

Weight status, cardiorespiratory fitness and high blood pressure relationship among 5-12 years old Chinese primary school children

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1 **Title:** Weight status, Cardiorespiratory fitness and high blood pressure relationship
2 among 5-12 years old Chinese primary school children

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4

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12 **Running title:** Weight status, fitness and blood pressure in children

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Summary Table

What is known about this topic

- Cardiorespiratory fitness (CRF) and adiposity contribute to high blood pressure (HBP), but their relative importance is unknown.
- Data analyzed these relationships among Chinese children is lacking.

What this study adds

- Hypertension is common in Chinese children (prevalence 15.3%), with higher prevalence in obese (40.5% and 45.9% in boys and girls respectively) and overweight (27.6% and 30.2%).
- Weight status is strongly associated with likelihood of high blood pressure in Chinese primary school aged children.
- There was no evidence that increased CRF modified the risk of HBP in overweight and obese children.

72 **Abstract**

73 Cardiorespiratory fitness (CRF) and adiposity contribute to high blood pressure (HBP)
74 in adults and children. However, their relative importance as risk factors is unknown.
75 We examined the relationships between weight status, CRF and HBP among Chinese
76 primary school children. A cross-sectional study was conducted with 4926 school
77 children aged 5–12 years. CRF was estimated from a modified Cooper test, body
78 mass index z-scores and weight categories were calculated from objective height and
79 weight measurements, and BP was measured using an electronic
80 sphygmomanometer. HBP was defined as >95th percentile based on reference
81 cut-offs for Chinese boys and girls. Generalized Linear Mixed Models, adjusting for
82 age, pubertal status and height, were developed for boys and girls to explore the
83 independent and combined associations between fitness, weight status and HBP. 752
84 (15.3%) children had HBP, with a higher prevalence in obese (40.5% and 45.9% in
85 boys and girls respectively) and overweight (27.6% and 30.2%) compared with
86 non-overweight (9.0% and 13.8%) children. HBP prevalence was lower in boys with
87 higher CRF (OR for highest vs. lowest CRF quartile in boys 0.64; 95%CI 0.46-0.89).
88 This association was not seen in girls. With weight status and CRF in the same model,
89 weight status, but not CRF, remained significantly associated with HBP (obesity in
90 boys: OR 4.19; 95%CI 2.63-6.67; in girls: OR 2.49; 95%CI 1.19-5.19). The interaction
91 effect for CRF and weight status was non-significant. Overweight/obesity was
92 significantly associated with HBP among children. There was no evidence of
93 modification of this relationship by CRF.

94

95 **Keywords:** Blood pressure; Cardiorespiratory fitness; Obesity, School children, China
96

97 **Introduction**

98 High blood pressure (HBP) is increasing in prevalence among children and youth, and
99 there is evidence that HBP is present in Chinese children as young as 5 years old¹.
100 Serial cross-sectional studies in China indicate that the prevalence in adults has
101 increased by 83.4% since 1991, affecting over a quarter of the population in
102 2007-2008²⁻⁵. There is increasing evidence of tracking of blood pressure (BP) levels
103 from childhood to adult life and hypertension in childhood is associated with higher
104 risk of cardiovascular disease and mortality in adulthood⁶⁻¹⁰. Two of the major
105 modifiable risk factors for hypertension include obesity and low cardiorespiratory
106 fitness (CRF)¹¹⁻¹⁴. However, the exact pathophysiological mechanisms through which
107 obesity and low CRF contribute to hypertension are not fully understood. Obesity is
108 likely to act through inter-related complex mechanisms related to diet, and
109 activation of the sympathetic nervous system causing vascular and renal injury¹⁵.
110 Similarly there are multiple hypotheses to explain the mechanisms by which
111 increased CRF alters blood pressure. Animal studies suggest that exercise training,
112 which increases CRF, alters vasomotor tone through endothelial and smooth muscle
113 adaptations¹⁶. In addition, a study in young adults has suggested that the
114 relationship between CRF and arterial stiffness is mediated by resting heart rate¹⁷.
115 There is some debate about the relative importance of CRF versus weight status as
116 risk factors for HBP and whether they act independently. There is a wealth of
117 evidence to suggest that low CRF is a potentially more important risk factor for

