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ORIGINAL ARTICLE

The association between low physical fitness and high body mass index or waist circumference is increasing with age in children: the 'Québec en Forme' Project

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Objective: To evaluate physical fitness and body composition of children involved in the 'Québec en Forme' (QEF) Project and to compare data obtained to the reference values of the 1981 Canada Fitness Survey (CFS).
Design: Cross-sectional study.
Subjects: A total of 1140 children (591 boys and 549 girls) of first (7 years), second (8 years) and fourth (10 years) grade from primary schools in the City of Trois-Rivières (Québec) were selected to participate in this study.
Measurements: Body mass index (BMI) and waist circumference (WC) were measured. The physical fitness tests included standing long jump, 1-min speed sit-ups and speed shuttle run.
Results: The prevalence of overweight in children ranged between 20 and 30%, which represents a substantial increase compared to the 1981 CFS. The relationship between BMI and WC was highly significant in boys and girls ($r = 0.90$ and 0.86, respectively, $P < 0.0001$). The negative correlations between BMI or WC and the performance in all physical fitness tests were mostly significant in children of both genders ($-0.16 \leqslant r \leqslant -0.45$, at least $P < 0.05$), and these relationships were significantly greater in older children ($P < 0.05$). Based on the 1981 CFS, only 4.7–14.1% of QEF boys still performed in the upper quartile of the distribution (fit boys), whereas 32.1–69% performed not much higher than the lower quartile (unfit boys) for each fitness test. In girls, the relative fitness decrease observed in 2003 was more pronounced since only 1–9.9% of subjects performed in the upper quartile of the distribution compared to 42.8–81.4% who did not perform higher than the lower quartile of the 1981 reference scores of the CFS.
Conclusion: This study shows that BMI and WC are negatively correlated with physical fitness and that these associations are more pronounced in older children. Furthermore, physical fitness of our cohort, especially in girls, was much lower than what was documented in the 1981 CFS in subjects of the same age. This study thus emphasizes the necessity to develop early interventions to improve physical fitness in children and to prevent the increase of childhood obesity.
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Keywords: physical activity; adiposity; fat; body composition; childhood

Introduction

The prevalence of childhood obesity is a major public health concern and has been increasing worldwide over the last decades.[1] In the Canadian population, the prevalence of overweight has tripled in boys and doubled in girls, and the prevalence of obesity has quintupled in both genders from 1981 to 1996.[2] In addition, several studies have reported a higher probability for obese children to remain obese in adulthood.[3–6] Because adult obesity is clearly linked to an increased risk of cardiovascular disease, hypertension, type 2 diabetes and even some cancers,[1,7,8] a long-term intervention has to be developed in order to prevent childhood obesity.

Besides, physical fitness is negatively associated to body composition and blood pressure in children,[9–12] which suggests an early development of cardiovascular risk factors in childhood. Johnson *et al.*[13] found that early life fat mass is the main predictor of increasing adiposity in children. They also found a significant negative relationship between aerobic fitness and the rate of body fat gain. In addition, another longitudinal study showed that the changes in

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aerobic fitness and muscular strength, from childhood to adolescence, explained 15% of the variability of body and abdominal adiposity in adolescence.[14] This suggests that health promotion programmes in childhood should target physical fitness in order to prevent the increasing prevalence of obesity.

To date, no studies have examined the relationship between physical fitness and body composition in a large population of children from low socio-economic status (SES). Moreover, little is known about the fitness–body composition or fat distribution associations between age groups in children from primary school programme. Therefore, the first aim of this study was to analyse the relationships between physical fitness and body mass index (BMI) or waist circumference (WC) in children of different ages from the 'Québec en Forme' (QEF) Project. As BMI is a surrogate marker of total adiposity and WC is related with total and abdominal fat, we also wanted to verify if the relationship between physical fitness and WC is independent of BMI. Furthermore, even though the secular trends of childhood obesity are well documented in the recent works of Lobstein *et al*.[1] for the IASO International Obesity Task Force, little is known about secular trends of physical fitness in children. In Canada, the latest physical fitness evaluation in children was performed in 1981 in the Canada Fitness Survey (CFS). Thus, another aim of this study was to compare the fitness performance of the QEF children to the reference values of the CFS reported in 1981 by age and gender.

