The Effects of Nutritional-Physical Activity School-based Intervention on Fatness and Fitness in Preschool Children

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ABSTRACT

Background: **Obesity is now the most common chronic pediatric disease. Early health education programs could serve to prevent and treat childhood obesity and its numerous complications.**
Aim: **To examine the effects of a randomized prospective school-based intervention on anthropometric measures, body composition, leisure time habits and fitness in preschool children.**
Children: **Fifty-four preschool children completed a 14-week combined dietary-behavioral-physical activity intervention and were compared to 47 age matched controls (age 5-6 yr).**
Results: **Daily physical activity was significantly greater in the intervention group compared to the controls (6,927 ± 364 vs 5,489 ± 284 steps/day, respectively; p <0.003). Favorable changes were observed in weight (0.35 ± 0.08 vs 0.9 ± 0.1 kg, p <0.0005), BMI percentile (-3.8 ± 1.3 vs 2.9 ± 1.5 kg/m^2, p <0.001), fat percent (by skinfolds, -0.65 ± 0.3 vs 1.64 ± 0.3%, p <0.028) and fitness (endurance time -3.55 ± 1.85 vs 3.16 ± 2.05%, p <0.017) in the intervention versus control groups.**
Conclusions: **A preschool, dietary/physical activity intervention may play a role in health promotion, prevention and treatment of childhood obesity.**

KEY WORDS

obesity, preschool, multidisciplinary treatment, exercise

INTRODUCTION

The prevalence of juvenile obesity is increasing worldwide and has reached epidemic proportions despite major efforts to promote weight reduction[1]. The underlying mechanisms for the increasing prevalence of childhood obesity are not completely clear, but it is clear that changes in food consumption and/or physical activity habits serve as an obesogenic environment, interact with the individual's genetic predisposition, and lead to obesity[2].

Recent data do not support an increase in caloric consumption over the last decade in North American children and adolescents (except for adolescent girls), and, in fact, a decrease in dietary fat consumption was demonstrated in both males and females[3]. Although other nutritional factors, such as dietary constituents and consumption of nutritionally poor and energy-dense foods, do play a role, the most probable cause for the juvenile obesity epidemic is related to the decline in habitual physical activity and energy expenditure[4].

Childhood obesity is associated with increased risk of hyperlipidemia, hypertension, insulin resistance, diabetes mellitus and arteriosclerosis later in life[5,6]. Long-term follow-up indicates that obese children and adolescents tend to become obese adults[7], and that adults who were obese children have increased morbidity and mortality rates independent of their adult weight[8]. Consequently, prevention and treatment of obesity must start during childhood.

We previously reported the favorable immediate and long-term effects of a structured multidisciplinary *after-school* intervention (nutritional, behavioral, exercise) on body mass index (BMI) and physical fitness in obese children and adolescents[9-11]. However, such interventions for the treatment of childhood obesity may not be generalized and affect only a fraction of the obese child population. Moreover, these programs were designed for children ages 6 years and above.

In view of the fact that the roots of obesity begin earlier in children's lives, the aim of the present study was to examine the prevalence of obesity among preschool children and to study prospectively the effects of a brief 14-week *school-based* health promotion intervention on body weight, BMI, BMI percentile, body composition, habitual physical activity and fitness in Israeli preschool children.

CHILDREN AND METHODS

One hundred and one healthy preschool children (ages 5-6 years) participated in the study. The study was approved by the institutional review board of Meir General Hospital, and the Israeli Ministry of Education. Children were included after their parents signed an informed consent form.

The study included all four preschool classes in the community of Oranit, Israel, an upper-middle socio-economic status community. The four preschool classes were randomly assigned to participate in the 4-month combined nutritional and physical activity intervention or to serve as controls (two preschool classes in each group). Seven parents did not sign the consent form and their children were not included in the study. Therefore, 54 children from the intervention group and 47 children from the control group started the program. No dropouts occurred during the intervention period. Measurements were performed in both groups at the beginning and at the end of the 4-month program.

