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ORIGINAL RESEARCH

The effects of an 8-week multicomponent inpatient treatment program on body composition and anaerobic fitness in overweight and obese children and adolescents

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Background: High intensity exercise is considered as an effective means for reducing body fat. The aims of the present study were to investigate (1) whether body mass would be lost and body composition would change and (2) whether variables of anaerobic fitness prior to the intervention period would be related to loss of body mass and changes in body composition in overweight and obese children and adolescents.

Methods: A total of 28 children and adolescents (19 boys, 9 girls) attended an 8-week multicomponent inpatient program. Caloric intake was based on the subject's weight and a daily energy deficit of ~500 kcal was targeted. At the beginning and at the end of the program, variables of anaerobic fitness were assessed using Wingate tests. Body composition was measured before and after the program using dual-energy X-ray absorptiometry.

Results: Body mass decreased by 11.4% ± 1.6% in boys and by 11.0% ± 2.8% in girls ($P < 0.001$). Fat mass decreased by 23.8% ± 6.1% in boys and by 21.5% ± 5.2% in girls ($P < 0.001$). The decrease in fat mass was associated with the decrease in body mass in boys ($r = 0.54$, $P = 0.017$) but not in girls ($P > 0.05$). The decrease in body mass and the decrease in fat mass were neither associated with overall energy expenditure nor with the energy deficit in both genders ($P > 0.05$). Mean power in W/kg increased in the Wingate tests by 95.4% ± 109.1% in boys and by 100.0% ± 119.9% in girls ($P < 0.001$).

Conclusions: Adjustments of the chronically positive imbalance of energy intake and energy expenditure of obese children and adolescents living in obesogenic environments should be addressed in a multisectoral approach. Future research in multicomponent childhood and adolescent weight loss programs should be directed towards a better understanding of the underlying complex dynamics in energy homeostasis which promote weight loss and changes in body composition due to high intensity exercise interventions.

Keywords: obesity, dual-energy X-ray absorptiometry, Wingate test, training, diet

Introduction

Pediatric obesity has not only become a global epidemic with a major impact on children and their parents[1] but it has also turned into a burden to national health systems.[1,2] Obesity in children is a severe medical condition associated with comorbidities such as hypertension, dyslipidemia, hyperinsulinemia, type 2 diabetes, respiratory insufficiency such as sleep apnea syndrome and asthma, orthopedic complications, and a reduced quality of life in general.[3] Weight status tracks with age and the risk of an overweight child becoming an obese adult also rises with age.[4]

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Effective weight management in overweight and obesity includes prevention, weight maintenance, management of comorbidities, and weight loss.[5] These components should be a part of an integrated, multisectoral approach which comprises environmental support for healthy diets and regular physical activity alongside a reduction in sedentary activity and behavior modification.[5,6] Until recently, low-to-moderate intensity aerobic exercise protocols have been applied in weight loss programs for obese children and adults.[7,8] However, a growing body of evidence suggests that high intensity exercise has the potential to be an economical and effective means for reducing fat mass of overweight individuals.[9] High intensity exercise provides more potent metabolic stimuli than low-to-moderate intensity exercise leading to increased lactate and catecholamine levels.[10] The high levels of catecholamines produced by high intensity exercise may underlie its ability to reduce visceral fat, as catecholamines have been shown to drive lipolysis and are mainly responsible for fat release from visceral fat stores. Also significantly, more β-adrenergic receptors have been found in visceral compared to subcutaneous fat, suggesting that high intensity exercise may have greater potential than steady-state exercise to reduce visceral fat.[20] Insulin sensitivity index, resting fat oxidation rate in the fasted state, and systolic blood pressure are improved 24 hours post Wingate anaerobic sprints.[11] Waist and hip circumferences decrease significantly.[11] Changes in specific metabolic pathways associated with glycolysis, aerobic metabolism, ß-oxidation, and mitochondrial biogenesis are greater after high intensity exercise than after traditional low-to-moderate intensity aerobic conditioning.[12] The obese individual's physical ability and mental strength to exercise at high intensities may thus be also a key element for success in a weight loss program consisting mainly of low to moderate intensity exercise interventions. Assessed peak power values (eg, mean power values, anaerobic capacity values, and fatigue index) can be used to interpret the overweight and obese patients' anaerobic abilities. In summary, chronic exposure to high intensity exercise results in significant increases in aerobic and anaerobic fitness, increased skeletal muscle capacity for fatty acid oxidation and glycolytic enzyme content, and increased insulin sensitivity.[9]