Methods

Overview of the project

The QEF Project is based on a new strategy to promote a healthy lifestyle by specifically focusing on sports and physical activity participation in children of low SES. This project is a partnership between the Lucie and André Chagnon Foundation and the Government of the Province of Québec (Canada). Its mission is to improve health and global autonomy of children and family by supporting the implementation of a long-term programme for sports and physical activities by local community. Furthermore, the QEF objectives are to favour a better social integration, to improve physical health and academic performance, to establish partnerships and to influence the norms, practices and policies in favour of the adoption of a healthy and active lifestyle.

The QEF model is a community network called Local Action Committee (LAC) composed by local community health centres, community and recreational centres, municipalities and schools. There are several LACs per region that are independently responsible for programming sports and physical activities.

The pilot study of the QEF Project was launched in the City of Trois-Rivières on September 2002 with four LACs involving 14 primary schools. The first evaluation was conducted in 1140 children attending these schools. Further details about this cohort are described in the next section.

Subjects

The evaluation was performed between January and March 2003 in 1140 Caucasian children (591 boys and 549 girls) of first, second and fourth grade of the primary school programme. The characteristics of these children are shown in Table 1. Each subject and his/her parents gave their written consent to participate in this study, which received approval of the Sainte-Justine Hospital Ethics Committee in Montréal.

Measurements

Anthropometric measurements of children were undertaken in a context of group evaluation in physical education class by trained kinesiologists. The height and weight of children were measured with physical education clothing (shorts and T-shirts) but with shoes removed. Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.1 kg using a standard dual reading scale. BMI was defined as weight/height^2, and expressed in kg/m^2 units. We used BMI as the index of overweight/obesity in childhood. Although there is no established BMI cutoff point for childhood obesity, age- and sex-specific cutoff points linked to adult cutoff points proposed by Cole *et al*.[15] were used. In addition, WC was measured according to standardized procedures, that is, at the line between the

Table 1 Characteristics of subjects

	Grade 1		*Grade 2*		*Grade 4*	
	Boys (n = 182)	*Girls (n = 196)*	*Boys (n = 217)*	*Girls (n = 192)*	*Boys (n = 192)*	*Girls (n = 161)*
Age (years)	6.9 ± 0.3	6.9 ± 0.3	7.9 ± 0.3	7.9 ± 0.3	10.0 ± 0.5	10.0 ± 0.4
Weight (kg)	24.3 ± 5.0	23.2 ± 4.3	27.2 ± 6.1	26.7 ± 6.5	34.0 ± 8.1	35.1 ± 8.2
Height (m)	1.21 ± 0.06	1.19 ± 0.06	1.26 ± 0.06	1.24 ± 0.07	1.37 ± 0.07	1.37 ± 0.07
BMI (kg/m^2)	16.5 ± 2.2	16.3 ± 2.1	17.0 ± 2.5	17.0 ± 2.8	18.0 ± 3.1	18.5 ± 3.4
WC (cm)	57.2 ± 5.7	55.6 ± 6.1	58.9 ± 7.0	58.7 ± 8.0	64.1 ± 8.6	63.9 ± 8.9

Abbreviations: BMI = body mass index; WC = waist circumference. Values are mean ± s.d.

lower border of the last rib and the upper border of the iliac crest.

The physical fitness tests were also performed in a physical education class. They included a standing long jump, a 1-min speed sit-ups test and a speed shuttle run. These tests were chosen from the 1981 CFS and were described elsewhere.[16] Briefly, muscular power was measured by standing long jump whereby children had two attempts to jump as far as possible from a standing position at the start. Muscular endurance was measured by 1-min speed sit-ups whereby children had 60 s to perform as many sit-ups as possible. Finally, the speed shuttle run was included to evaluate the capacity and agility of children to run back and forth four times a 10 m distance as fast as possible.

Statistical analysis

Characteristics of the sample were described by mean score ± s.d. Pearson's correlation coefficients were calculated to quantify the associations between the performance in all physical fitness tests and body composition (BMI and WC) variables in all academic grades. These correlations were subsequently compared by gender and between grades with a test of homogeneity of correlation coefficients.[17] In addition, as BMI is a surrogate marker of total adiposity and WC is related with total and abdominal fat, we performed partial correlation analyses while partialling out the effect of BMI to verify if the relationship between physical fitness and WC is independent of BMI. Finally, we compared the physical fitness of our sample to data obtained in the 1981 CFS. We used quartile values in order to differentiate the fit and unfit child. Fit and unfit children were classified as having a score in the upper and lower quartiles, respectively, of the 1981 CFS distribution. This method permitted to observe the evolution of the fitness condition of the Canadian children tested in comparison with the previous data obtained in 1981 for the same physical tests. Statistical significance was set at a P-value <0.05. All statistical analyses were performed with the JMP version 3.2.2 software (SAS Institute, Cary, NC, USA).