Intervention design

A group that included pediatricians, a registered dietitian, an exercise physiologist, youth exercise coaches and the preschool staff designed the intervention protocol. The major challenge was to ensure the transferability of the intervention, so that if successful, it would be possible and cost effective to apply it in a large number of preschools.

The intervention group preschool teachers were instructed so that all the nutritional aspects of the intervention and the majority of exercise classes were performed by the preschool staff (i.e. teacher and assistant teacher). Adherence to the program was followed by the registered dietitian and by the youth exercise coaches team. Control group participants continued the regular preschool schedule.

Parents of both the intervention and control groups were invited for two orientation lectures (childhood obesity and beneficial effects of exercise in children) during the first 2 months of the program. The lectures were given by the physicians who followed the program.

Nutritional intervention

The nutritional intervention was designed mainly to improve nutritional education. The intervention consisted of integrating into the current curriculum nutritional topics, such as basic knowledge about major food groups and the food pyramid, what are vitamins?, food choices, food preparation and cooking methods, fast-food versus home cooking, and drinking and eating habits. The topics were taught through short lectures/talks, games and book reading.

In addition, children received dietary information using working sheets/flyers on important nutritional issues, such as what do popular Israeli foods contain?, fruits and vegetables, what is calcium and why is it important, special dietary consideration during holidays, and how to deal with food during celebrations, vacations, restaurants, etc. All topics were prepared with the preschool teachers and made appropriate for the cognitive and social developmental levels of preschool children.

Physical activity program

All intervention children participated in a 45 minutes per day exercise training (six days/week). Twice a week the training was directed by a professional youth coach. During the rest of the week physical activity was coordinated by the preschool teacher and/or her assistant. During these days the training was divided into three 15 minute sessions. The physical activity sessions were performed indoors and/or outdoors, and were based on circuit training. The activities were designed to mimic the type and intensity of exercise that preschool children normally perform. These activities varied in duration and intensity, and were designed primarily as games to encourage enthusiasm and participation of the children. Endurance type activities accounted for most of the time spent in training (about 20% team sports, and 80% running games), with attention also given to coordination and flexibility skills.

Children were encouraged by the study staff to reduce sedentary activities (e.g. television viewing, video games) and to increase their after school physical activity.

Anthropometric measurements

Standard, calibrated scales and stadiometers were used to determine height, weight, and BMI (kg/m^2). Since BMI changes with age, BMI-for-age percentile was calculated according to the Center for Disease Control growth charts[12] using the following equation:

$$C = M (1 + LSZ)^2 (1/L)$$

where C represents the age (in months) adjusted percentile for a given measurement (e.g. BMI), M represents the age-related median, S represents the age-related standard deviation, L represents the age-related power in the Box-Cox transformation, and Z represents the z-score.

The age-adjusted z-score that corresponds to the exact percentile for a given measurement was calculated using the following equation:

$$Z = \frac{[(X/M)^2 L] - 1}{LS}$$

where X represents the physical measurement (e.g. weight, length, head circumference, stature or calculated BMI value) and the L, M and S values are again collected from the appropriate table corresponding to the age (in months) of the child.

Triceps and subscapular skinfold thickness was measured to the nearest 0.1 mm, using Holtain skinfold calipers (CMS weighing equipment Ltd, Crymych, UK). Measurements were made on the left side of the body. All measurements (baseline and 14 weeks) were performed by the same trained individual. Calculations of percent body fat were made using standard equations[13].

Physical activity assessment

Physical activity level was assessed using pedometers (Stepometers™). This device measures the number of steps of each individual. Physical activity was evaluated during school hours (8.00-13.00) and after school hours for three consecutive weekdays. Measurements were performed twice during the intervention, and the mean of the two measurements (six days) is presented.

Fitness assessment

Fitness was assessed using a 600-m field-test run. Participants performed the 600-m run before and at the end of the 14-week program. All children were encouraged throughout the test by the staff in order to achieve their best performance.

Statistical analysis

Two sample t-test was used to determine baseline differences between the control and intervention groups. A two-way repeated measures ANOVA was used to compare the effect on body weight, height, BMI, BMI percentiles, percent body fat, physical activity and fitness between the intervention and control groups with time serving as the within group, and intervention as the between group factor. When differences between the two groups were identified, a post hoc analysis was performed. Statistical significance was taken at $p < 0.05$. Data are presented as means ± standard error of the mean (SEM).