Most treatment studies for overweight and obese children and adolescents are based on outpatient treatment programs because of the significantly higher costs of better controlled inpatient settings.[3,13] A number of studies indicated a greater weight loss, a loss of fat mass, and a preservation of lean body mass in multicomponent inpatient intervention modalities including dietary restriction, regular physical activity, and behavioral modification.[3,14,15] A multicomponent inpatient treatment program for several months is a valuable option for obese children.[3,16] Several studies confirmed the success of such intervention strategies in reducing body weight and fat mass and improving physical fitness at the same time.[3,14,15] Loss of body mass and changes in body composition in the course of an 8-week multicomponent inpatient treatment program for overweight and obese class I–III children and adolescents and possible relations to the subject's initially assessed anaerobic fitness shall be identified since the effect of a multicomponent inpatient treatment program on anaerobic fitness and performance has not been investigated.

The aims of the present study were to investigate (1) whether body mass would be lost and body composition would change and (2) whether variables of anaerobic fitness of overweight and obese class I–III children and adolescents prior to the intervention period would be related to loss of body mass and changes in body composition. We hypothesized that body mass would be lost and body composition would change and that these losses and changes would be related to anaerobic fitness prior to the intervention period.

Subjects and methods

Subjects

From an initial total of 122 subjects, 28 (19 boys, 9 girls) overweight and obese class I–III (mean body mass index of 32.5 ± 4.8 kg/m^2 for boys and 35.1 ± 8.6 kg/m^2 for girls) children and adolescents who provided a full and complete set of data were included in the study. They all attended the 8-week multidisciplinary inpatient obesity program at the Alpine Children's Hospital in Davos, Switzerland. Age and anthropometric characteristics of the subjects are presented in Table 1. The study participants were recruited from referrals to the 8-week weight loss program by general pediatricians throughout Switzerland for the treatment of obesity. Exclusion criteria included secondary obesity and underlying disease. Subjects and their parents or caregivers provided written informed consent. Ethical approval was obtained from the Graubünden cantonal ethics commission in Chur, Switzerland.

Table 1 Age and anthropometric characteristics of the subjects

	Girls (n = 9)	Boys (n = 19)
Age (years)	15.1 ± 1.5	13.8 ± 1.8
Body mass (kg)	93.7 ± 19.4	92.1 ± 16.8
Body mass index (kg/m^2)	35.1 ± 8.6	32.5 ± 4.8
Percent body fat (%)	48.3 ± 5.3	45.5 ± 4.3

Note: Values are mean ± standard deviation.

Anthropometric measurements

Body mass was registered every morning, with the child wearing light clothing and no shoes using a digital balance scale (Seca® Model 910; Seca Medizinische Waagen und Messsysteme, Hamburg, Germany) to the nearest 0.1 kg. Body height was measured at the beginning and the end of the program to the nearest 0.5 mm, using a wall-mounted stadiometer (Seca®; Seca Medizinische Waagen und Messsysteme). Body mass index (kg/m^2) was calculated using body mass in kilograms divided by body height in meters squared (m^2). Percent body fat, lean body mass, and fat mass were measured at the beginning and the end of the study (week 1 and then again at week 8) using dual-energy X-ray absorption, (Lunar Prodigy® Model 8743; General Electric Company, Fairfield, CT, USA).