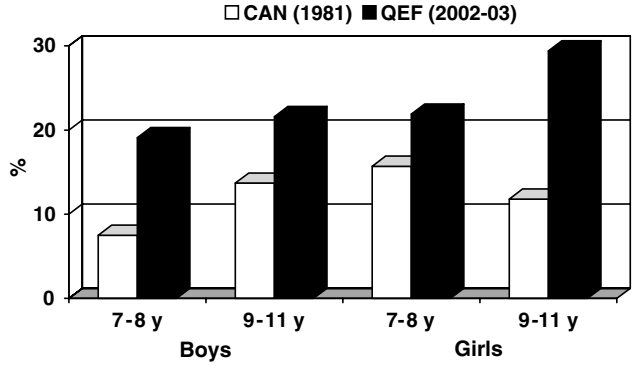

Figure 1 Overweight prevalence of children in the QEF Project compared to the 1981 CFS.

Results

The prevalence of overweight in children of this study ranged between 20 and 30% (Figure 1), which represents a substantial increase compared to the 1981 CFS. Girls seemed to be more overweight than boys, with one-third of 10-year-old girls presenting such a condition.

The relationship between BMI and WC was highly significant in boys and girls ($r=0.90$ and 0.86, respectively, $P<0.0001$). The correlations between BMI and the performance in all physical fitness indicators were negative and significant (see Table 2). In 8- and 10-year-old subjects, the correlations were significant for all physical fitness tests in boys ($-0.17\leqslant r\leqslant -0.44$, $P<0.01$) and girls ($-0.25\leqslant r\leqslant -0.45$, $P<0.01$). There was also a significant correlation for 1-min speed sit-ups in 7-year-old girls ($r=-0.24$, $P<0.001$). With respect to WC and fitness tests, there were also negative correlations for all fitness tests in both genders at all ages ($-0.16\leqslant r\leqslant -0.41$, $P<0.05$), except for 7-year-old subjects in speed shuttle run for boys and standing long jump for girls (Table 3).

Tables 2 and 3 also show that the negative associations between physical fitness and body composition were significantly greater in older children. To ascertain this finding, we performed a homogeneity correlation coefficients test to determine the existence of differences between the fitness–body composition correlations at different ages. The correlations for speed shuttle run or 1-min speed sit-ups with BMI in 10-year-old boys were significantly higher than

Table 2 Correlations between BMI and the performance in all physical fitness tests by grade and gender

	BMI					
	Grade 1		*Grade 2*		*Grade 4*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
Standing long jump	NS	NS	−0.27***	−0.32***	−0.40***	−0.32***
1-min speed sit-ups	NS	−0.24**	−0.19**	−0.26**	−0.44***	−0.45***
Speed shuttle run	NS	NS	−0.17*	−0.34***	−0.36***	−0.25*

Abbreviation: NS = nonsignificant. *$P<0.01$. **$P<0.001$. ***$P<0.0001$.

Table 3 Correlations between WC and the performance in all physical fitness tests by grade and gender

	WC					
	Grade 1		*Grade 2*		*Grade 4*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
Standing long jump	−0.16†	NS	−0.25**	−0.23*	−0.39***	−0.28**
1-min speed sit-ups	−0.17†	−0.19†	−0.16†	−0.17†	−0.41***	−0.39***
Speed shuttle run	NS	−0.18†	−0.22*	−0.27**	−0.36***	−0.25*

Abbreviations: NS = nonsignificant; WC = waist circumference. †$P<0.05$. *$P<0.01$. **$P<0.001$. ***$P<0.0001$.

those observed in 8-year-old boys ($r=-0.36$ vs -0.17, and -0.44 vs -0.19, respectively, $P<0.05$). In girls, the correlation between 1-min speed sit-ups and BMI in 10-year-old subjects was significantly greater than those observed in their 7- and 8-year-old counterparts ($r=-0.45$ vs -0.24 and -0.26, respectively, $P<0.05$).

