Effects of dietary intervention and strength training on blood lipid level in obese children

R Y T Sung, C W Yu, S K Y Chang, S W Mo, K S Woo, C W K Lam

Aims: To evaluate effects of a low energy diet, with or without strength training, on blood lipid profile in obese children.

Methods: Eighty-two obese children were enrolled into a six-week dietary programme, and were randomly allocated to a training group or a non-training group. The training group underwent regular exercise sessions with emphasis on strength training.

Results: Height increased significantly, with a non-significant reduction in body mass index. Fat-free mass increased significantly in the training group. Serum total cholesterol was significantly reduced in both groups. The LDL:HD ratio significantly decreased in the training group.

Conclusion: Results support the potentially beneficial effects of both diet and physical training. Further and longer term evaluation of such programmes is required.

Obesity has become the commonest paediatric nutritional problem in Hong Kong, affecting 10–13% of children aged 6–18. Public health concern at the increasing prevalence of childhood obesity has led to the establishment in local hospitals and health centres of clinics aimed at dietary changes, exercise, and weight reduction in obese children. Attendance and adherence to advice is often poor, however, and the potential benefit of such clinics has yet to be evaluated. Therefore, we took advantage of the summer vacation to mount and monitor the effects in obese children of a six-week programme of dietary intervention, with or without additional exercise training. The physical training programme emphasised strength training, in contrast to previously reported regimes which have generally focused on aerobic, including weight-bearing exercises, frustration with which could lead to poor adherence, particularly in obese children. Strength training may improve body composition by increasing lean mass and muscle strength, thereby facilitating exercise performance and aerobic energy expenditure. We report the changes of body composition and serum lipid levels in children who participated in the six-week intervention programme.

METHODS

Subjects
Invitations were sent via school teachers for obese 8–11-year-old children in 13 local primary schools. A total of 170 children and their parents showed interest and underwent basic anthropometric measurements with an introductory explanation of the programme. All children whose weight was greater than 120% of the median weight for height were assessed medically. Those with a history of diabetes, renal or cardiovascular disease, or steroid therapy, and whose sexual maturity status was more advanced than stage 2 by Tanner's criteria were excluded. A total of 151 children (99 males and 52 females, ratio 2:1) were eligible; to maintain the same sex ratio a sample of 54 males and 28 females were randomly selected from a computer-generated list of numbers. Further randomisation was done separately in boys and girls by asking the child to pick out a sealed opaque envelope with a note inside inviting the child either to the training or non-training group. The study protocol was approved by the ethics committee of the Chinese University. Informed consent forms were signed by the parents of all participating children.

Exercise training programme
Physical fitness was assessed at the beginning and at the end of the six-week programme. A “ten repetition maximum” (10-RM) was determined for biceps curl, shoulder press, bench press, triceps extension, quadriceps extension, straight...
lipoprotein were assayed by rate nephelometry (Array, Beckman Instruments, Brea, CA, USA).

Serum lipid profile

Fasting serum total cholesterol (TC) and triglyceride were assayed enzymatically using the Boehringer Mannheim Hitachi 911 analyser. High density lipoprotein (HDL) cholesterol was measured after phosphotungstate magnesium precipitation. Low density lipoprotein (LDL) cholesterol was calculated by the Friedewald formula. The hospital laboratory performing the lipid analyses is internationally accredited, with intra-assay imprecision of cholesterol measurement <3%.

Serum apolipoproteins A-I (apo A-I) and B (apo B), and Lp(a) were assayed by rate nephelometry (Array analyser, Beckman Instruments, Brea, CA, USA), with intra-assay imprecision of <3%.

Statistics

All data are presented as mean (SD). Between group differences were analysed by Student’s t test, and changes from the start to the end of the six week programme were compared by repeated measures ANOVA. Sex was entered into the model to increase the precision of between group comparison.

RESULTS

The non-training groups had a slightly lower body weight and lean body mass at the start of the study, but the difference was not significant (table 1). Median attendance at the training class was 83% (interquartile range: 77% to 100%). All training sessions were attended by 75% or more children (range: 75% to 97.7%). Height increased significantly in both groups during the six weeks of the programme, and body mass index declined, though not to the point of statistical significance. In the training group, fat free mass increased (+2.3%) significantly more than in the non-training group (0.9%) after the programme.

