Short Communication

# Effects of a summer program for weight management in obese children and adolescents in Shanghai

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Objective: To investigate the effects of a combined intervention of diet and physical activity on body composition, resting energy expenditure (REE) and metabolic factors in obese children and adolescents. Methods: Twenty obese children and adolescents aged 7 to 17 years completed a 4-week summer camp program which focussed on personal behaviour, including energy-restricted diets and supervised physical activity. Anthropometry, bioelectrical impedance, ultrasonography (US) for subcutaneous and hepatic fat, and abdominal Magnetic Resonance Imaging assessments were made and blood pressure (BP) recorded before and after the 4-week intervention. Results: 1) Weight loss was 7.2±2.2 kg, with losses of 5.5±2.2 kg and 1.7±1.2 kg in fat mass (FM) and fat free mass (FFM), respectively, with associated reductions in abdominal and hip fat and in the waist/hip circumference ratio and in BP. 2) There were no significant changes in REE or in its ratio with weight. 3) Reductions in uric acid, total cholesterol, triglycerides, LDL cholesterol, HbA1C, insulin, C-Peptide and insulin resistance (HOMA-IR) and the ratio of fatty liver were observed, but not in the inflammatory marker hsCRP. Conclusions: With behavioural intervention during a summer camp, body fat and its distribution were favourably changed, but with some loss of lean mass. However, there were no detectable reductions in REE. Weight management programs which achieve fat loss with maintenance of REE ought to be more sustainable.

**Key Words: weight losing summer program, obese of children and adolescents, body composition, resting energy expenditure, biochemical metabolism**

## INTRODUCTION

The increasing prevalence and complications of childhood and adolescent obesity require both more effective prevention and therapy.[1] Attention to personal behaviours, medication and surgery are among the therapeutic options. Of these, dietary and physical activity behaviours should have priority, because physical activity results in greater energy expenditure, which is not only of general health benefit but also allows the consumption of more nutritious food.[2] Weight change itself does not necessarily reflect overall health benefit. There are risks of loss of muscle mass and an associated reduction in resting energy expenditure (REE) with energy restriction as the sole intervention. Improvements in metabolic functions are usually seen with reductions in fat mass itself, however, continued behavioural intervention increases the likelihood of sustained benefits for up to 2 years.[3] There are limited data for the management of the young obese, so in 2007 we studied 20 obese children and adolescents who participated in a weight management summer camp for 4 weeks. Changes in weight, body composition, fatness and energy expenditure, blood pressure and metabolic health were evaluated.

## SUBJECTS AND METHODS

### *Subjects*

From July to August in 2007, 20 obese children and adolescents (11 boys and 9 girls) took part in a weight management summer camp in Shanghai. Their ages ranged from 7 to 17 years. The average BMI was 28.0±4.3 kg/m$^2$. For inclusion subjects satisfied the obesity diagnosis criteria was based on "Body mass index reference standards for the screening of overweight and obesity in Chinese children and adolescents" released in 2004, with cut-off points of $p(95)$ for obesity.[4] Exclusion criteria were those who suffered from endocrine, congenital metabolic or genetic diseases or took medicines which affected energy expenditure or had lost weight in the past three months whether by diet, taking weight-loss medication or more physical exercise than normal. Twenty subjects were

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Manuscript received 19 February 2013. Initial review completed 06 September 2013. Revision accepted 08 February 2014.
doi: 10.6133/apjcn.2014.23.3.02

invited to participate, were medically assessed, and informed consent provided by each individual and their parents. The study was approved by the ethics committee of Jiao Tong University, Shanghai, China.

***Obesity intervention plan***

A 4-week supervised program of an energy-restricted but nutritionally complete diet along with physical exercise was provided.

***Diet plan***

According to age, nutrient-replete and energy-restricted diets were provided, and ranged from 1338-1883 kcal/d. The energy percentages provided by protein, fat and carbohydrate were 19.4±2.4%, 20.7±3.7%, 60.0±4.4% respectively, while energy distributions at breakfast, lunch and supper were 25.4±4.6%, 42.7±5.8% and 31.8±1.9%, respectively.

***Exercise routine***

Exercise training involved four fully supervised 45-minute sessions per day with items primarily aerobic such as gymnastics, swimming, basketball playing, supplemented with interesting activities such as Nordic walking and dragon boat races. The intensity of exercise was gradually increased, with the maximal heart rate (MHR) rising from 40-50% to 60-70%.