The correlations between WC and physical fitness tests were also higher in older children. Indeed, the homogeneity correlation coefficients test showed that boys aged 10 years had a higher coefficient of correlation than 7- and 8-year-old boys for 1-min speed sit-ups ($r=-0.41$ vs -0.17 and -0.16, respectively, $P<0.05$) and for standing long jump in 7-year-old boys ($r=-0.39$ vs -0.16, $P<0.05$). In girls, the correlation for 1-min speed sit-ups in 10-year-old subjects was also significantly higher than those found in their 7- and 8-year-old counterparts ($r=-0.39$ vs -0.19 and -0.17, respectively, $P<0.05$). In addition, as BMI is a surrogate marker of total adiposity and WC is related with total and abdominal fat, we verified if the relationship between physical fitness and WC was independent of BMI by performing partial correlation analyses while partialling out the effect of BMI. In this regard, we found that all the associations were not significant when partialling out the effect of BMI, suggesting that the associations between physical fitness tests and WC were not independent of BMI.

Finally, data collected in the QEF Project for each physical fitness test were compared to those obtained in the 1981 CFS. In this regard, we used a classification based on quartiles in order to differentiate the 1981 fit and unfit child. Thus, fit and unfit children were classified as having a score in the upper and lower quartiles, respectively, of the 1981 CFS distribution. This method permitted to observe the evolution of the fitness condition of the Canadian children tested in the QEF Project in comparison with the previous data obtained in 1981 for the same physical tests. Therefore, based on the data of the 1981 CFS, only 4.7–14.1% of QEF boys still performed in the upper quartile of the distribution (fit boys), whereas 32.1–69% performed not much higher than the lower quartile (unfit boys) for each fitness test. In girls, the relative fitness decrease observed in 2003 was more pronounced since only 1–9.9% of subjects performed in the upper quartile of the distribution compared to 42.8–81.4% who did not perform higher than the lower quartile of the 1981 reference scores of the CFS. This deterioration in physical fitness performance is illustrated in Figures 2–4.

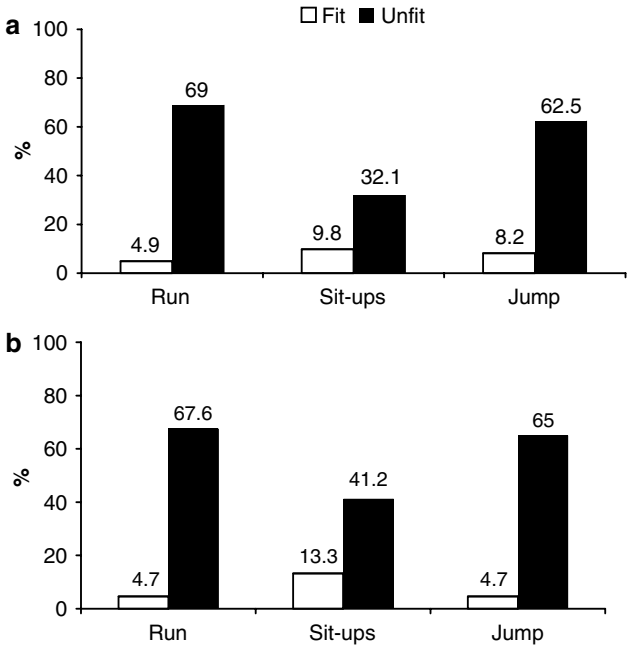

Figure 2 Percentage of fit (upper quartile) and unfit (lower quartile) boys (**a**) and girls (**b**) in first grade (7 years) by using the quartiles reference values of the 1981 CFS.

Discussion

This study is the first one to evaluate the relationship between physical fitness and BMI or WC in a large population of children from low SES. Our results indicate that the association between low physical fitness and high BMI or WC is significant and is increasing with age in children.