Nutritional intervention and physical activity program

Based on a 3-day food record, a nutritionist performed a qualitative and quantitative analysis of the child's/adolescent's food intake. The caloric intake was based on the subject's weight at entry into the program. Children/adolescents of 50 kg to 80 kg received ~1400 kcal/day and subjects over 80 kg received ~1600 kcal/day. The macronutrient composition of the diet was based on the recommendations of the healthy food pyramid and consisted of: 55%–60% carbohydrates, 25%–30% fat, and 15%–20% protein, distributed as five regular meals per day. Low/non-calorie drinks such as water or sugarless tea were unrestricted.[3] All patients received an individually adapted physical activity program with the aim of supporting weight reduction and motivating them to include physical activity as part of their daily routine, and encouraging them to maintain an active lifestyle on a long-term basis. The daily exercise program included two sessions, and focused on endurance type activities to improve aerobic performance. Attention was also focused on physical coordination and flexibility skills. A typical exercise session lasted 60–90 minutes, was performed in groups, and was supervised by exercise therapists: for example, in summertime, 4-km walks or ball games (basketball, hockey, soccer, and handball); in wintertime, indoor swimming plus water games, ice activities, or snowboarding and an activity once per week that involved 4–5 hours of either hiking (in summertime), or 4–5 h of downhill skiing or snow shoe walking (in wintertime). Other activities included ergometric cycling and strength training. Over the weekends, patients performed at least 60 minutes of supervised ergometric cycling per day and other activities in their free time. Exercise sessions were controlled by a specified heart rate (50%–75% of maximal heart rate) with heart rate monitors (Polar® S610i; Polar Electro Oy, Kempele, Finland). A daily energy deficit of ~500 kcal was targeted in coordination with the individually adapted physical activity program.[3]

Anaerobic exercise testing

At the beginning and at the end of the 8-week multidisciplinary inpatient obesity program, peak mechanical power (W), Peak P-20 (W/kg body mass), mean power (W), mean power/kg body mass (W/kg), minimum power (W), minimum power/kg body mass (W), work (J), work/kg body mass (J/kg), time to peak (seconds), and Fatigue Index (W/second) were assessed by performing a Wingate-20-Seconds anaerobic test using a magnetically braked cycle ergometer (Ergoline® ergometrics 900; Ergoline GmbH, Bitz, Germany). Prior to testing, subjects were familiarized with the test procedure. Before each test session, the cycle ergometer was adjusted individually, including height of the seat and the handlebars; seat locations were kept constant throughout the study. Throughout the testing session the patient was verbally encouraged by the staff to achieve maximal effort. The Wingate-20-Seconds anaerobic test is a valid and reliable method of assessing a subject's anaerobic capacity and power.[17,18] It is characterized by the maximum power output of the lower extremities. A maximum cadence at a preset break factor has to be reached and maintained. The time needed to reach the maximum output and the drop of power during the initial 20 seconds are measured.[17,18] The protocol of the Wingate-20-Seconds anaerobic test consisted of a 5 minute warm up at 1 W/kg body mass at 60 rpm, followed by a pretest of 6 seconds all-out. After a break of 3–5 minutes and a short rest period of up to 60 seconds and 2–3 minutes of activity at 1 W/kg body mass at 60 rpm the actual Wingate-20-Seconds anaerobic test was carried out. Body mass was entered according to the measurements made during the initial test. The break factor was adjusted according to the Lode factory settings, 0.55 for boys $<$ 14 years, 0.70 for boys $>$ 14 years, 0.53 for girls $<$ 14 years, and 0.67 for girls $>$ 14 years.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics (Version 19; IBM Corporation, Armonk, NY, USA). Results were checked for normal distribution and presented as mean ± standard deviation. Results before the intervention and after the intervention were compared using paired *t*-tests. Potential correlations between changes in variables were investigated using Pearson correlation. Significance was

Table 2 Changes in body mass and body composition for boys (n = 19)

Variable	Pre	Post	Absolute change	Percentage change	Significance
Body mass (kg)	92.1 ± 16.8	81.6 ± 15.2	–10.5 ± 2.3	–11.4 ± 1.6	***
Fat mass (kg)	40.9 ± 8.5	31.5 ± 8.1	–9.4 ± 1.8	–23.8 ± 6.1	***
Lean body mass (kg)	48.7 ± 9.3	47.5 ± 8.9	–1.2 ± 1.5	–2.3 ± 3.0	**

Notes: Values are mean ± standard deviation. **$P < 0.01$; ***$P < 0.001$.

accepted at $P < 0.05$ (two-sided for *t*-tests). Data in the text are given as mean ± standard deviation. A power calculation was performed according to Gatsonis and Sampson.[19] To achieve a power of 80% (two-sided Type I error of 5%) to detect a minimal association between performance and anthropometric characteristics of 20% (ie, coefficient of determination $r^2 = 0.2$) a sample of 40 participants was required.