RESULTS

The children's characteristics are summarized in Table 1. No significant differences in age, gender, body weight and height, BMI, BMI percentiles, body fat, and fitness were found between groups prior to the combined nutritional and physical activity intervention (Table 1). The overall prevalence of overweight and obesity (BMI $>85^{th}$ percentile) among the preschool children was 22%.

TABLE 1

Baseline characteristics - no baseline differences were found between the control and intervention groups

	Control n = 47	Intervention n = 54
Gender M/F	25/22	33/21
Age (months)	67 ± 0.7	66 ± 0.6
Weight (kg)	20.0 ± 0.5	19.8 ± 0.4
Height (cm)	111.7 ± 0.8	111.9 ± 0.7
BMI (kg/m^2)	15.9 ± 0.2	15.7 ± 0.2
BMI percentile	57.7 ± 4.4	53.2 ± 4.0
Body fat (%)	17.9 ± 0.8	18.1 ± 0.8
Exercise time (sec)	253 ± 4	252 ± 6
Obese (>95th %ile)	3 (6.4%)	4 (7.4%)
Overweight (85-95th %ile)	8 (17%)	7 (13.0%)
Overall overweight	11 (23.4%)	11 (20.4%)

TABLE 2

The effect of the intervention on the study participants

	Control n = 47		Intervention n =54)	
Gender M/F	25/22		33/21	
	Pre	**Post**	**Pre**	**Post**
Age (months)	67 ± 0.7	70 ± 0.7	66 ± 0.6	69 ± 0.6
Weight (kg)	19.9 ± 0.5	20.8 ± 0.5*	19.8 ± 0.4	20.2 ± 0.5*†
Height (cm)	111.7 ± 0.8	113.1 ± 0.8*	111.9 ± 0.7	113.3 ± 0.8*
BMI (kg/m^2)	15.9 ± 0.2	16.2 ± 0.3*	15.7 ± 0.2	15.7 ± 0.2†
BMI percentile	57.1 ± 4.4	59.4 ± 4.5*	53.2 ± 4.0	50.3 ± 4.3*†
Body fat (%)	17.9 ± 0.8	18.8 ± 1.0*	18.1 ± 0.8	18.1 ± 0.8†
Exercise time (sec)	253 ± 4	259 ± 6	252 ± 6	238 ± 5*†
Obese (>95th %ile)	3 (6.4%)	5 (10.6%)	4 (7.4%)	3 (5.6%)
Overweight (85-95th %ile)	8 (17%)	6 (12.8%)	7 (13.0%)	8 (14.8%)
Overall overweight	11 (23.4%)	11(23.4%)	11 (20.4%)	11 (20.4%)

Data are presented as mean ± SEM.
* $p < 0.05$ for within group difference; † $p < 0.05$ between groups difference.

Daily physical activity was significantly greater in the intervention group compared to the control children (6,927 ± 364 vs 5,489 ± 284 steps/day, respectively; $p < 0.003$). This was due to both increased physical activity during school hours (3,104 ± 165 vs 2,365 ± 135 steps; $p < 0.001$), and due to after-school physical activity (3,822 ± 277 vs 3,123 ± 180 steps, in the intervention vs control groups, respectively; $p < 0.04$).

The effect of the intervention on body weight, body height, BMI, BMI percentiles, body fat (by skinfolds), and fitness is summarized in Table 2 and Figure 1. Following the 14-week intervention there were significant between group differences in changes in body weight, BMI, BMI percentile, body fat and fitness, demonstrating a beneficial effect of the intervention. Although the overall number of overweight children (>85th percentile) did not change in either groups (n = 11), one child in the intervention group classified at baseline as obese (>95th percentile) reduced BMI and was reclassified as overweight following the intervention. In the control group, however, two children classified as overweight at baseline increased their BMI percentile and were reclassified as obese after the 14 weeks follow-up. When we compared only the overweight and obese children from both groups (BMI >85th percentile; n = 11 in each group), there was a significant decrease in percent body fat (-0.92 ± 0.4% vs 1.8 ± 0.9%, $p < 0.02$) and improvement in fitness (-6.9 ± 4.1 vs 6.9 ± 3.1, $p < 0.018$) in the intervention compared to the control group, respectively. No adverse events were reported.