The present study showed a higher overweight prevalence in children from the pilot study of the QEF Project than what was documented in the 1981 CFS data.[2] This represents an increase in prevalence from about 10 to 20% in boys, whereas the older girls displayed the highest prevalence,

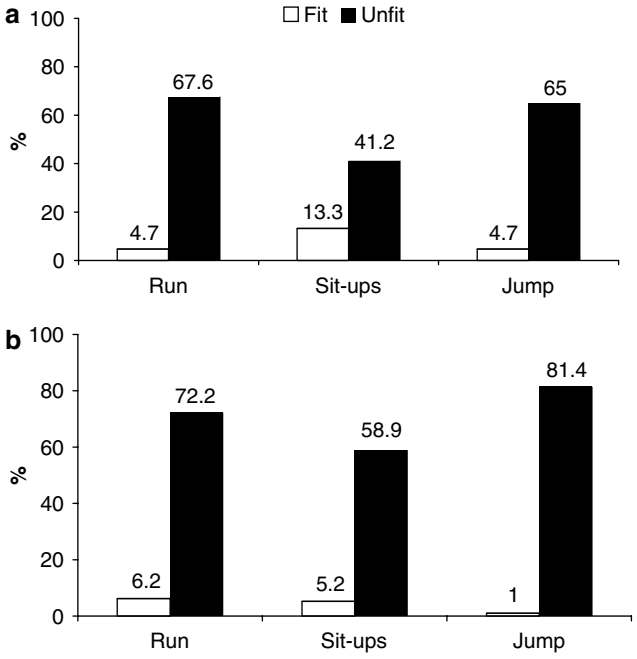

Figure 3 Percentage of fit (upper quartile) and unfit (lower quartile) boys (**a**) and girls (**b**) in second grade (8 years) by using the quartile reference values of the 1981 CFS.

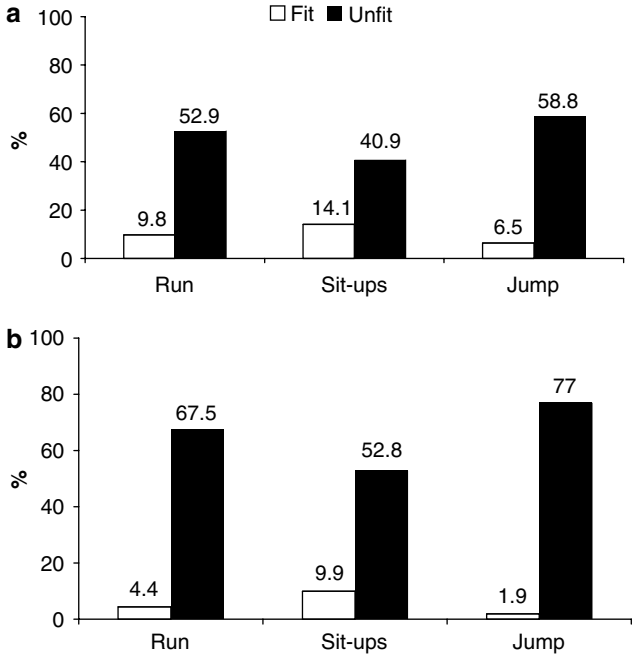

Figure 4 Percentage of fit (upper quartile) and unfit (lower quartile) boys (**a**) and girls (**b**) in fourth grade (10 years) by using the quartile reference values of the 1981 CFS.

which almost reached 30%. This prevalence is consistent with a recent literature review on childhood obesity by Lobstein *et al*.[1] for the IASO International Obesity Task Force.

Other investigators have reported an association between physical fitness and body composition in children.[18–25] However, some of these studies were conducted with a small number of subjects, whereas others included children and adolescents in the same analyses. It has also been reported that overweight as well as obese children showed a lower physical fitness than normal children.[19,26–28] In one study, the negative relationship between physical fitness and WC has also been documented.[19] The results of the present study are concordant with these observations since physical fitness was significantly associated with BMI of boys and girls in grades 2 and 4. In addition, there were associations with WC in grades 1, 2 and 4, except for speed shuttle run for boys and standing long jump for girls in grade 1.

The most innovative contribution of this study pertains to the demonstration of significant differences in the fitness–body composition correlations between age/grade groups. To document this issue, a test of homogeneity of correlation coefficients was used to compare correlations between age/grade groups for each gender. We observed that the relationships were higher in older children, particularly for 1-min speed sit-ups in boys and girls. Thus, beyond the confirmation of a detrimental impact of BMI and WC on physical fitness in the first years of school, our data suggest that this relationship is accentuating over time. Moreover, this lends support to the relevance to focus on good practices of physical activities as early as possible in the school curriculum of children.