Results

Energy intake and energy expenditure

During the 8-week program, boys consumed 86,063 ± 5348 kcal and expended 114,063 ± 5348 kcal. Girls consumed 85,866 ± 5600 kcal and expended 113,866 ± 5600 kcal. This resulted in an energy deficit of ~28,000 kcal for each subject.

Changes in body composition

Body mass, fat mass and lean body mass decreased in both boys (Table 2) and girls (Table 3).

For boys, the decrease in fat mass was associated with the decrease in body mass ($r = 0.54$, $P = 0.017$). In girls however, the decrease in fat mass was not associated with the decrease in body mass ($r = 0.18$, $P = 0.64$). Regarding the changes in lean body mass, no association was found between the decrease in body mass and the decrease in lean body mass in boys ($r = 0.30$, $P > 0.05$). In girls, the decrease in body mass and the decrease in lean body mass were associated ($r = 0.68$, $P < 0.05$). For boys, both the decrease in body mass ($r = –0.31$) and the decrease in fat mass ($r = 0.21$) were neither associated with the overall energy expenditure ($P > 0.05$) nor with the energy deficit during the 8-week program ($P > 0.05$). Also for girls, both the decrease in body mass ($r = –0.63$) and the decrease in fat mass ($r = –0.20$) were neither associated with the overall energy expenditure ($P > 0.05$) nor with the energy deficit during the 8-week program ($P > 0.05$). In boys, body mass ($r = 0.73$, $P < 0.01$) and lean body mass ($r = 0.85$, $P < 0.001$) before the interventions were associated with peak power. For girls, body mass ($r = 0.73$, $P < 0.05$) and lean body mass ($r = 0.75$, $P < 0.05$) were associated with peak power.

Changes in performance

Improvements in mean power (W/kg) were highly significant ($P < 0.001$) for both boys (Table 4) and girls (Table 5) expressed in absolute terms and in percent. Boys showed a highly significant change ($P < 0.001$) in minimum power (W). The increase in minimum power (W/kg) was significant in both genders; highly significant ($P < 0.001$) for boys and significant ($P < 0.05$) to a lesser degree for girls. Peak power in absolute terms did not change significantly in both genders. The pre/post change in work (J/kg) was significant ($P < 0.05$) for girls, and the percentage peak 20 (W/kg) improvement was significant ($P < 0.05$) for boys. The decrease in body mass showed no association with the improvement in mean power for both boys ($r = –0.27$) and girls ($r = –0.19$) ($P > 0.05$).

Anaerobic fitness and changes in body mass and body composition

Tables 6 and 7 illustrate the correlations of the variables of anaerobic fitness prior to the intervention and changes in body composition in the course of the program. Statistical significance was only reached in the correlation of relative mean power prior to the intervention ($r = –0.79$, $P < 0.05$) and loss of fat mass in girls. Correlations of peak power in W/kg and mean power in W/kg before the intervention program with delta% body mass, delta% fat mass, and delta% lean body

Table 3 Changes in body mass and body composition for girls (n = 9)

Variable	Pre	Post	Absolute change	Percentage change	Significance
Body mass (kg)	93.7 ± 19.4	83.0 ± 14.8	–10.7 ± 4.8	–11.0 ± 2.8	***
Fat mass (kg)	44.3 ± 13.2	34.9 ± 11.7	–9.3 ± 2.6	–21.5 ± 5.2	***
Lean body mass (kg)	47.8 ± 8.8	45.3 ± 7.4	–2.5 ± 4.5	–4.5 ± 8.7	

Notes: Values are mean ± standard deviation. ***$P < 0.001$.