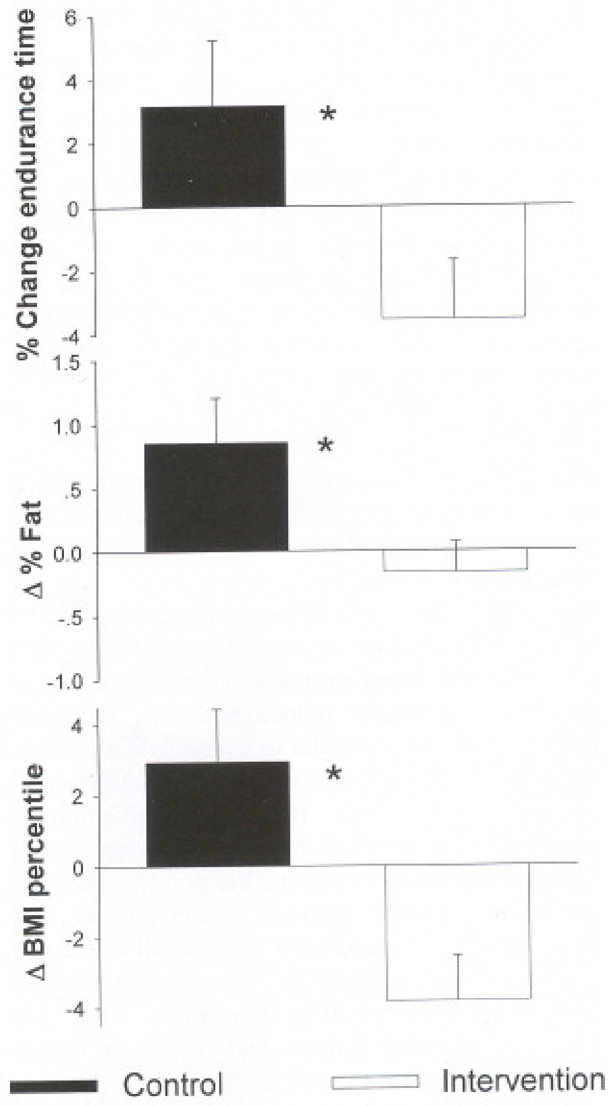

Fig. 1: BMI percentile, percent fat and fitness changes in the intervention and control groups. There was a significant between group difference in all three outcome variables (* $p < 0.05$).

DISCUSSION

Childhood obesity has gained epidemic proportions in recent years, and the prevalence of childhood and particularly adolescent obesity in Israel is among the highest compared to European countries and the USA[14]. Very few studies have examined the prevalence of childhood obesity in preschool years. Thorpe *et al.* examined the rate of obesity in New York City public elementary schools and reported an overall 48% prevalence rate of overweight (BMI 85-95th percentile) in preschool children, with 23% prevalence of obesity (BMI >95th percentile)[15]. Both African-Americans and in particular Hispanic children had significantly higher rates of obesity compared to Caucasians. The present study demonstrates an overall 22% prevalence rate of overweight, with 8% of obesity in Israeli preschool children. This is a higher proportion than the expected value of 15%, and suggests that childhood obesity is an important public health issue from very early stages of life, and that preventive and therapeutic intervention must start as early as the preschool years.