Table 1 Body characteristics before and after six week programme of dietary control, with or without exercise training

<table>
<thead>
<tr>
<th></th>
<th>Training After</th>
<th>Training Change (after − before)</th>
<th>Non-training After</th>
<th>Non-training Change (after − before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>41 (27/14)</td>
<td>41 (27/14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>145.9 (6.6)</td>
<td>147.4 (6.9)*</td>
<td>1.4 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>54.6 (9.1)</td>
<td>55.2 (9.5)</td>
<td>0.6 (1.5)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.3 (3.1)</td>
<td>25.3 (3.1)*</td>
<td>-0.2 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>21.2 (5.3)</td>
<td>21.2 (5.6)</td>
<td>-0.03 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>34.2 (5.1)</td>
<td>35.0 (5.1)*</td>
<td>0.8 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Fat/total mass (%)</td>
<td>37.9 (4.1)</td>
<td>37.3 (4.2)*</td>
<td>-0.7 (1.5)</td>
<td></td>
</tr>
</tbody>
</table>

Results expressed as mean (SD).

BMI, body mass index.

*p<0.05 compared to before; **p<0.05 for comparison between changes in the two groups.

Table 2 Serum lipids and apolipoproteins before and after six week programme of dietary control, with or without exercise training

<table>
<thead>
<tr>
<th></th>
<th>Training After</th>
<th>Training Change (after − before)</th>
<th>Non-training After</th>
<th>Non-training Change (after − before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mmol/l)</td>
<td>4.8 (0.7)</td>
<td>4.5 (0.8)*</td>
<td>-0.3 (0.5)</td>
<td></td>
</tr>
<tr>
<td>TG (mmol/l)</td>
<td>1.2 (0.5)</td>
<td>1.5 (0.7)</td>
<td>0.3 (0.6)</td>
<td></td>
</tr>
<tr>
<td>HDLC (mmol/l)</td>
<td>1.3 (0.3)</td>
<td>1.2 (0.3)</td>
<td>-0.1 (0.2)</td>
<td></td>
</tr>
<tr>
<td>LDL-C (mmol/l)</td>
<td>2.9 (0.8)</td>
<td>2.6 (0.8)*</td>
<td>-0.4 (0.5)</td>
<td></td>
</tr>
<tr>
<td>TC-HDL</td>
<td>3.9 (1.1)</td>
<td>3.8 (0.9)</td>
<td>-0.1 (0.4)</td>
<td></td>
</tr>
<tr>
<td>TG-HDL</td>
<td>1.0 (0.5)</td>
<td>1.3 (0.8)*</td>
<td>0.3 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Apo A1 (mg/dl)</td>
<td>130.6 (19.4)</td>
<td>128.2 (20.3)</td>
<td>-2.4 (12.6)</td>
<td></td>
</tr>
<tr>
<td>Apo B (mg/dl)</td>
<td>81.6 (20.1)</td>
<td>80.5 (19.7)</td>
<td>-1.1 (10.1)</td>
<td></td>
</tr>
</tbody>
</table>

Results expressed as mean (SD).

TC, total cholesterol; LDL-C, low density lipoprotein cholesterol; HDLC, high density lipoprotein cholesterol; TG, triglyceride; Apo A1, apolipoprotein A1; ApoB, apolipoprotein B.

*p<0.05 compared with before; **p<0.05 for comparison between changes in the two groups.

The diets reported in the three day diet records, both before and at the end of the programme, were similar in the two groups (table 3) and the changes observed supported adherence to the prescribed diets. Energy, fat, carbohydrate,
and protein intake were all significantly lower at the end of the six week programme; the relative contribution to energy intake of fat was lower, of carbohydrate was higher, and of protein was unchanged.

No training related injuries were reported during the programme.

**DISCUSSION**

The increased prevalence of obesity in children is of concern, particularly in relation to the risk of cardiovascular disease. The importance of introducing measures in early life to control weight and to prevent adverse clinical consequences is becoming recognised.