Table 4 Changes in performance variables for boys (n = 19)

Variable	Pre	Post	Absolute change	Percentage change	Significance
Peak power (W)	652.8 ± 174.6	625.3 ± 186.8	–28.2 ± 98.1	–3.71 ± 4.6	
Peak 20 (W/kg)	7.2 ± 1.4	7.8 ± 1.4	0.6 ± 1.2	7.2 ± 1.4	*
Mean power (W)	456.9 ± 132.8	467.0 ± 167.5	10.1 ± 91.4	2.7 ± 23.7	
Mean power (W/kg)	3.4 ± 1.1	5.9 ± 1.4	2.5 ± 1.3	95.4 ± 109.1	***
Minimum power (W)	305.9 ± 115.5	326.6 ± 196.0	20.7 ± 44.8	16.6 ± 81.9	***
Minimum power (W/kg)	3.5 ± 1.1	4.1 ± 1.9	0.6 ± 1.8	34.4 ± 104.3	***
Work (J)	9137.9 ± 2656.4	8707.4 ± 2887.1	–430.5 ± 2,634.2	–1.8 ± 27.5	
Work (J/kg)	101.0 ± 23.5	136.9 ± 121.4	35.9 ± 120.9	39.4 ± 120.1	
Time to peak (seconds)	2.2 ± 1.5	2.8 ± 1.8	0.6 ± 1.5	76.0 ± 176.6	
Fatigue index (W/second)	22.7 ± 10.9	18.6 ± 7.7	–4.1 ± 9.8	–5.3 ± 45.9	

Notes: Values are mean ± standard deviation. $^*P < 0.05$; $^{***}P < 0.001$.

mass in did not reach statistical significance in both genders with the previously mentioned exception.

Discussion

Body mass, fat mass, and lean body mass decreased in both boys and girls as hypothesized.

Weight loss per week was greater than generally recommended for outpatient treatment programs (0.25 to 0.50 kg/week). This can be partly explained by the intensive exercise program and the relatively low daily energy expenditure. Loss of fat free mass is most likely attributed to the restricted energy intake.[3] For boys, the decrease in fat mass was associated with the decrease in body mass. In girls, however, the decrease in fat mass was not associated with the decrease in body mass. A definitive explanation for this difference cannot be given. Gender specific patterns regarding changes in body composition between girls and boys in the course of the program may be involved.

An important finding in this study was that anaerobic fitness of overweight and obese class I–III children and adolescents prior to the intervention period was not related to loss of body mass and changes in body composition. Only relative mean power was associated with the loss of fat mass in girls. This finding is in contrast with other studies, suggesting that subjects in good anaerobic fitness are more likely to lose weight and fat mass and to preserve lean body mass.[9,20]

The fact that only in girls mean power in W/kg was negatively correlated to loss of fat mass was surprising as both genders showed highly significant pre/post improvements in anaerobic fitness. The loss of lean body mass in relative terms was twice as high in boys as in girls. However, when expressed in absolute terms these losses were very small in both genders, an intended consequence of the subjects' regular physical activity during the program.

Another main finding was that the decrease in body mass and fat mass were neither associated with the overall energy expenditure nor with the energy deficit during the 8-week program in both girls and boys. This finding incorporates and confirms the separate observations of previous investigators.[21,22] Numerous acute responses and chronic metabolic adaptions to the dietary intervention and the physical activity program may be involved, including compensatory changes in resting and non-resting energy expenditure as well as sleeping and sedentary activity lipid

Table 5 Changes in performance variables for girls (n = 9)