118 premature all-cause mortality and cardiovascular mortality than obesity, and that
119 amongst individuals with obesity, physical activity and CRF can significantly positively
120 impact on obesity and the subsequent risk of cardiovascular disease¹⁸⁻²³. Trials that
121 compare the effects of diet only versus diet and physical activity interventions in
122 obese adolescents, suggest that whilst both interventions result in reduction of BP,
123 the addition of exercise results in normalization of forearm vascular conductance
124 (similar to that seen in non-overweight children), whereas this is not seen in the diet
125 only group²⁴. Thus CRF may have effects on vascular health independently of weight
126 status, although the exact mechanisms are not fully understood. Other studies
127 suggest that higher levels of physical activity or CRF do not compensate for obesity in
128 relation to cardiovascular risk²⁵⁻²⁶. Therefore, there is a need to further understand
129 the relative importance of these two risk factors and their relationship with one
130 another. A better understanding of the relationship between weight status, CRF and
131 HBP in this age group would help to shape recommendations for interventions to
132 improve the health of children and adolescents.

133 The prevalence of overweight and obesity in school-aged children in China (aged
134 5-12 years) has increased more rapidly than that seen in most Western countries²⁷⁻²⁸,
135 with the prevalence in some urban regions approaching those in developed
136 countries²⁹⁻³⁰. In addition a report on the Physical Fitness and Health Surveillance of
137 Chinese School Students in 2010 revealed that CRF in children has been decreasing
138 during the past twenty five years³¹. Given the significant increases in these two
139 major cardiovascular risk factors in Chinese children, we aimed to explore the

140 prevalence of HBP and its relationship with these two risk factors, and also to
141 examine the potential modification effect of CRF on the association between weight
142 status and HBP. We hypothesized that both obesity and CRF would be associated
143 with HBP in this population of children, and that CRF would attenuate the
144 association between obesity and HBP.

145

146 **Methods**

147 We included a sub-group of participants who had the relevant measurements from a
148 larger cross-sectional study that aimed to determine the prevalence and risk factors
149 for childhood obesity in primary school-aged children in Guangzhou³². A multi-stage
150 stratified cluster random sampling procedure was used to obtain a representative
151 sample of primary school children in grades 1-5 (aged 5-12 years). Five of the ten
152 urban districts were selected using a random number generator. Within each of
153 these, all primary schools were stratified by public (residents) or private (migrant)
154 status, and six were randomly chosen with a 2:1 ratio from each stratum. Permission
155 for the study was not obtained for one of the private schools, leaving 29
156 participating schools. Within each school two classes per grade were randomly
157 selected. The exclusion criteria included: children with invalid anthropometric
158 measurements or questionnaire information and no parental consent.

159 Written informed consent was sought from the parents of 11445 eligible children
160 through schools, resulting in 9917 (86.6%) participants (1403 children with no
161 parental consent or invalid questionnaire; 125 children with invalid anthropometric

162 measurements). Data collection took place from April to June 2014, with
163 anthropometric, CRF (reduced Cooper test) and blood pressure measurements
164 undertaken in school, by trained research staff using standardized procedures and
165 instruments (see details below). All consented children had measurements of their
166 height and weight, but more detailed measurements, including blood pressure and
167 the reduced Cooper test, were undertaken on a subsample (children from one of the
168 two classes per grade were randomly selected; n=4926 including 2725 boys and
169 2201 girls).

170 The study was approved by the Ethical Committee of the Guangzhou Center for
171 Disease Control and Prevention and the University of Birmingham Research Ethics
172 Committee. Permissions to conduct the study were granted by the Departments of
173 Education and Health.

174 **Anthropometric and BP measurements**

175 Height and weight were measured with subjects wearing light clothing and without
176 shoes. Weight was measured to the nearest 0.1 kg using an electronic scale
177 (JH-1993T, weighing Apparatus Co. Ltd. Dalian). Height was recorded to the nearest
178 0.1 cm with a TGZ height tester (Dalian) according to the following protocol: no shoes,
179 heels together, and student's heels, buttocks, shoulders, and head touching the
180 vertical surface with line of sight aligned horizontally.