***Measurements of various indexes***

Observations were made one week before the intervention and the second day after its completion.

***Physical examination***

Physical measurements included height, weight, waist circumference (WC), hip circumference (HC) and blood pressure. The anthropometrical examinee stood comfortably, with the distance between the two feet the same as that between the coxa, with shoulders relaxed, both upper extremities hung naturally and eyes forward. Height was measured using a wall-mounted stadiometer, with shoes and caps taken off and the back pressed against the stadiometer to read the value. WC was measured using a new plastic tape at the level of the umbilicus with subjects in the standing position. HC was measured at the point of maximum circumference over the buttocks. The blood pressure was measured using a digital electronic device (Omron HEM-759P type, Omron China Co., LTD). Each anthropometric reading was accurate to the nearest 0.1 cm, measured twice and the values averaged.

***Bioelectrical Impedance Analysis (BIA)***

Body composition was also assessed by the bioelectrical impedance method (Inbody720, from Korean Biospace Company). Bath, sauna, intense drastic exercise, and eating prior to measurement were prohibited. The bladder was empty and subjects stood quietly for 5 mins (to avoid fluid redistribution caused by postural alteration) before test and the temperature in the room was set at 20-25℃. When measured, subjects dressed in light clothing, stood on the electrode contact surface of the apparatus with bare feet, and held the electrode with arms hung naturally and the angles between both upper extremities and trunk kept at 15℃. Indices comprised body weight (Wt), body mass index (BMI), fat free mass (FFM), fat mass (FM), percent body fat (PBF), waist-hip ratio (WHR) and abdominal fat (visceral fat area, $VFA_{BIA}$)

***Ultrasonography (US)***

Sonographic measurements were performed using a B-mode ultrasound (LOGIQ500) in the supine position, with a frequency of 2-4 MHZ. Subcutaneous fat thickness was defined as the thickness of the parumbilical fat tissue between the skin-fat interface and Hunter's line. Measurements were made thrice and averaged. Screening for fatty liver was based on a B ultrasonic diagnosis according to the standards promulgated by the Chinese Medical Association (Hepatologists for fatty liver and alcoholic liver disease group, 2003).[5] All measurements were performed by the same medical technician.

***Magnatic Resonance Imaging (MRI)***

A SIGNA TWINSPEED 1.5 T (GE, America) MRI was used.[6] Subjects were supine and underwent whole-abdomen MR imaging. During scanning, the Field of View（FOV）was set as 48 cm × 48 cm, with the thickness of each section at 10 mm, and matrix at 512 × 512. Sigma Scan Pro 5 and Photoshop were used to analyze each section based on the image threshold value segmentation method and abdominal subcutaneous fat area ($SFA_{MRI}$) and visceral fat area ($VFA_{MRI}$) were calculated.

***REE measurement***

REE was measured by indirect calorimetry (USA Medical Graphics Corporation, MedGraphics). The apparatus was calibrated according to the manufacturer's directions before each test. Measurements were completed in the morning after a 12-h fast and a minimum 30-min rest period. The subjects were asked to refrain from all vigorous activity after arising and to report situations which required exclusion like any abnormal conditions such as fever, insomnia, starvation or engorgement the day before. The REE was measured in a quiet, thermoneutral (20-25 ℃) room with the subject resting comfortably in the supine position. Measurements were recorded at 1-min intervals for a minimum of 15-30 mins, and then REE was printed automatically.

***Metabolic parameters***

All subjects were requested to fast for 12 hours overnight until venous blood was taken, within 1 week before and on the first day after the 4-week intervention. Analytes measured included fasting plasma glucose (FPG), insulin, C-peptide, total cholesterol (TC), triglyceride (TG), HDL cholesterol, LDL cholesterol, uric acid (UA), glycosylated haemoglobin (HBA1C) and high-sensitivity C-reactive protein (hsCRP). At 2 hours after a standard meal, venous blood was taken for plasma glucose (2hPG), insulin (2hIns) and C-peptide (2hC-peptide). Insulin resistance was estimated according to a homeostasis model assessment (HOMA-IR, HOMA=fasting insulin (μU/mL) × fasting glucose (mmol/L)/22.5).

***Statistical analysis***

Statistical analysis was performed with the SPSS software package (version 13.0). All data were expressed as mean ± standard deviation (SD), and the paired sample T test was used to compare the measurements obtained at physical examination, with body composition, REE, and the ratios of fatty liver and various metabolic parameters before and after the intervention, with $p<0.05$ considered statistically significant.