The present study was of short duration, from expediency in order to minimise interruption of school learning during term time and encourage participation. It nevertheless provided promising evidence in these growing children of an improvement in lean (fat free) body mass in the group also undergoing exercise training, and of changes consistent with a reduction in body mass index. Although the reduction in body mass index was modest and did not reach statistical significance, parents and children were not disappointed because they had been warned not to expect the rapid weight loss seen with adult programmes. The aim, in these growing children, was to prevent them getting more obese and developing related complications by a change in eating habits.

Total cholesterol level was reduced by 6%, while HDL and LDL cholesterol were also slightly reduced in the non-training group and training group respectively. The LDL:HDL cholesterol ratio was significantly decreased in the training group, but slightly increased in the non-training group, indicating that the strength training programme may have a beneficial effect on the lipid composition.

A standard low energy balanced diet was chosen because of its long term safety and beneficial impact on lipid profile. It appeared to be well tolerated, as confirmed by monitoring of dietary intake, menus for which were individually tailored and encouraged provision by continued supervision. The small increase in triglycerides (significant in the study as a whole) was unexpected; it may be related to the quite large relative increase in carbohydrate intake, derived mainly from rice. Reductions in triglyceride level have been reported in obese adults on high protein, fat reduced diets, but not in those on high carbohydrate, fat reduced diets. Reduced triglyceride level without change in HDL cholesterol has also been observed in children slightly older than in our study, following regimes of dietary control with exercise training; the differences may be ascribed to their more rigorous dietary restriction, with much less carbohydrate (to the point of ketosis) but more protein.

The exercise regime, which proved acceptable, was, unlike in most previous studies, designed to include strength training to improve muscle development, and also to be varied so as to retain the children’s interest. An increase in lean mass will increase oxygen consumption. Exercise training may also facilitate motor function and enhance exercise safety. It was, as anticipated, associated with a significant improvement of body composition with an increase in lean body mass and decrease in percentage body fat. We did not find any further improvement in serum lipid profile with exercise, as has been reported in normal children following a six month programme of balanced diet, with or without exercise training.

In conclusion, our findings provide support for the potentially beneficial effects in obese children of both diet and exercise. There is a need for further and longer term evaluation of such regimes.

**ACKNOWLEDGEMENTS**

We are most grateful to Professor Andrew Henderson for his critical review of the manuscript and his valuable suggestions. We are also very grateful to Mr Raymond So (the Hong Kong Sports Institute) and Dr MB Katan (Wageningen Centre for Food Sciences and Division of Human Nutrition and Epidemiology) for useful discussions. We also thank Mr Patrick Lau and his students in the Department of Sports Science and Physical Education, Chinese University of Hong Kong, for their assistance in running the training class. This project was supported by a grant from the University Grant Council, Hong Kong.

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**REFERENCES**


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**Table 3** Daily intake of energy and macronutrients before and after the intervention