Secular trends of physical fitness in children have received little attention in the literature. However, a recent Danish study performed in two cohorts of 9-year-old children (one tested in 1985–1986 and the other one in 1997–1998) showed a higher body fat and a lower physical fitness in boys tested in 1997–1998, but not in girls.[29] Another study evaluating representative cohorts of 7- to 19-year-old Polish children revealed a decreasing physical fitness of children between 1979 and 1999.[30] In addition, a study conducted in 850 college students aged 18.2 ± 0.7 years showed that physical fitness decreased in the last two decades, whereas adiposity was twice as high in unfit students compared to their fit counterparts.[31] Since the assessment of the 1981 CFS, an objective measure of physical fitness in Canada has not been performed in a comparable cohort. Hence, we decided to compare our results to this fitness survey in order to document the trends of physical fitness nowadays. In this regard, the results presented above are perceived to reflect a huge impairment of physical fitness over the last 25 years. However, since our cohort was from a low SES population as well as from a specific region of the Province of Québec, it was not possible to generalize our findings to other children of Canada. Nevertheless, the poor physical fitness observed in our cohort, especially in girls, showed that contemporary children would be at higher risk to develop obesity and related diseases in a near future.

The QEF Project is an adapted programme that includes the participation of the school, the community members as

well as the family in order to promote sports and physical activity participation in children. An important objective of this project is to prevent the development of obesity over the school years. However, because 20–30% of children are already overweight, they will also require effective strategy to prevent obesity in adulthood. Indeed, it is well documented that the presence of obesity in childhood and/or in adolescence increases by five- to ninefold the risk to be obese in adulthood.[32,33] In this respect, further studies being undertaken in the context of the QEF Project will document the impact of a school-based programme on childhood obesity development from underprivileged neighbourhoods. Finally, by promoting physical activity participation, the QEF Project also has the potential to enhance social and cognitive development in children.

Conclusion

This study shows that BMI and WC are negatively correlated with physical fitness and that these associations are more pronounced in older children. Furthermore, physical fitness of our cohort, especially in girls, was much lower than what was documented in the 1981 CFS in subjects of the same age. Therefore, the negative trend and increased polarization for physical fitness and obesity in Canadian children, with the difference between the fit and the unfit and the difference between the lean and the fat being greater in 2003 than in 1981, suggests a future generation with a higher degree of cardiovascular disease risk. This study thus emphasizes the necessity to develop early interventions to improve physical fitness in children and to prevent the increase of childhood obesity.

