (28) suggested

296 that exercise training would increase BDNF synthesis, facilitating learning  
297 and maintenance of cognitive functions by improving synaptic plasticity,  
298 acting as a neuroprotective agent, increasing blood flow in the brain and  
299 enhancing neuroelectric functionality. It is known that genetics may account  
300 for approximately 50% of CRF (37) and cognition (10). Thus, genetic  
301 background may have an influence on the association between CRF and  
302 academic performance.

303 The mechanisms underlying the association between CRF and  
304 academic performance in girls may be, at least partially, attributed to the  
305 lower levels of physical activity experienced by girls compared to boys (47).  
306 Similarly, hormonal changes associated with menarche (27) could lead to  
307 psychological alterations such as problems with interpersonal skills and  
308 internalizing behaviors (15). Academic performance is typically lower in boys  
309 as was observed here (albeit non-significant), and, moreover, even normal  
310 weight girls appear to be less fit than overweight boys. These differences  
311 may have masked the relationship in boys.

312 The relationship between CRF and academic performance has been  
313 investigated mainly using CRF field-based exercise tests (7, 38, 43, 50).  
314 However, evidence suggests that the association between CRF and  
315 academic performance might be protocol/test dependent, as reported by  
316 Dwyer et al. (13), Haapala et al. (20) and Van Der Niet et al. (48). This  
317 dependency may be partly attributed to motor skills and running efficiency  
318 (24), rather than pure CRF. A shuttle run test which measures cardiovascular  
319 and motor performance (i.e. considers both CRF and motor skills) seems to

320 be adequate to assess the effects of CRF on children's academic  
321 performance (20).

322         There are some limitations to consider in this study. First, maturation  
323 was not measured. Other potential confounding factors such as physical  
324 activity, race, familiar characteristics and family support were also not  
325 measured. Our sample consisted mainly of children from SES classes C and  
326 D (75% of participants). Therefore, we should be careful on generalization of  
327 data. Other limitations from this study include the indirect assessment of  
328 CRF. There are concerns on the use of the 20-meters shuttle run to predict  
329  $VO_{2max}$  as it might underestimate participants' maximal capacity due to the  
330 effect of body composition (34) and motivation (17). The cross-sectional  
331 design of the study limits our ability to make assumptions about the causal  
332 nature of the CRF and academic performance.

333         Nevertheless, the study has some strengths including use of linear  
334 models to assess the association between the variables. We also included a  
335 number of potential confounders that are consistent with previous literature  
336 on the topic, including SES, BMI, body fat and sex. Additionally, most studies  
337 on this topic generally examined populations in the United States and used  
338 SES proxies such as student eligibility for free or reduced-price lunch in  
339 schools and only measured mother's education (5, 9, 38, 43). We believe  
340 that the use of our SES measurement tool, which assesses the purchasing  
341 power of families and educational level of both parents, is more accurate to  
342 assess SES and verify the influence on academic performance. BMI is  
343 commonly used to define overweight, but is not a measure that is specific to  
344 adiposity (8). Skinfold measurements are a more direct indicator of adiposity

345 and can be used to provide information on the association between adiposity  
346 and academic performance. However, on the other hand the BMI analysis  
347 enhances the comparability of the results from the present study with other.

348 Based on the results of this study, we believe that interventions to  
349 improve CRF in children should be promoted, not only to promote health  
350 benefits but also cognition and academic achievement. Additionally, we  
351 suggest that educational information should be provided to physical  
352 education teachers and sports coaches on the importance of developing CRF  
353 in children for improvement on academic performance.

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#### 360 **Competing interests**

361 Authors declare no competing interests

362

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541 **Table 1.** Anthropometry, fatness cardiorespiratory fitness and academic  
 542 performance of students according to sex.