181 Blood pressure was measured by the same trained nurse using an electronic
182 sphygmomanometer (Omron HEM-7211, Dalian) at the right arm with students in
183 the seated position after at least 5 minutes of rest in a quiet classroom. The cuff size

184 was based on the length and circumference of the upper arm and was chosen to be
185 as large as possible without having the elbow skin crease obstruct the stethoscope.
186 Two consecutive readings were taken on the same arm with a two-minute interval
187 between each reading; the mean of the 2 measures was used for analysis. Systolic
188 blood pressure (SBP) was defined by the first Korotkoff sound (appearance of sounds),
189 and diastolic blood pressure (DBP) was defined by the fourth Korotkoff sound (sound
190 muffling).

191 **CRF measurements**

192 CRF was assessed using a reduced Cooper test³³. The full 12-minute Cooper test has
193 been shown to be a very good predictor of maximum oxygen intake³⁴, but is
194 inappropriate to administer to young children within a school setting³⁵. We therefore
195 opted for the reduced Cooper test (6-minute) which has been successfully used in
196 primary school aged children and can be easily administered within school settings³³.
197 Children were asked to run counter clockwise along a track of fixed size (marked
198 rectangle measuring 9×18m) as many times as they could within 6 minutes. The
199 exercise was undertaken outdoors on level ground. Outdoor climate varies little
200 from day to day in Guangzhou, where it is generally warm and humid. We
201 incentivized children to make a maximal effort by explaining that the test results
202 would be included in their school report. However, if they lacked the physical
203 strength to run at any point, they were allowed to walk. The distance covered
204 (measured in meters) was timed by a trained physical education teacher within
205 school, using a stopwatch (CASIO, HS-70W stopwatch) to the nearest 0.1s. The

206 physical education teacher recorded the number of complete laps done by each child,
207 and estimated the distance for any incomplete laps at the end of the reduced Cooper
208 test.

209 **Other measurements**

210 All children over the age of 9 years were assessed for whether or not they were
211 pubertal by self-report, by asking girls if they had reached menarche and boys if they
212 had experienced a first nocturnal emission. These questions were asked by a trained
213 physician when the physical measurements were being undertaken.

214 **Statistical Analysis**

215 Body mass index (BMI; $[\text{weight (kg)}]/[\text{height (m)}]^2$), was calculated and standard
216 deviation scores (BMI z-score) derived using the age and sex specific WHO growth
217 reference for school-aged children³⁶. BMI z-scores were used to classify participants
218 as non-overweight ($\leq 1\text{SD}$), overweight ($> 1\text{SD}$, $\leq 2\text{SD}$) or obese ($> 2\text{SD}$). HBP was
219 defined as systolic or diastolic BP above the 95th percentile for age and gender
220 specific reference cut-offs for Chinese children and adolescents³⁷. As we were using a
221 reduced Cooper test, we were unable to calculate the VO_2 max from the distance run
222 using reference tables, therefore the distance covered was categorized into quartiles
223 based on the child's age and sex, using the study data as the reference, with further
224 categorization into higher (3rd and 4th quartiles) or lower (1st and 2nd quartiles)
225 CRF.

226 Summary statistics (mean \pm SD and percentages) were used to describe participant
227 characteristics, prevalence of hypertension and the proportion of participants in the

228 different CRF categories. Differences in characteristics between the sexes or weight
229 status groups were determined using t-tests, analysis of covariance and Chi-square
230 tests, where appropriate. Generalized linear mixed models, with school as a random
231 effect to account for clustering, were used to examine the relationships between HBP
232 as a dependent variable and CRF or weight status as independent variables by sex,
233 both adjusted for age, pubertal status, and height (adjusted model I)³⁸. A further
234 model included both weight status, CRF and weight status \times CRF as covariates
235 (adjusted model II) by sex. We also examined differences in prevalence of HBP, mean
236 SBP and mean DBP in those with high CRF compared to those with low CRF in each of
237 the weight status subgroups to further explore the potential modification effect of
238 CRF on the relationship between weight status and HBP. Finally, we carried out
239 sensitivity analyses using the criteria introduced by international obesity taskforce
240 (IOTF). Data were analyzed using SPSS 21.0 statistical software package (SPSS Inc.,
241 Chicago, IL). A 2-tailed P value less than 0.05 was considered statistically significant.

