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

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35	Summary Table	
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37 38	What is known about this topic	
39	• Cardiorespiratory fitness (CRF) and adiposity contribute to high blood pressure	ē
40	(HBP), but their relative importance is unknown.	
41	 Data analyzed these relationships among Chinese children is lacking. 	
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43	What this study adds	
44	• Hypertension is common in Chinese children (prevalence 15.3%), with higher	r
45	prevalence in obese (40.5% and 45.9% in boys and girls respectively) and	ł
46	overweight (27.6% and 30.2%).	
47	• Weight status is strongly associated with likelihood of high blood pressure in	۱
48	Chinese primary school aged children.	
49	ullet There was no evidence that increased CRF modified the risk of HBP in	۱
50	overweight and obese children.	
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72 Abstract

Cardiorespiratory fitness (CRF) and adiposity contribute to high blood pressure (HBP) 73 in adults and children. However, their relative importance as risk factors is unknown. 74 75 We examined the relationships between weight status, CRF and HBP among Chinese primary school children. A cross-sectional study was conducted with 4926 school 76 children aged 5–12 years. CRF was estimated from a modified Cooper test, body 77 78 mass index z-scores and weight categories were calculated from objective height and 79 weight measurements, and ΒP 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 age, pubertal status and height, were developed for boys and girls to explore the 82 83 independent and combined associations between fitness, weight status and HBP. 752 (15.3%) children had HBP, with a higher prevalence in obese (40.5% and 45.9% in 84 boys and girls respectively) and overweight (27.6% and 30.2%) compared with 85 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). This association was not seen in girls. With weight status and CRF in the same model, 88 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 effect for CRF and weight status was non-significant. Overweight/obesity was 91 92 significantly associated with HBP among children. There was no evidence of 93 modification of this relationship by CRF.

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Keywords: Blood pressure; Cardiorespiratory fitness; Obesity, School children, China
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97 Introduction

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

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

The prevalence of overweight and obesity in school-aged children in China (aged 5-12 years) has increased more rapidly than that seen in most Western countries²⁷⁻²⁸, with the prevalence in some urban regions approaching those in developed countries²⁹⁻³⁰. In addition a report on the Physical Fitness and Health Surveillance of Chinese School Students in 2010 revealed that CRF in children has been decreasing during the past twenty five years³¹. Given the significant increases in these two major cardiovascular risk factors in Chinese children, we aimed to explore the prevalence of HBP and its relationship with these two risk factors, and also to examine the potential modification effect of CRF on the association between weight status and HBP. We hypothesized that both obesity and CRF would be associated with HBP in this population of children, and that CRF would attenuate the association between obesity and HBP.

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146 Methods

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

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

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

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

174 Anthropometric and BP measurements

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

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

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

191 CRF measurements

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

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

209 Other measurements

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

214 Statistical Analysis

Body mass index (BMI; [weight (kg)]/[height (m)]²), was calculated and standard 215 deviation scores (BMI z-score) derived using the age and sex specific WHO growth 216 reference for school-aged children³⁶. BMI z-scores were used to classify participants 217 as non-overweight (≤1SD), overweight (>1SD, ≤2SD) or obese (>2SD). HBP was 218 defined as systolic or diastolic BP above the 95th percentile for age and gender 219 specific reference cut-offs for Chinese children and adolescents³⁷. As we were using a 220 reduced Cooper test, we were unable to calculate the VO₂ max from the distance run 221 using reference tables, therefore the distance covered was categorized into quartiles 222 223 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) CRF. 225

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

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

242

243 Results

244 Characteristics of the Study Sample

Among 4926 children in the sub-group who had BP measurements, 4,726 (2,725 boys and 2,201 girls) had complete data for the reduced Cooper test, BP, and weight and height, and so were included in the analysis. Descriptive characteristics of the sample are shown in Table 1. Overall 10.9% of children were overweight and an additional 6.9% were obese, with rates being higher in boys compared with girls. Almost all children (100% of boys and 96.5% of girls) were pre-pubertal. Boys covered a greater distance in the reduced Cooper test (899.4 vs 864.8 m) and had a higher SBP compared with girls (107.6 vs 106.1 mmHg). SBP and DBP increased with increasing age in boys and girls. Around 15% of children had HBP, with prevalence rates being similar in boys and girls and no significant difference in prevalence by age.

256 Relationship between weight status and CRF among school children

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

Association between weight status, CRF and HBP among school children

There was a clear relationship between weight status and HBP, with prevalence of 9.0% (boys) and 13.8% (girls) in non-overweight children, 27.6% (boys) and 30.2% (girls) in overweight children, and 40.5% (boys) and 45.9% (girls) in obese children. Similarly there was a relationship between lower CRF and higher risk of hypertension in boys (prevalence of HBP 18.2% in the lowest versus 11.8%in the highest fitness quartile), although no clear relationship between fitness levels and BP was seen in 273 girls (Table 3).

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

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

294 Sensitivity Analyses

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

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304 Discussion

We found that weight status is strongly associated with the likelihood of HBP in 305 306 primary school aged children, and that in boys, but not in girls, the level of CRF was also inversely associated with HBP. However, when both CRF and weight status were 307 included in the same model, only the association between weight status and HBP 308 309 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 finding of a strong association between weight status and blood pressure in children 311 312 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 in adulthood³⁹. 314

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

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

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

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

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

361

362 Conflict of Interest

363 The authors declare that they have no competing interests.

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and girls aged 5 to 12 years (n=4920).							
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	$-0.45 \pm 1.15^{*}$	-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 \pm 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)	$64.7{\pm}7.4$ [#]	$65.0{\pm}7.4$ [#]	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)				
Neter Continuous might a sum described by means to standard desiritien. Cotoe sight assisted							

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

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

	Cardiorespiratory fitness (Reduced Cooper test)								
	N	1^{st}	2^{nd}	3 rd	4 th		Lower	Higher	
	IN	Quartile	Quartile	Quartile	Quartile		Fitness	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				
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	

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

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).

	HBP				
Characteristics		Unadjusted model	Adjusted model I	Adjusted model II	
	Number (%)	OR(95% CI)	OR(95% CI)	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)	

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

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.

	Boys(n=2725)				Girls(n=2201)			
Characteristics	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

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

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.