Variable	Pre	Post	Absolute change	Percentage change	Significance
Peak power (W)	640.9 ± 183.1	644.2 ± 189.1	3.3 ± 75.7	1.4 ± 12.9	
Peak 20 (W/kg)	6.9 ± 1.4	7.8 ± 1.8	0.9 ± 1.1	12.8 ± 15.8	
Mean power (W)	436.4 ± 129.7	435.4 ± 119.6	–1.0 ± 43.8	–1.2 ± 10.8	
Mean power (W/kg)	3.4 ± 1.4	5.6 ± 1.5	2.2 ± 0.8	100.0 ± 119.9	***
Minimum power (W)	303.6 ± 109.7	328.4 ± 74.7	24.8 ± 64.4	25.2 ± 63.2	
Minimum power (W/kg)	3.4 ± 1.4	4.0 ± 1.2	0.6 ± 0.5	39.6 ± 71.6	*
Work (J)	8728.9 ± 2593.9	8708.6 ± 2392.6	–20.0 ± 876.6	–1.2 ± 10.8	
Work (J/kg)	96.7 ± 29.5	107.3 ± 31.3	10.6 ± 11.4	12.8 ± 13.2	*
Time to peak (seconds)	2.8 ± 1.5	2.9 ± 2.0	1.0 ± 0.8	10.4 ± 44.6	
Fatigue index (W/second)	20.9 ± 9.3	20.3 ± 8.9	–0.6 ± 5.9	–1.9 ± 28.1	

Notes: Values are mean ± standard deviation. $^*P < 0.05$; $^{***}P < 0.001$.

Table 6 Correlations of variables of anaerobic fitness prior to the intervention to changes in body composition for boys (n = 19)

Variable	Delta% body mass	Delta% fat mass	Delta% lean body mass
Peak power in W/kg pre	r = 0.11	r = −0.13	r = 0.05
Mean power in W/kg pre	r = 0.06	r = −0.21	r = 0.14

oxidation rates.[23,24] The improved satiety response to a meal and the also enhanced sensitivity of appetite control could be factors that should be considered.[25] Moreover, recent research indicated that the macronutrient content of the energy-restricted diet might influence body compositional alterations following exercise regimens.[26] Providing adequate amounts of protein during weight loss may be especially important in preserving lean body mass.[27]

Another factor that should be considered is the weight loss due to the loss of water. The depletion of water binding glycogen stores has a significant effect on the apparent weight lost and the degree of recidivism after a period of dieting.[28] Fluid balance changes can thus dissociate the relationship between body mass and energy balance.[29] Uncoupled respiration, protein turnover, and sympathetic nervous system activity may also contribute to increased energy expenditure and fat oxidation after exercise.[20]

The highly significant changes in body composition for boys and girls were in line with the literature.[14,15] Weight loss was mainly attributed to loss of fat mass. As there are likely to be responders and non-responders in every exercise, a fat loss trial calculating mean fat loss alone hides the significant fat loss achieved by some individuals. Thus, it is feasible that high intensity fat loss programs are effective for producing a clinical decrease in fat (greater than 6% of fat mass).[9] Lean body mass was preserved to a large degree in both genders due to the exercise interventions.

The improvements in anaerobic fitness when expressed in relative terms were impressive for both boys and girls. For instance, subjects kept their absolute mean power almost constant pre/post but lost a highly significant amount of weight (boys: −11.4% ± 1.6%, $P < 0.001$; girls: −11.0% ± 2.8%, $P < 0.001$) during the intervention. This resulted in also highly significant improvements (boys: 95.4% ± 109.1%, $P < 0.001$; girls: 100.0% ± 119.9%, $P < 0.001$) when expressed in relative figures. Peak power in absolute terms did not change significantly, but as with absolute mean power, relative mean power increased due to the loss of weight. In addition to metabolic adaptions, the improvements can also be partly explained by the acquisition of a certain degree of motor skillfulness.[30] Moreover it is very likely that the sedentary subjects gained confidence in their bodies' abilities during the program. Thus psychological factors may also play a role in the explanation of the enhanced performance.

Table 7 Correlations of variables of anaerobic fitness prior to the intervention to changes in body composition for girls (n = 9)

Variable	Delta% body mass	Delta% fat mass	Delta% lean body mass
Peak power in W/kg pre	r = −0.61	r = −0.44	r = −0.19
Mean power in W/kg pre	r = −0.12	r = −0.79*	r = 0.26

Note: *$P < 0.05$.