<table>
<thead>
<tr>
<th>Training</th>
<th>Before</th>
<th>After</th>
<th>Change (after − before)</th>
<th>Non-training</th>
<th>Before</th>
<th>After</th>
<th>Change (after − before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>15.56 (5.11)</td>
<td>12.27 (3.43)</td>
<td>−2.83</td>
<td>15.56 (6.00)</td>
<td>12.72 (3.93)</td>
<td>−2.88</td>
<td></td>
</tr>
<tr>
<td>CHO (g)</td>
<td>215 (7.57)</td>
<td>190 (5.73)</td>
<td>−25</td>
<td>215 (8.18)</td>
<td>194 (5.47)</td>
<td>−22</td>
<td></td>
</tr>
<tr>
<td>% energy</td>
<td>55.9 (8.4)</td>
<td>60.9 (8.7)*</td>
<td>5</td>
<td>55.6 (7.5)</td>
<td>61.8 (7.1)*</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>Protein (g)</td>
<td>75.9 (31.7)</td>
<td>65.4 (29.9)</td>
<td>−10.5</td>
<td>76.9 (33.2)</td>
<td>61.7 (24.5)</td>
<td>−15.2</td>
<td></td>
</tr>
<tr>
<td>% energy</td>
<td>19.3 (4.4)</td>
<td>20.7 (4.5)</td>
<td>0.9</td>
<td>19.2 (5.7)</td>
<td>19.1 (3.8)</td>
<td>−0.3</td>
<td></td>
</tr>
<tr>
<td>Fat (g)</td>
<td>43.3 (18.0)</td>
<td>28.1 (16.4)*</td>
<td>−15.2</td>
<td>43.7 (21.7)</td>
<td>27.9 (12.9)*</td>
<td>−15.8</td>
<td></td>
</tr>
<tr>
<td>% energy</td>
<td>24.6 (6.4)</td>
<td>19.1 (6.9)*</td>
<td>−5.5</td>
<td>24.9 (6.1)</td>
<td>19.2 (5.1)*</td>
<td>−5.7</td>
<td></td>
</tr>
<tr>
<td>SFA (g)</td>
<td>13.2 (5.9)</td>
<td>8.9 (5.6)*</td>
<td>−4.3</td>
<td>13.8 (7.0)</td>
<td>8.8 (4.6)*</td>
<td>−5</td>
<td></td>
</tr>
<tr>
<td>MUFA (g)</td>
<td>15.1 (6.6)</td>
<td>10.4 (6.9)*</td>
<td>−4.7</td>
<td>16.1 (8.1)</td>
<td>10.2 (4.9)*</td>
<td>−5.9</td>
<td></td>
</tr>
<tr>
<td>PUFAd (g)</td>
<td>5.8 (2.6)</td>
<td>4.1 (2.5)</td>
<td>−1.7</td>
<td>5.8 (3.4)</td>
<td>3.9 (1.6)*</td>
<td>−1.9</td>
<td></td>
</tr>
<tr>
<td>P:S</td>
<td>0.5 (0.2)</td>
<td>0.5 (0.2)</td>
<td>0</td>
<td>0.4 (0.1)</td>
<td>0.5 (0.3)</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>M:S</td>
<td>1.2 (0.2)</td>
<td>1.2 (0.2)</td>
<td>0</td>
<td>1.2 (0.1)</td>
<td>1.2 (0.2)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cholesterol</td>
<td>240 (136)</td>
<td>217 (130)</td>
<td>−24</td>
<td>262 (132)</td>
<td>206 (119)</td>
<td>−56</td>
<td></td>
</tr>
</tbody>
</table>

Results expressed as mean (SD).

CHO, carbohydrate; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFAd, polyunsaturated fatty acid; P:S, ratio of polyunsaturated to saturated fatty acids; M:S, ratio of monounsaturated to saturated fatty acids.

*p<0.05 compared with before (Student’s paired t test), after Bonferroni adjustment. All comparisons of the changes were non-significant.
The adult fashion for body piercing seems to have had a strange spin-off in children. Over a period of 51 days (13 April to 3 June 2000) 24 children aged 5–15 years attended Sheffield Children’s Hospital because of problems related to the body application of small magnets (S McCormick and colleagues Emergency Medicine Journal 2002;19:51–3).

These magnets are neodymium magnets, made from a mixture of iron, boron, and neodymium, and they are said to be five to ten times stronger than ordinary magnets. They measure 7 mm × 4 mm × 1 mm.

The children applied paired magnets across body parts (nose 11, penis 3, ear 1) or swallowed them (9). One child, a girl of 9 years, had swallowed several magnets during attempts to imitate tongue piercing and presented initially with diarrhoea and vomiting diagnosed as gastroenteritis. Two days later she came back with abdominal pain and bile stained vomiting. x-ray showed opacities in the lower abdomen and at laparotomy there was a “mass of magnets” in the peritoneal cavity and she had one perforation of the caecum and five of the small bowel. She spent one week in the intensive care unit and another week on the ward before going home. She had swallowed the magnets separately over a period of time and they had therefore been able to pass into the bowel separately and attract each other across bowel loops. In the other eight children who had swallowed magnets they stuck together as a single mass in the stomach and the children came to no harm.

The magnets were so strong that it was very difficult to slide or pull them apart and attempts to do so caused pain. Of the 11 children with magnets in the nose two needed general anaesthesia for their removal and most had to be referred to the ear, nose, and throat department because the magnets could not be removed in the emergency department. Several children had necrosis of nasal mucosa. One of the three boys who had got a fold of penile skin caught between the magnets needed sedation with midazolam before they could be removed.

Children were selling these magnets for a penny each in the schoolyard but where they got them from is not known. Most of the children came from a fairly restricted area within the city and local press publicity markedly reduced the number of cases.
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