242

243 **Results**

244 **Characteristics of the Study Sample**

245 Among 4926 children in the sub-group who had BP measurements, 4,726 (2,725
246 boys and 2,201 girls) had complete data for the reduced Cooper test, BP, and weight
247 and height, and so were included in the analysis. Descriptive characteristics of the
248 sample are shown in Table 1. Overall 10.9% of children were overweight and an
249 additional 6.9% were obese, with rates being higher in boys compared with girls.

250 Almost all children (100% of boys and 96.5% of girls) were pre-pubertal. Boys
251 covered a greater distance in the reduced Cooper test (899.4 vs 864.8 m) and had a
252 higher SBP compared with girls (107.6 vs 106.1 mmHg). SBP and DBP increased with
253 increasing age in boys and girls. Around 15% of children had HBP, with prevalence
254 rates being similar in boys and girls and no significant difference in prevalence by
255 age.

256 **Relationship between weight status and CRF among school children**

257 There was a significant association between CRF and weight status (Table 2), with a
258 higher proportion of non-overweight children being in the highest quartile for CRF
259 (28.5% boys and 25.8% girls) compared with those who were obese (6.1% boys and
260 6.6% girls). Significant differences were clearly seen in the proportions of children in
261 the high and low CRF categories across weight status groups, with 54.7% of
262 non-overweight boys, 42.8% of overweight boys and 20.1% of obese boys in the high
263 CRF group. The corresponding percentages of girls in the high CRF group were 51.5%,
264 39.2% and 19.7% for the non-overweight, overweight and obese categories,
265 respectively.

266 **Association between weight status, CRF and HBP among school children**

267 There was a clear relationship between weight status and HBP, with prevalence of
268 9.0% (boys) and 13.8% (girls) in non-overweight children, 27.6% (boys) and 30.2%
269 (girls) in overweight children, and 40.5% (boys) and 45.9% (girls) in obese children.
270 Similarly there was a relationship between lower CRF and higher risk of hypertension
271 in boys (prevalence of HBP 18.2% in the lowest versus 11.8% in the highest fitness
272 quartile), although no clear relationship between fitness levels and BP was seen in

273 girls (Table 3).

274 In the adjusted models (model I; adjusted for age, pubertal status, height), the
275 likelihood of having HBP was significantly higher for boys and girls who were
276 overweight (OR 3.51; 95%CI 2.62-4.70 and 1.93; 1.34-2.78 respectively) or obese (OR
277 5.55; 4.07-7.57 and 4.11; 2.37-7.13 respectively) compared with those who were
278 non-overweight. There was also a statistically significant trend for reduced risk of
279 HBP with increasing quartile of CRF in boys (OR for 4th vs 1th quartile CRF 0.64;
280 95%CI 0.46-0.89, $p < 0.05$), but not in girls (OR for 4th vs 1th quartile CRF 0.70; 95%CI
281 0.43-1.13, $p > 0.05$). In the combined weight status and CRF model, simultaneously
282 adjusted for age, pubertal status, height and weight status \times CRF (adjusted model II),
283 weight status but not CRF remained significantly associated with HBP in both boys
284 and girls. The likelihood of having HBP was significantly higher for boys and girls who
285 were overweight (OR 2.96; 95%CI 1.71-5.11 and 1.75; 1.00-3.06 respectively; $p < 0.05$)
286 or obese (OR 4.19; 2.63-6.67 and 2.49; 1.19-5.19 respectively; $p < 0.05$) compared
287 with those who were non-overweight (Table 3). The interaction term for weight
288 status and CRF was non-significant in the models.

289 Table 4 shows the mean SBP, DBP and prevalence of hypertension among those with
290 high or low CRF within each weight status category (non-overweight, overweight,
291 obese). All measures of BP were similar within the weight status categories
292 irrespective of CRF level, and BP and prevalence of HBP were greater with increasing
293 weight status in both boys and girls.

294 **Sensitivity Analyses**

295 Repeating the analyses for factors associated with HBP, using the IOTF categorization
296 of weight status, did not alter the findings. The magnitude and direction of effect of
297 all variables reported above remained similar to the main analysis, although the
298 absolute values differed (likelihood of HBP for those in obese compared with
299 non-overweight category in model II was 5.06 (95%CI 2.94 to 8.73, $p<0.05$) in boys
300 and 2.34 (95%CI 1.38 to 4.09, $p<0.05$) in girls, whilst likelihood of HBP for those in
301 highest vs lowest quartile for reduced Cooper test was 0.89 (95%CI 0.59 to 1.33,
302 $p>0.05$) and 0.75 (95%CI 0.46 to 1.22, $p>0.05$) respectively).