The effectiveness of inpatient weight reduction programs seems to be undisputed and can be mainly explained by compliance.[31] However, very limited evidence suggests that these improvements can be maintained over the 12 months following the end of treatment.[32] The amount of absolute or relative weight change associated with behavioral interventions in these settings is generally modest and varies by intervention intensity and setting.[32]

The quality of the anthropometric data collected throughout the program, including the assessment of the subjects' body composition by using the current gold standard dual-energy X-ray absorption, is a main strength of our study. A limitation of our study lies in the Wingate protocol itself. It is very short in duration, but highly demanding nonetheless, as unfit overweight and obese sedentary subjects have to tolerate substantial exercise-induced pain. It is therefore possible that some of the subjects did not go to their very limits, resulting in data of reduced significance. Furthermore, the measurements of dietary intake and energy expenditure are based on potentially error prone reports and calculations. The subject's intake of medications was not assessed. Puberty status and menstrual cycle (if applicable) remained unregarded. Moreover, due to incomplete data in energy intake and training, the number of subjects was reduced from an initial pool of 122 to a total of 28 (9 girls, 19 boys).

Conclusion

Adjustments of the chronically positive imbalance of energy intake and energy expenditure of obese children and adolescents living in obesogenic environments should be addressed in a multisectoral approach. Future research in multicomponent childhood and adolescent weight loss programs should be directed towards a better understanding of the underlying complex dynamics in energy homeostasis which promote weight loss and changes in body composition due to high intensity exercise interventions.