Acknowledgements

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References

1 Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. *Obes Rev* 2004; **5** (Suppl 1): 4–85.
2 Tremblay MS, Katzmarzyk PT, Willms JD. Temporal trends in overweight and obesity in Canada, 1981–1996. *Int J Obes Relat Metab Disord* 2002; **26**: 538–543.
3 Freedman DS, Khan LK, Dietz WH, Srinivasan SR, Berenson GS. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. *Pediatrics* 2001; **108**: 712–718.
4 Power C, Lake JK, Cole TJ. Body mass index and height from childhood to adulthood in the 1958 British born cohort. *Am J Clin Nutr* 1997; **66**: 1094–1101.
5 Guo SS, Roche AF, Chumlea WC, Gardner JD, Siervogel RM. The predictive value of childhood body mass index values for overweight at age 35 y. *Am J Clin Nutr* 1994; **59**: 810–819.
6 Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Prev Med* 1993; **22**: 167–177.
7 Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med* 1992; **327**: 1350–1355.
8 Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Relat Metab Disord* 1999; **23** (Suppl 2): S2–S11.
9 Gutin B, Basch C, Shea S, Contento I, DeLozier M, Rips J *et al*. Blood pressure, fitness, and fatness in 5- and 6-year-old children. *JAMA* 1990; **264**: 1123–1127.
10 Stewart KJ, Brown CS, Hickey CM, McFarland LD, Weinhofer JJ, Gottlieb SH. Physical fitness, physical activity, and fatness in relation to blood pressure and lipids in preadolescent children. Results from the FRESH Study. *J Cardiopulm Rehab* 1995; **15**: 122–129.
11 Perry AC, Tremblay LM, Signorile JF, Kaplan TA, Miller PC. Fitness, diet and coronary risk factors in a sample of southeastern US children. *Appl Hum Sci* 1997; **16**: 133–141.
12 Rump P, Verstappen F, Gerver WJ, Hornstra G. Body composition and cardiorespiratory fitness indicators in prepubescent boys and girls. *Int J Sports Med* 2002; **23**: 50–54.
13 Johnson MS, Figueroa-Colon R, Herd SL, Fields DA, Sun M, Hunter GR *et al*. Aerobic fitness, not energy expenditure, influences subsequent increase in adiposity in black and white children. *Pediatrics* 2000; **106**: E50.
14 Janz KF, Dawson JD, Mahoney LT. Increases in physical fitness during childhood improve cardiovascular health during adolescence: the Muscatine Study. *Int J Sports Med* 2002; **23** (Suppl 1): S15–S21.
15 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; **320**: 1240–1243.
16 Canadian Association for Health Physical Education and Recreation, CAHPER. *Fitness Performance II, Test Manual*. The Canadian Association for Health, Physical Education and Recreation, 1980.
17 Snedecor GW, Cochran WG. *Statistical Methods*, 6th edn, Iowa State University Press: Ames, IA, 1967.
18 Malina RM, Beunen GP, Classens AL, Lefevre J, Vanden Eynde BV, Renson R *et al*. Fatness and physical fitness of girls 7 to 17 years. *Obes Res* 1995; **3**: 221–231.
19 Okely AD, Booth ML, Chey T. Relationships between body composition and fundamental movement skills among children and adolescents. *Res Q Exerc Sport* 2004; **75**: 238–247.
20 Grund A, Dilba B, Forberger K, Krause H, Siewers M, Rieckert H *et al*. Relationships between physical activity, physical fitness, muscle strength and nutritional state in 5- to 11-year-old children. *Eur J Appl Physiol* 2000; **82**: 425–438.
21 Chatrath R, Shenoy R, Serratto M, Thoele DG. Physical fitness of urban American children. *Pediatr Cardiol* 2002; **23**: 608–612.
22 Gray A, Smith C. Fitness, dietary intake, and body mass index in urban Native American youth. *J Am Diet Assoc* 2003; **103**: 1187–1191.
23 Norman AC, Drinkard B, McDuffie JR, Ghorbani S, Yanoff LB, Yanovski JA. Influence of excess adiposity on exercise fitness and performance in overweight children and adolescents. *Pediatrics* 2005; **115**: e690–e696.
24 Ara I, Vicente-Rodriguez G, Jimenez-Ramirez J, Dorado C, Serrana-Sanchez JA, Calbet JA. Regular participation in sports is associated with enhanced physical fitness and lower fat mass in prepubertal boys. *Int J Obes Relat Metab Disord* 2004; **28**: 1585–1593.
25 Guerra S, Ribeiro JC, Costa R, Duarte J, Mota J. Relationship between cardiorespiratory fitness, body composition and blood

pressure in school children. *J Sports Med Phys Fitness* 2002; **42**: 207–213.
26 Pongprapai S, Mo-suwan L, Leelasamran W. Physical fitness of obese school children in Hat Yai, southern Thailand. *Southeast Asian J Trop Med Public Health* 1994; **25**: 354–360.
27 Bettiol H, Rona RJ, Chinn S. Variation in physical fitness between ethnic groups in nine year olds. *Int J Epidemiol* 1999; **28**: 281–286.
28 Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes Res* 2003; **11**: 434–441.
29 Wedderkopp N, Froberg K, Hansen HS, Andersen LB. Secular trends in physical fitness and obesity in Danish 9-year-old girls and boys: Odense School Child Study and Danish substudy of the European Youth Heart Study. *Scand J Med Sci Sports* 2004; **14**: 150–155.
30 Przeweda R, Dobosz J. Growth and physical fitness of Polish youths in two successive decades. *J Sports Med Phys Fitness* 2003; **43**: 465–474.
31 Tremblay A, Chiasson L. Physical fitness in young college men and women. *Can J Appl Physiol* 2002; **27**: 563–574.
32 Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 1997; **337**: 869–873.
33 Magarey AM, Daniels LA, Boulton TJ, Cockington RA. Predicting obesity in early adulthood from childhood and parental obesity. *Int J Obes Relat Metab Disord* 2003; **27**: 505–513.