303

304 **Discussion**

305 We found that weight status is strongly associated with the likelihood of HBP in
306 primary school aged children, and that in boys, but not in girls, the level of CRF was
307 also inversely associated with HBP. However, when both CRF and weight status were
308 included in the same model, only the association between weight status and HBP
309 remained significant. In contrast to our hypothesis, there was no evidence in our
310 analyses that higher CRF attenuated the association between obesity and HBP. Our
311 finding of a strong association between weight status and blood pressure in children
312 is in line with reports from other studies and systematic reviews, and suggests that
313 tackling obesity in childhood may help reduce the burden of cardiovascular disease
314 in adulthood³⁹.

315 Previous studies have suggested that higher CRF could attenuate the effects of
316 obesity on cardiovascular health and there is evidence from longitudinal studies to

317 suggest that higher CRF is associated with lower cardiovascular mortality among
318 those who are obese^{21,40}. A recent large longitudinal study of adolescents in the US
319 reported a significant interaction between CRF and weight status in predicting risk of
320 hypertension, and an association between lower CRF and HBP, even among those
321 who were not overweight⁴¹. Among the Chinese children in our study, we did not
322 find any evidence that increasing fitness levels were associated with lower BP once
323 weight status was taken into account. Our findings are similar to those from another
324 study in 9-12 year old children in the USA⁴². These differences may be due to the
325 cross-sectional nature of these two studies, with the effects of CRF on blood
326 pressure becoming apparent in the longer term. There is some limited evidence to
327 suggest that CRF in childhood predicts later increases in blood pressure⁴³⁻⁴⁴. It may
328 also be related to the younger age of the children in these studies, suggesting that
329 weight status is the predominant predictor of HBP in childhood⁴⁵, with CRF becoming
330 more important in later life. The younger age of participants in this study sample
331 may also potentially explain the observed difference between boys and girls in
332 relation to the association between CRF and HBP. The majority of children in this
333 study were pre-pubertal, and there is some evidence that pre-pubertal girls have
334 stiffer large arteries compared with boys⁴⁶. This could make them less responsive to
335 blood pressure changes irrespective of CRF levels. However, even without the
336 moderating effect of CRF on obesity and the risk of cardiovascular disease, CRF is an
337 important factor in increasing longevity¹⁸⁻²¹, and may positively impact on the
338 prognosis of hypertension. Therefore improving CRF should be prioritized as an

339 intervention target alongside obesity. Another important consideration is the role of
340 physical activity, as this contributes to both CRF⁴⁷ and reduction in obesity,
341 (particularly vigorous intensity physical activity⁴⁸⁻⁴⁹. Physical activity has also been
342 shown to be important in protecting against all cause mortality in epidemiological
343 studies⁵⁰.

344 Strengths of our study include the large representative sample of children, the
345 inclusion of objective standardized anthropometric, blood pressure and CRF
346 measurements, and adjustment for school level clustering, which accounts for
347 potential confounding from important socioeconomic factors.

348 Limitations include the use of only one measure of physical fitness and the lack of a
349 validated method of estimating VO2 max from the reduced Cooper test. We also did
350 not have information on family history of HBP or on salt and dietary intake, which
351 could be important confounding factors and ideally should be adjusted for within the
352 analyses. Finally, the cross-sectional nature of the study limits interpretation of
353 causal associations.

354 In conclusion, our results demonstrated that overweight/obesity is strongly
355 associated with HBP in both boys and girls. This supports recent evidence in the US
356 where the increasing prevalence of HBP is attributed to the rise in overweight and
357 obesity among young children and youth⁵¹⁻⁵⁴. Given the rising prevalence of
358 childhood obesity in China, it is imperative that comprehensive strategies are put
359 into place to tackle obesity in order to reduce the future burden of cardiometabolic
360 disease.

361

362 **Conflict of Interest**

363 The authors declare that they have no competing interests.

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Table 1: Anthropometric and physiological parameters in Chinese boys and girls aged 5 to 12 years (n=4926).