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Disclosure

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References

1. World Health Organisation. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser*. 2000;894:i–xii, 1–253.
2. Spruijt-Metz D. Etiology, treatment and prevention of obesity in childhood and adolescence: a decade in review. *J Res Adolesc*. 2011;21(1):129–152.
3. Knöpfli BH, Radtke T, Lehmann M, et al. Effects of a multidisciplinary inpatient intervention on body composition, aerobic fitness, and quality of life in severely obese girls and boys. *J Adolesc Health*. 2008;42(2):119–127.
4. Field AE, Cook NR, Gillman MW. Weight status in childhood as a predictor of becoming overweight or hypertensive in early adulthood. *Obes Res*. 2005;13(1):163–169.
5. World Health Organization. *Global strategy on diet, physical activity and health.* Obesity and overweight. Geneva: World Health Organization; 2003. Available from: http://www.who.int/dietphysicalactivity/media/en/gsfs_obesity.pdf. Accessed November 12, 2012.
6. Makkes S, Halberstadt J, Renders CM, Bosmans JE, van der Baan-Slootweg OH, Seidell JC. Cost-effectiveness of intensive inpatient treatments for severely obese children and adolescents in The Netherlands; a randomized controlled trial (HELIOS). *BMC Public Health*. 2011;11:518.
7. Poirier P, Després JP. Exercise in weight management of obesity. *Cardiol Clin*. 2001;19(3):459–470.
8. Lakka TA, Bouchard C. Physical activity, obesity and cardiovascular diseases. *Handb Exp Pharmacol*. 2005;170:137–163.
9. Boutcher HS. High-intensity intermittent exercise and fat loss. *J Obes*. 2011;2011:868305.
10. Trapp EG, Chisholm DJ, Boutcher SH. Metabolic response of trained and untrained woman during cycle exercise. *Am J Physiol Regul Integr Comp Physiol*. 2007;293(6):R2370–R2375.
11. Whyte LJ, Gill JM, Cathcart AJ. Effect of 2 weeks of sprint interval training on health-related outcomes in sedentary overweight/obese men. *Metabolism*. 2010;59(10):1421–1428.
12. Earnest CP. Exercise interval training: an improved stimulus for improving the physiology of pre-diabetes. *Med Hypotheses*. 2008;71(5):752–761.
13. Spear BA, Barlow SE, Ervin C, et al. Recommendations for treatment of child and adolescent overweight and obesity. *Pediatrics*. 2007;120 Suppl 4:S254–S288.
14. Deforche B, De Bourdeaudhuij I, Debode P, et al. Changes in fat mass, fat-free mass and aerobic fitness in severely obese children and adolescents following a residential treatment programme. *Eur J Pediatr*. 2003;162(9):616–622.
15. Dao HH, Frelut ML, Peres G, Bourgeois P, Navarro J. Effects of a multidisciplinary weight loss intervention on anaerobic and aerobic aptitudes in severely obese adolescents. *Int J Obes Relat Metab Disord*. 2004;28(7):870–878.
16. Braet C, Tanghe A, Bode PD, Franckx H, Winckel MV. Inpatient treatment of obese children: a multicomponent programme without stringent calorie restriction. *Eur J Pediatr*. 2003;162(6):391–396.
17. Klasnja A, Drapsin M, Lukac D, Drid P, Obadov S, Grujić N. Comparative analysis of two different methods of anaerobic capacity assessment in sedentary young men. *Vojnosanit Pregl*. 2010;67(3):220–224.
18. Bar-Or O. The Wingate anaerobic test. An update on methodology, reliability and validity. *Sports Med*. 1987;4(6):381–394.
19. Gatsonis C, Sampson AR. Multiple correlation: exact power and sample size calculations. *Psychol Bull*. 1989;106(3):516–524.
20. Heydari M, Freund J, Boutcher SH. The effect of high-intensity intermittent exercise on body composition of overweight young males. *J Obes*. 2012;2012:480467.
21. Kempen KP, Saris WH, Westerterp KR. Energy balance during an 8-wk energy-restricted diet with and without exercise in obese women. *Am J Clin Nutr*. 1995;62(4):722–729.
22. Chaput J-P, Klingenberg L, Rosenkilde M, Gilbert J-A, Tremblay A, Sjödin A. Physical activity plays an important role in body weight regulation. *J Obes*. 2011;2011:pii:360257.
23. Leibel RL, Rosenbaum M, Hirsch J. Changes in energy expenditure resulting from altered body weight. *N Engl J Med*. 1995;332(10):621–628.
24. Lazzer S, Vermorel M, Montaurier C, Meyer M, Boirie Y. Changes in adipocyte hormones and lipid oxidation associated with weight loss and regain in severely obese adolescents. *Int J Obes (Lond)*. 2005;29(10):1184–1191.
25. Martins C, Kulseng B, King NA, Holst JJ, Blundell JE. The effects of exercise-induced weight loss on appetite-related peptides and motivation to eat. *J Clin Endocrinol Metab*. 2010;95(4):1609–1616.
26. Stiegler P, Cunliffe A. The role of diet and exercise for the maintenance of fat-free mass and resting metabolic rate during weight loss. *Sports Med*. 2006;36(3):239–262.
27. Evans EM, Mojtahedi MC, Thorpe MP, Valentine RJ, Kris-Etherton PM, Layman DK. Effects of protein intake and gender on body composition changes: a randomized clinical weight loss trial. *Nutr Metab (Lond)*. 2012;9(1):55.
28. Kreitzman SN, Coxon AY, Szaz KF. Glycogen storage: illusions of easy weight loss, excessive weight regain, and distortions in estimates of body composition. *Am J Clin Nutr*. 1992;56(Suppl 1):292S–293S.
29. Pietrobelli A, Allison DB, Heshka S, et al. Sexual dimorphism in the energy content of weight change. *Int J Obes Relat Metab Disord*. 2002;26(10):1339–1348.
30. Sartorio A, Narici MV, Fumagalli E, Faglia G, Lafortuna C. Aerobic and anaerobic performance before and after a short-term body mass reduction program in obese subjects. *Diabetes Nutr Metab*. 2001;14(1):51–57.
31. Summerbell CD, Watts C, Higgins JP, Garrow JS. Randomised controlled trial of novel, simple, and well supervised weight reducing diets in outpatients. *BMJ*. 1998;317(7171):1487–1489.
32. Whitlock EP, O'Connor EA, Williams SB, Beil TL, Lutz KW. Effectiveness of weight management programs in children and adolescents. *Evid Rep Technol Assess (Full Rep)*. 2008;170:1–308.