## RESULTS

***Changes in of anthropometric characteristics and body composition***

Height increased 0.7±0.6 cm ($p<0.01$), weight decreased 7.2±2.2 kg ($p<0.01$), with 5.5±2.2 kg and 1.7±1.2 kg losses in FM and FFM respectively, amounting to 76.4% and 23.6% of the total body weight loss. Significant decreases were also observed in BMI, PBF, WC, HC and WHR (Table 1).

***Change on abdominal fat***

After the intervention of 4 weeks, the $SFT_{US}$, $VFA_{BIA}$, $SFA_{MRI}$ and $VFA_{MRI}$ were all significantly reduced, with decreases of 8.6±4.5 mm, 23.0±13.0 $cm^2$, 65.4±35.8 $cm^2$ and 22.6±8.6 $cm^2$ ($p<0.01$), respectively (Table 2).

***REE***

The before and after values of REE from 1936±789 kcal to 1902±575 kcal were not significantly different. Furthermore, the REE/BW at baseline did not differ from that after intervention (27.5±9.4 kcal . kg-1 to 29.8±6.7 kcal . kg-1 , Table 3).

***Change in metabolic parameters and in fatty liver***

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) also decreased significantly by 11.7±10.0 mmHg and 8.3±11.1 mmHg, respectively ($p<0.01$). Metabolic variables such as uric acid (UA), total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL), HBA1C, Insulin, C-Peptide, 2hC-Peptide and HOMA-IR also decreased after 4 weeks, by 78.1±68.5 umol/L, 0.9±0.6 mmol/L, 0.4±0.4 mmol/L, 1.0±0.5 mmol/L, 0.2±0.2%, 5.4±4.8 UIU/mL, 0.9±1.1 ng/mL, 3.2±4.9 ng/mL and 1.0±1.1, respectively ($p<0.01$, Table 1). In addition, the fatty liver index decreased during the intervention (65% (13/20) vs. 40% (8/20), $p=0.025$).

## DISCUSSION

Indices of obesity intervention effectiveness usually focus on weight change, which does not necessarily reflect effects on body composition or energy regulation.[7] DeStefano found that obese boys, in a 12-week exercise intervention, had little weight change yet remarkable decreases in FM, and increases in FFM and REE.[8]

In a 4-week energy-limiting nutritious diet combined with aerobic exercise, weight loss mainly resulted from body fat loss. The indices that reflected fat mass and distribution such as FM, PBF, WC, HC and ratio of visceral fat to trunk fat (WHR) were shown to improve. The four indices of abdominal subcutaneous fat or visceral fat,

**Table 1.** Changes in the anthropometric characters, body composition and cardiovascular metabolic parameters after intervention (mean±SD)

| Item† | Basal | After | Δ‡ | $p$* |
|---|---|---|---|---|
| Ht (cm) | 159±9.3 | 160±9.3 | -0.7±0.6 | <0.001 |
| Wt (kg) | 71.8±16.4 | 64.6±15.1 | 7.2±2.2 | <0.001 |
| BMI (kg/$m^2$) | 28.0±4.3 | 25.1±4.0 | 2.9±0.9 | <0.001 |
| FM (kg) | 27.3±9.6 | 21.8±8.3 | 5.5±2.2 | <0.001 |
| FFM (kg) | 44.5±9.2 | 42.8±9.3 | 1.7±1.2 | <0.001 |
| PBF (%) | 37.5±6.1 | 33.3±6.3 | 4.2±1.9 | <0.001 |
| WC (cm) | 92.0±9.6 | 84.9±9.1 | 7.1±3.2 | <0.001 |
| HC (cm) | 98.5±8.7 | 91.4±9.6 | 7.0±3.4 | <0.001 |
| WHR | 0.92±0.05 | 0.89±0.04 | 0.03±0.02 | <0.001 |
| SBP (mmHg) | 119±13.0 | 107±8.1 | 11.7±10.0 | <0.001 |
| DBP (mmHg) | 71.9±10.0 | 63.6±8.7 | 8.3±11.1 | 0.003 |
| UA (umol/L) | 390±79 | 312±73 | 78.1±68.5 | <0.001 |
| TC (mmol/L) | 4.2±0.8 | 3.2±0.4 | 0.9±0.6 | <0.001 |
| TG (mmol/L) | 1.0±0.4 | 0.6±0.2 | 0.4±0.4 | <0.001 |
| HDL (mmol/L) | 1.4±0.3 | 1.3±0.3 | 0.1±0.3 | 0.082 |
| LDL (mmol/L) | 2.5±0.6 | 1.5±0.3 | 1.0±0.5 | <0.001 |
| hsCRP (mg/L) | 2.5±3.4 | 4.9±16.4 | -2.4±17.0 | 0.533 |
| HBA1C (%) | 5.3±0.3 | 5.1±0.3 | 0.2±0.2 | 0.001 |
| Insulin (UIU/mL) | 9.8±4.9 | 4.4±2.8 | 5.4±4.8 | <0.001 |
| FPG (mmol/L) | 4.3±0.4 | 4.5±0.3 | -0.1±0.4 | 0.137 |
| C-Peptide (ng/mL) | 3.2±1.4 | 2.3±1.5 | 0.9±1.1 | 0.002 |
| 2hIns (UIU/mL) | 30.6±21.1 | 23.1±28.1 | 7.5±37.2 | 0.376 |
| 2hPG (mmol/L) | 4.8±0.7 | 5.3±0.8 | -0.5±0.8 | 0.005 |
| 2hC-Peptide (ng/mL) | 9.2±4.1 | 6.0±2.9 | 3.2±4.9 | 0.009 |
| HOMA-IR | 1.9±1.2 | 0.9±0.6 | 1.0±1.1 | 0.001 |