Several investigators previously reported the favorable immediate effects of structured multi-disciplinary interventions on BMI, body composition and physical fitness in obese children and adolescents[9-11,16-18]. Moreover, encouragingly, multi-disciplinary pediatric programs seem to be more successful than adult programs in maintaining these beneficial effects for 1, 5 or 10 years following the intervention[11,19,20]. However, due to the organizational complexity and the high cost, these structured multi-disciplinary interventions are feasible only for a minority of obese children, and fewer than 20% of them initiate treatment[9]. Therefore, more effective preventive and therapeutic approaches should include the development of generalizable school-based interventions. Surprisingly, very few school-based programs for the prevention and treatment of childhood obesity have been reported. These programs have been shown to decrease overweight, reduce sedentary behaviors and improve dietary intake in overweight and obese children[21,22]. A review of school-based intervention programs found that the mean reduction in percentage of overweight children was 10%[23]. Consistent with these results, the present combined nutritional-physical activity intervention was associated with a significant attenuation of the age-associated body weight, BMI and body fat increase, with a decrease in BMI percentiles, and with increased physical activity and improved fitness. Moreover, the fact that there were no dropouts of participants throughout the intervention period emphasizes the importance of school-based programs for health education and for the prevention and treatment of the childhood obesity epidemic.

It is important to note that BMI increases naturally with age. Therefore, we believe that in a growing pediatric population, a better approach for understanding the effect of longitudinal weight management program must use age-adjusted BMI percentiles, as in the present study. A significant mean difference of about 7% change in age-adjusted BMI percentiles between the control and intervention groups is clinically important. The overall number of obese children did not change following the intervention. However, some of the children with obesity (BMI >95th percentile) in the intervention group were reclassified as overweight (BMI 85-95th percentile). Moreover, since obesity is frequently complicated by insulin resistance, abnormal lipid profile and hypertension[24], many of these associated complications may be reversed after such a decrease in age-adjusted BMI percentiles[25]. We can only speculate that the changes in body composition have a beneficial effect on health even though the increase in muscle mass probably attenuated the decrease in weight or BMI percentile. Unfortunately, the effect of the intervention on obesity-related complications was not tested in the present study.

Today's children's sedentary lifestyle, and the increased inactivity in Western societies, is a major contributor to the increased prevalence of childhood obesity[26,27]. Therefore, physical activity was a major focus of our intervention. The significant increase in daily physical activity in the intervention group during both school and after-school hours indicates that our goal was achieved. This increase led to a significant improvement in fitness in the intervention participants. The fact that after-school physical activity was also increased is encouraging, since it suggests that the children (or their parents) assimilated the importance of habitual physical activity. These results are consistent with the recent recommendations of Datar *et al.* that expanding physical education instruction time in kindergarten children to at least 5 hours of physical activity per week (close to the recommended levels, and to the amount of physical activity performed in the present study) could markedly reduce the prevalence of childhood overweight and obesity, predominantly in girls[28]. Improved physical fitness might be very important because in addition to its effect on weight loss, it can have other beneficial health effects, such as increased insulin sensitivity, improved lipid profile, decreased blood pressure and reduced risk of coronary heart disease later in life[29], as well as beneficial psychosocial effects.

Finally, the positive effects of our brief school-based combined nutritional-physical activity intervention on body weight, BMI percentiles, body fat, physical activity, and fitness are especially encouraging since the program was delivered mainly by the preschool staff, and not by external professional personnel. Moreover, the program was incorporated into the existing preschool core curriculum, and did not require major investment of time or expenses.

This program may serve as an effective model and preventive strategy for the nationwide campaign against sedentary lifestyle, inactivity and overweight in preschools and elementary schools. Further studies are needed to assess the relative contribution of exercise versus diet to the positive effects on body weight and body composition. The long-term effects of this intervention are yet to be elucidated.