Variables	Boys (2725)	Girls (2201)	Total (4926)
Mean age, years (SD)	9.3±1.5	9.3±1.5	9.3±1.5
Pre-Pubertal, n (%)	2725 (100)	2125 (96.5)	4850 (98.5)
Overweight, n (%)	348 (12.8)	189 (8.6)*	537 (10.9)
Obese, n (%)	279 (10.2)	61 (2.8)*	340 (6.9)
BMI-z score	-0.01±1.37	-0.45±1.15*	-0.21±1.30
Reduced Cooper test (distance run in m)	899.4±133.4	864.8±163.0*	884.0±148.4
SBP, mmHg (Mean ± SD)			
	107.6±9.6 [§]	106.1±9.7 [§]	106.9±9.7
5-6 years (n=320)	101.8±8.8	101.9±8.1	101.9±8.5
7-8 years (n=1868)	105.6±9.3	103.3±9.0	104.6±9.2
9-10 years (n=1977)	109.0±9.1	107.6±9.7	108.3±9.4
11-12 years (n=761)	111.4±9.7	110.8±9.3	111.15±9.6
DBP, mmHg (Mean ± SD)	64.7±7.4 [#]	65.0±7.4 [#]	64.9±7.4
5-6 years (n=320)	61.1±7.1	61.9±6.4	61.5±6.8
7-8 years (n=1868)	63.3±7.2	63.3±7.2	63.3±7.2
9-10 years (n=1977)	65.8±7.1	66.2±7.4	66.0±7.2
11-12 years (n=761)	67.0±7.3	67.5±6.8	67.2±7.1
High SBP, n (%)			
Yes	367 (13.5)	327 (14.9)	694 (14.1)
High DBP, n (%)			
Yes	100 (3.7)	102 (4.6)	202 (4.1)
HBP, n (%)			
Yes	398 (14.6)	354 (16.1)	752 (15.3)

505 **Note:** Continuous variables were described by means ± standard deviation. Categorical variables
506 are described by frequency (%). * Statistical significant between boys and girls, P<0.05. § SBP
507 increased with increasing age in boys and girls, P<0.05. # DBP increased with increasing age in
508 boys and girls, P<0.05.

Table 2: Relationship between weight status and cardiorespiratory fitness among school children in Guangzhou, China.

	N	Cardiorespiratory fitness (Reduced Cooper test)							
		1 st Quartile	2 nd Quartile	3 rd Quartile	4 th Quartile	Lower Fitness	Higher Fitness		
		%	%	%	%	P-value	%	%	P-value
Boys									
Non-overweight	2098	21.5	23.8	26.2	28.5		45.3	54.7	
Overweight	348	27.9	29.3	24.7	18.1	<0.001	57.2	42.8	<0.001
Obese	279	49.8	30.1	14	6.1		79.9	20.1	
Girls									
Non-overweight	1951	24.7	23.9	25.6	25.8		48.5	51.5	
Overweight	189	31.7	29.1	20.6	18.5	0.001	60.8	39.2	<0.001
Obese	61	44.3	36.1	13.1	6.6		80.3	19.7	
		Mean distance (m) + SD	Mean distance (m) + SD	Mean distance (m) + SD	Mean distance (m) + SD		Mean distance (m) + SD	Mean distance (m) + SD	
Boys									
Non-overweight	2098	761.0±85.0	868.8±39.3	951.0±49.3 [§]	1060.8±76.4		816.2±84.9 [§]	997.4±82.5	
Overweight	348	750.3±86.4	865.5±38.5	941.5±44.8	1047.9±95.7		810.8±97.3	993.0±99.9	
Obese	279	740.3±85.7	863.3±41.7	933.4±43.0	1034.0±54.2		786.6±93.7	969.6±63.9	
Girls									
Non-overweight	1951	737.0±80.2	838.3±24.6	905.4±41.7	1151.6±98.2 [§]		785.4±78.7	1021.9±65.8 [§]	
Overweight	189	734.3±85.0	837.7±32.4	896.3±33.7	986.9±68.5		784.2±81.6	941.8±70.5	
Obese	61	735.8±73.2	835.7±29.4	896.0±34.7	976.0±79.1		781.6±77.4	922.7±63.4	

Note: weight status (defined using WHO 2007 reference standard); 1st Quartile: 1%-25% percentiles, 2nd Quartile: 26%-50% percentiles; 3rd Quartile: 51%-75% percentiles, 4th Quartile: 76%-100% percentiles. § Reduced Cooper test decreased with weight status in boys and girls, P<0.05. Lower Fitness (1st and 2nd Quartile); Higher Fitness (3rd and 4th Quartile).