†All data were expressed as mean ± standard deviation; ‡Δ=the data of basal-after intervention; * $p$ values were determined by the paired sample T test, with $p<0.05$ considered statistically significant.
Ht: height; Wt: weight; BMI: body mass index; FM: fat mass; FFM: fat free mass; PBF: percent body fat; WC: waist circumference; HC: hip circumference; WHR: waist-hip ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; UA: uric acid; TC: total cholesterol; TG: triglyceride; HDL: high density lipoprotein; LDL: low density lipoprotein; hsCRP: high-sensitivity C-reactive protein; $HBA_{1C}$: hemoglobin $A_{1c}$; FBG: fasting blood glucose; 2hIns: 2 hours of postprandial insulin; 2hPG: 2 hours of postprandial blood glucose.

**Table 2.** Changes of abdominal fat after intervention (mean±SD)

| Abdominal fat† | Basal | After | Δ‡ | p* |
|---|---|---|---|---|
| $SFT_{US}$ (mm) | 28.9±6.2 | 20.3±4.6 | 8.6±4.5 | <0.001 |
| $VFA_{BIA}$ ($cm^2$) | 83.8±44.6 | 60.8±38.5 | 23.0±13.0 | <0.001 |
| $SFA_{MRI}$ ($cm^2$) | 275±77.6 | 210±63.9 | 65.4±35.8 | 0.001 |
| $VFA_{MRI}$ ($cm^2$) | 64.7±20.3 | 42.1±16.4 | 22.6±8.6 | <0.001 |

†All data were expressed as mean ± standard deviation; ‡Δ=the data of basal-after intervention; *$p$ values were determined by the paired sample T test, with $p$<0.05 considered statistically significant.
Subcutaneous fat thickness ($SFT_{US}$) was assessed by the Sonographic measurements. Visceral fat area ($VFA_{BIA}$) was assessed by the bioelectrical impedance analysis method. Subcutaneous fat area ($SFA_{MRI}$) and Visceral fat area ($VFA_{MRI}$) were assessed by MRI.

**Table 3.** Changes in REE after intervention (mean±SD)

| Item† | Basal | After | △‡ | p* |
|---|---|---|---|---|
| REE (kcal/d) | 1936±789 | 1902±575 | 33.7±682 | 0.827 |
| REE/Wt (kcal/kg·d) | 27.5±9.4 | 29.8±6.7 | -2.3±8.3 | 0.226 |

†REE (resting energy expenditure) and REE/Wt were expressed as mean ± standard deviation.
‡Δ= the data of basal-after intervention.
*$p$ values were determined by the paired sample T test, with $p$<0.05 considered statistically significant.

namely $SFT_{US}$, $VFA_{BIA}$, $SFA_{MRI}$ and $VFA_{MRI}$, also demonstrated reduction.[9] In our study, FFM fell with body weight loss, which is inconsistent with previous studies where exercise intervention maintains or increases FFM. However, we restricted, dietary energy intake along with aerobic exercise, thus resulting, presumably, in both FM and FFM reductions.[8,10]