Variables	Girls	Boys	T	P
	N=193	N=199		
Age (years)	12.04±0.72	12.19±0.76	-1.81	0.07
Body Mass (kg)	43.86±9.25	42.51±12.39	0.32	0.74
Stature (cm)	148.91±7.14	147.51±8.14	1.36	0.17
BMI (kg/m <sup>2</sup> )	19.69±3.37	19.27 ±4.36	0.11	0.90
BMI-percentiles	58.81±27.70	53.77±32.23	1.66	0.98
Triceps skinfolds (mm)	16.87±5.10	15.64±6.54	2.06	0.03
Calf skinfolds (mm)	17.48±4.26	16.04±4.99	3.07	<0.001
Sum of skinfolds (mm)	34.36±8.95	31.69±11.03	2.62	<0.001
Number of shuttles completed	21.73±10.12	32.45±14.49	-8.43	<0.001
VO <sub>2max</sub> (ml·kg <sup>-1</sup> min <sup>-1</sup> )	42.38±2.19	49.41±2.84	-27.42	<0.001
Portuguese (score)	4.70±2.00	4.30±2.10	1.81	0.07
Mathematics (score)	3.75±2.02	3.95±2.36	-0.91	0.36
Overall average (score)	4.22±1.71	4.14±2.00	0.45	0.65

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556 **Table 2.** Children's academic performance predicted by estimated VO<sub>2max</sub>  
 557 (ml/kg/min) crude and adjusted analysis (model 1 and model 2).

Dependent variable	$\beta$ (SE)	B standardized	p
<b>Girls</b>			
<sup>a</sup> Performance in Portuguese			
Crude	0.129 (0.064)	0.143	0.047
Model 1	0.163 (0.069)	0.181	0.019
Model 2	0.149 (0.067)	0.166	0.027
<sup>b</sup> Performance in Mathematics			
Crude	0.146 (0.066)	0.159	0.027
Model 1	0.147 (0.070)	0.159	0.039
Model 2	0.155 (0.068)	0.168	0.025
<sup>c</sup> Performance Overall			
Crude	0.138 (0.055)	0.177	0.014
Model 1	0.155 (0.059)	0.199	0.010
Model 2	0.152 (0.058)	0.195	0.009
<b>Boys</b>			
<sup>a</sup> Performance in Portuguese			
Crude	-0.014 (0.053)	-0.019	0.789
Model 1	-0.056 (0.062)	-0.075	0.371
Model 2	-0.052 (0.057)	-0.071	0.358
<sup>b</sup> Performance in Mathematics			
Crude	-0.010 (0.059)	-0.011	0.873
Model 1	-0.102 (0.069)	-0.123	0.142
Model 2	-0.067 (0.063)	-0.081	0.291
<sup>c</sup> Performance Overall			
Crude	-0.012 (0.049)	-0.017	0.811
Model 1	-0.079 (0.058)	-0.114	0.175
Model 2	-0.060 (0.053)	-0.086	0.261

558 Model 1: Adjusted for absolute skinfold thickness and SES (socioeconomic status)- Girls: aF=3.982;  
 559 p=0.047; r=0.143; r<sup>2</sup>=0.020; SEE (Std. Error of the Estimate) =1.961. aF\*= 2.350; P=0.026; r=0.190;  
 560 r<sup>2</sup>=0.036; SEE=1.956. bF=4.968; p=0.027; r=0.159; r<sup>2</sup>=0.025; SEE=2.001. bF\*=2.577; p=0.055; r=0.198;  
 561 r<sup>2</sup>=0.039; SEE=1.997. cF=6.150; p=0.014; r=0.177; r<sup>2</sup>=0.031; SEE=1.688. cF\*=3.147; p=0.026; r=0.218;  
 562 r<sup>2</sup>=0.048; SEE=1.682. Boys: aF=0.072; p=0.789; r=0.019; r<sup>2</sup>=0.000; SEE=2.104. aF\*= 0.671; p=0.571;  
 563 r=0.101; r<sup>2</sup>= 0.010; SEE=2.104. bF=0.026; p=0.873; r=0.011; r<sup>2</sup>=0.000; SEE=2.371. bF\*=2.180; p=0.092;  
 564 r=0.180; r<sup>2</sup>=0.032; SEE=2.344. cF= 0.057; p=0.811; r=0.017; r<sup>2</sup>=0.000; SEE=1.977. cF\*=1.603; p=0.190;  
 565 r=0.155; r<sup>2</sup>=0.024; SEE=1.963. Model 2: Adjusted for BMI-percentiles and SES- Girls: aF=7.057; p=0.009;  
 566 r=0.189; r<sup>2</sup>=0.036; SEE=1.946. aF\*= 2.124; P=0.025; r=0.181; r<sup>2</sup>=0.033; SEE=1.960. bF=8.515; p=0.004;  
 567 r=0.207; r<sup>2</sup>=0.043; SEE=1.983. bF\*=2.597; p=0.054; r=0.199; r<sup>2</sup>=0.040; SEE=1.997. cF=10.776; p=0.001;  
 568 r=0.231; r<sup>2</sup>=0.053; SEE=1.668. cF\*=3.175; p=0.025; r=0.219; r<sup>2</sup>=0.048; SEE=1.682. Boys: aF=0.020;  
 569 p=0.065; r=0.032; r<sup>2</sup>=0.001; SEE=2.103. aF\*= 1.187; p=0.316; r=0.134; r<sup>2</sup>= 0.018; SEE=2.096. bF=0.084;  
 570 p=0.772; r=0.021; r<sup>2</sup>=0.000; SEE=2.371. bF\*=1.965; p=0.121; r=0.171; r<sup>2</sup>=0.029; SEE=2.348. cF= 0.172;  
 571 p=0.679; r=0.030; r<sup>2</sup>=0.001; SEE=1.976. cF\*=1.904; p=0.130; r=0.169; r<sup>2</sup>=0.028; SEE=1.959