Table 3: Generalized linear mixed model analysis of the association between weight status, cardiorespiratory fitness and HBP among school children in Guangzhou, China.

Characteristics	HBP	Likelihood of HBP		
	Number (%)	Unadjusted model OR(95% CI)	Adjusted model I OR(95% CI)	Adjusted model II OR(95% CI)
Boys(n=2725)				
Children's weight status				
Non-overweight	2098(9.0) **	Reference	Reference	Reference
Overweight	348(27.6)	3.94(2.97-5.22) **	3.51(2.62-4.70) **	2.96(1.71-5.11) **
Obese	279(40.5)	7.03(5.28-9.37) **	5.55(4.07-7.57) **	4.19(2.63-6.67) **
Reduced Cooper test				
1 st quartile	688(18.2) **	Reference	Reference	Reference
2 nd quartile	685(15.5)	0.81(0.61-1.09)	0.71(0.56-1.02)	0.69(0.44-1.07)
3 rd quartile	675(12.9)	0.64(0.47-0.88) *	0.64(0.47-0.89) *	0.88(0.58-1.33)
4 th quartile	677(11.8)	0.59(0.43-0.81) *	0.64(0.46-0.89) *	0.87(0.56-1.35)
Girls (n=2201)				
Children's weight status				
Non-overweight	1951(13.8) **	Reference	Reference	Reference
Overweight	189(30.2)	2.66(1.89-3.73) **	1.93(1.34-2.78) **	1.75(1.00-3.06) **
Obese	61(45.9)	5.16(3.04-8.75) **	4.11(2.37-7.13) **	2.49(1.19-5.19) **
Reduced Cooper test				
1 st quartile	568(15.3)	Reference	Reference	Reference
2 nd quartile	543(17.3)	1.14(0.83-1.59)	1.14(0.85-1.54)	1.14(0.83-1.57)
3 rd quartile	547(18.6)	1.25(0.90-1.74)	0.92(0.66-1.29)	1.01(0.71-1.43)
4 th quartile	543(13.1)	0.81(0.57-1.17)	0.70(0.43-1.13)	0.71(0.43-1.18)

Note: Adjusted model I: Adjusted for age, height and pubertal status. Adjusted model II: Model includes age, height, pubertal status, weight status (WHO 2007 categories), CRF quartiles and weight status×CRF quartiles.** P<0.001, * P<0.05.

Table 4: The mean SBP, DBP and prevalence of hypertension across weight status and cardiorespiratory fitness groups among Chinese schoolboys and girls in Guangzhou.

Characteristics	Boys(n=2725)				Girls(n=2201)			
	Hypertension		Mean ± SD		Hypertension		Mean ± SD	
	Number	%	SBP	DBP	Number	%	SBP	DBP
Reduced Cooper test								
Non-overweight								
Higher fitness	1147	8.7	105.49±8.77	63.28±6.99	1004	14.1	105.28±9.36	64.32±7.25
Lower fitness	951	9.4	105.86±8.75	63.81±6.81	947	13.4	105.12±9.36	64.52±7.18
P-value		0.61	0.33	0.08		0.64	0.71	0.54
Overweight								
Higher fitness	149	28.2	113.62±9.42	67.70±7.19	74	31.1	111.85±9.69	67.96±7.00
Lower fitness	199	27.1	111.92±9.55	67.65±7.27	115	29.6	111.79±9.19	69.28±6.50
P-value		0.83	0.10	0.95		0.83	0.97	0.19
Obese								
Higher fitness	56	44.6	116.46±9.96	70.62±6.80	12	66.7	117.63±5.96	72.33±6.22
Lower fitness	223	39.5	115.68±9.10	70.17±7.54	61	49.5	115.78±10.65	71.43±7.97
P-value		0.48	0.57	0.69		0.11	0.43	0.72

Note: Weight status (defined using WHO 2007 reference standard); Lower fitness refer to 1st Quartile and 2nd Quartile fitness and Higher fitness refer to 3rd Quartile and 4th Quartile fitness.