REE is the basic measure of energy expenditure, to which exercise and the specific dynamic effect of food are added. REE occupies 2/3 of total energy expenditure, which is mainly determined by the amount of metabolically active tissue. FFM, the principle determinant of REE, explains 82% of the REE variance among young subjects.[11,12] More than 10 years ago, Goran et al, showed that differences in children's REE are related to three factors, namely FFM, gender and FM, just as for that of adults.[13] We have found in a study of obese children that BMI is correlated positively to REE, but negatively to REE/BW.[14] Restriction of energy intake can reduce metabolic rate through weight loss and decrease in metabolically active tissue.[15] In the present study, where physical activity was combined with energy restriction, there was no detectable associated decrease in REE with those in BW, BMI, FFM, FM or other indices. The decrease in FFM (23.6% of total body weight loss) was apparently tolerable in the short term.

The absolute value of REE decreased after the intervention while the ratio of REE/BW increased, on account of a FM decrease which was 76.4% of total body weight loss. FFM after intervention occupied more of body composition; meanwhile, the REE/BW ratio increased. Thus, after our intervention, BMI displayed an inverse trend to that for REE/BW in accord with our former study where BMI outcome correlated negatively with REE/BW in obese children.[14] An increase in REE/BW should be favourable for body weight maintenance after intervention. Even short term intervention may allow longer-term benefits in body compositional health.

Meanwhile, risk factor profiles in SBP, DBP, uric acid, total cholesterol, triglyceride, low density lipoprotein, HBA1C, Insulin, C-Peptide, 2hC-Peptide and HOMA-IR and fatty liver measurements (down from 65% to 40%) all improved significantly with the intervention ($p$<0.01). But FBP did not change and 2hPG increased for reasons which are not obvious, although insulin sensitivity improved.

Obesity is now considered to be an inflammatory state, where weight loss is associated with decreased insulin resistance and inflammatory markers.[16,17] However in our study, hsCRP did not change. Perhaps sample size was limiting or the stress of the 4-week diet and energy control with increasing exercise intensity may have been adverse in these respects. A similar explanation may apply to the failure of FPG and 2hPG to decrease.

An important limitation of our study is that we studied young Shanghainese some of whom were pubescent. There are reservations about energy restriction during growth and development. Wherever possible the first objective in obesity management will be for negative energy balance to be achieved through increased physical activity rather than through energy restriction. When energy restriction is required in addition to physical activity approaches, great care needs to be taken that the diet meets nutritional needs. Another limitation is that we have not reported effects on food choice or physical activity in follow-up.

### *Conclusions*

This study showed that short term intervention in personal behaviours can lead to significant reductions in body weight and in indices of fatness such as abdominal fat, FM, PBF, WC, HC and WHR. Obesity-related health risk factors including BP, serum lipids and liver fat can also be ameliorated in this way. Neither REE nor REE/BW changed. Our study suggests that if such a program were extended or repeated, maintained or increased basal energy expenditure might reduce the risk of a rebound increase in body fatness.

### AUTHOR DISCLOSURES

The authors have declared that no competing interests exist.

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# 上海肥胖儿童青少年减肥夏令营的效果评估

目的：结合身体成分测定、静息能量消耗和代谢因素分析，探讨肥胖儿童青少年进行饮食和运动的综合干预效果。方法：20名7-17岁的肥胖儿童青少年参与并完成了为时四周的夏令营项目。该项目重点关注个体行为，包括饮食限制和运动训练。在项目开始前和结束后分别进行人体学测量、生物电阻抗、腹部超声和核磁共振测定（评估腹部皮下和肝内脂肪），以及血压测定。结果： 1. 总体重平均减轻 7.2±2.2 kg, 脂肪质量减少5.5±2.2 kg，去脂体质量减少1.7±1.2 kg, 并分别与腹部和臀部脂肪、腰臀比、血压的减少相关联。2. 静息能量代谢测定值与体重矫正后的静息能量代谢值的变化无统计学意义。 3. 尿酸、总胆固醇、甘油三酯、低密度脂蛋白、糖化血红蛋白、胰岛素、C肽及胰岛素抵抗指标(HOMA-IR)明显降低，脂肪肝的发生率也明显减少，但hsCRP无显著差异。结论：通过四周的减肥夏令营的行为干预，能有效改善体脂肪含量及其分布，也会损失一定量的去脂组织，但静息能量代谢无减少。提示如能延长这种体重管理项目的干预期限，可有效地维持基础能量消耗，使减脂效果更好。

**关键词：减肥夏令营、肥胖儿童青少年、体成分、静息能量代谢、 生化代谢**