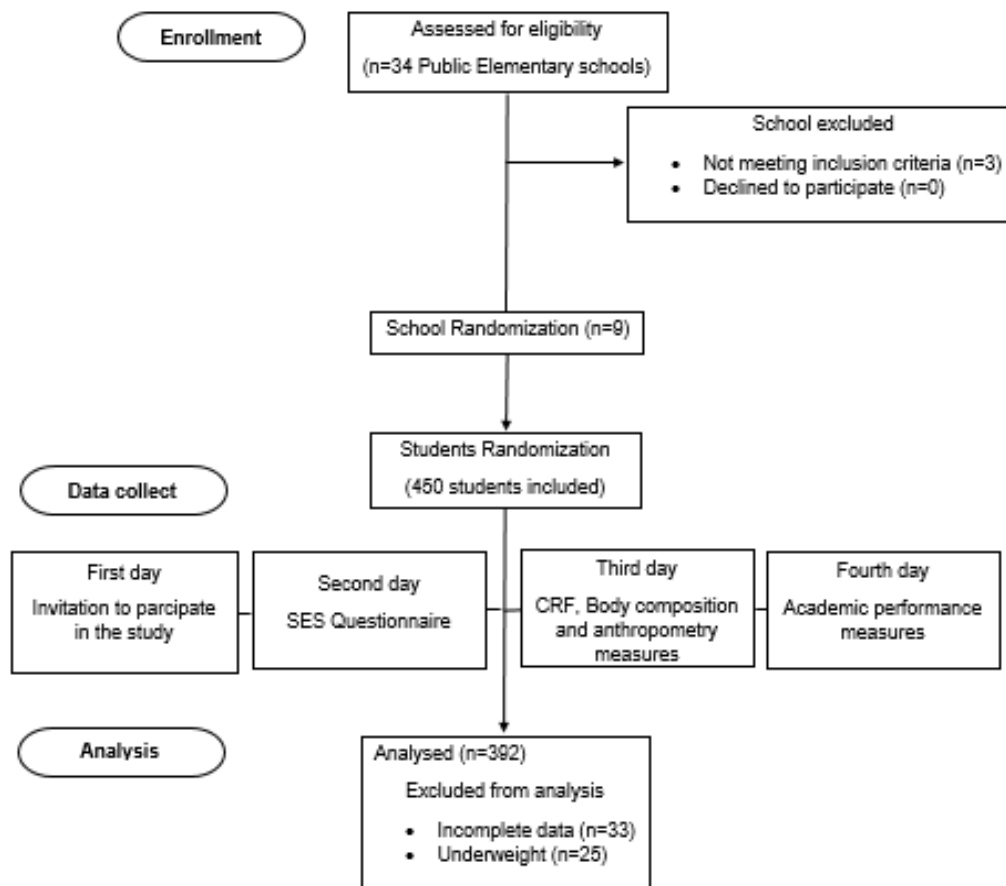


Figure 1. Study design