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REFERENCES

1. Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. Arch Pediatr Adolesc Med 1995; 149: 1085-1091.
2. Clement K, Ferre P. Genetics and the pathophysiology of obesity. Pediatr Res 2003; 53: 721-725.
3. Troiano RP, Briefel RR, Carroll MD, Bialostosky K. Energy and fat intakes of children and adolescents in the United States: data from the National Health and Nutrition Examination Surveys. Am J Clin Nutr 2000; 72 (Suppl): 1343S-1353S.
4. Bar-Or O, Foreyt J, Bouchard C, Brownell KD, Dietz WH, Ravussin E, Salbe AD, Schwenger S, St Jeor S, Torun B. Physical activity, genetic, and nutritional considerations in childhood weight management. Med Sci Sports Exerc 1998; 30: 2-10.
5. Mossberg HO. 40-year follow-up of overweight children. Lancet 1989; ii: 491-493.
6. Berenson GS, Srinivasan SR, Bao W, Newman WP III, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med 1998; 338: 1650-1656.
7. 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.
8. 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.
9. Eliakim A, Kaven G, Berger I, Friedland O, Wolach B, Nemet D. The effect of a combined intervention on body mass index and fitness in obese children and adolescents - a clinical experience. Eur J Pediatr 2002; 161: 449-454.
10. Eliakim A, Friedland O, Kowen G, Wolach B, Nemet D. Parental obesity and higher pre-intervention BMI reduce the likelihood of a multidisciplinary childhood obesity program to succeed - a clinical observation. J Pediatr Endocrinol Metab 2004; 17: 1055-1061.
11. Nemet D, Barkan S, Epstein Y, Friedland O, Kowen G, Eliakim A. Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity. Pediatrics 2005; 115: e443-449.
12. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF, Johnson CL. 2000 CDC Growth Charts for the United States: methods and development. Vital Health Stat 11 2002; 246: 1-190.
13. Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Van Loan MD, Bemben DA. Skinfold equations for estimation of body fatness in children and youth. Hum Biol 1988; 60: 709-723.
14. Lissau I, Overpeck MD, Ruan WJ, Due P, Holstein BE, Hediger ML. Body mass index and overweight in adolescents in 13 European countries, Israel, and the United States. Arch Pediatr Adolesc Med 2004; 158: 27-33.
15. Thorpe LE, List DG, Marx T, May L, Helgerson SD, Frieden TR. Childhood obesity in New York City elementary school students. Am J Public Health 2004; 94: 1496-1500.
16. Maziekas MT, LeMura LM, Stoddard NM, Kaercher S, Martucci T. Follow up exercise studies in paediatric obesity: implications for long term effectiveness. Br J Sports Med 2003; 37: 425-429.
17. Epstein LH, Wing RR, Penner BC, Kress MJ. Effect of diet and controlled exercise on weight loss in obese children. J Pediatr 1985; 107: 358-361.
18. Sothern MS, Udall JN Jr, Suskind RM, Vargas A, Blecker U. Weight loss and growth velocity in obese children after very low calorie diet, exercise, and behavior modification. Acta Paediatr 2000; 89: 1036-1043.

19. Epstein LH, Valoski AM, Kalarchian MA, McCurley J. Do children lose and maintain weight easier than adults: a comparison of child and parent weight changes from six months to ten years. Obes Res 1995; 3: 411-417.
20. Epstein LH. Methodological issues and ten-year outcomes for obese children. Ann NY Acad Sci 1993; 699: 237-249.
21. Gortmaker SL, Peterson K, Wiecha J. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. Arch Pediatr Adolesc Med 1999; 153: 409-418.
22. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. JAMA 1999; 282: 1561-1567.
23. Story M. School-based approaches for preventing and treating obesity. Int J Obes Relat Metab Disord 1999; 23 (Suppl 2): S43-S51.
24. Steinberger J, Daniels SR. Obesity, insulin resistance, diabetes, and cardiovascular risk in children: an American Heart Association scientific statement from the Atherosclerosis, Hypertension, and Obesity in the Young Committee (Council on Cardiovascular Disease in the Young) and the Diabetes Committee (Council on Nutrition, Physical Activity, and Metabolism). Circulation 2003; 107: 1448-1453.
25. Reinehr T, Andler W. Changes in the atherogenic risk factor profile according to degree of weight loss. Arch Dis Child 2004; 89: 419-422.
26. Sothern MS. Obesity prevention in children: physical activity and nutrition. Nutrition 2004; 20: 704-708.
27. Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord 2004; 28: 1238-1246.
28. Datar A, Sturm R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. Am J Public Health 2004; 94: 1501-1506.
29. Carnethon MR, Gidding SS, Nehgme R, Sidney S, Jacobs DR Jr, Liu K. Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. JAMA 2003; 290: 3092-3100.