Successful Strategy to Improve Glucose Tolerance in Thai Obese Youth

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Background: *Childhood obesity is an emerging national health problem in Thailand. Our previous study found that one third of obese children and adolescents had impaired glucose tolerance (IGT) and 2.6 percent had already developed type 2 diabetes mellitus. An immediate strategy needs to be established in order to improve these metabolic problems.*
Objective: *To determine whether diet and exercise education for lifestyle modification with or without metformin therapy in our diabetes clinic is enable to improve these metabolic problems.*
Material and Method: *Twenty-six Thai obese children and adolescents with IGT, who received at least 6 months of treatment consisting of lifestyle modification alone or lifestyle modification and metformin (combined treatment) were enrolled into this study. Each patient underwent the second 2-hour oral glucose tolerance test (OGTT). Plasma glucose, insulin levels, HbA_1C and lipid profiles were measured. The results were compared with historical pre-treatment data.*
Results: *Approximately 1 year after intervention, 19 out of 26 patients with IGT completed the second 2-hour OGTT. Sixteen patients (84.2%) successfully reversed to be normal glucose tolerance whereas 3 patients (15.8%) remained IGT. Body mass index (BMI), BMISDS, 2-hour plasma glucose, basal insulin level, 2-hour insulin level were significantly decreased after treatment in normal OGTT group (Ps < 0.05). Treatment with lifestyle modification alone and combined treatment indifferently improved the abnormal glucose tolerance in our patient (83.3% vs. 84.6%).*
Conclusion: *Impaired glucose tolerance in obese youth is a reversible abnormality by lifestyle modification with or without metformin.*

Keywords: *Obesity, Impaired glucose tolerance, Diabetes mellitus, Lifestyle modification, Metformin, Children, Adolescents*

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Since the past two decades, the incidence of childhood obesity has been increasing worldwide[1,2]. In Thailand, there has been dramatically increased incidence of childhood obesity throughout the country. A public health survey reported the increased prevalence of childhood obesity from 5.8% in 1990 to 13.3% in 1996 in Bangkok[3]. The other study, in the Southern part of Thailand, also showed an increased incidence of obesity in school children, aged 6-12 years, from 12.2% to 15.6% during 1991 to 1993[4]. These children are at risk for developing metabolic syndrome, including type 2 diabetes mellitus, dyslipidemia, hypertension and atherosclerotic cardiovascular disease[5]. Our previous study demonstrated that 33.8% of Thai obese children and adolescents had impaired glucose tolerance (IGT) and 2.6% had already developed type 2 diabetes mellitus[6].

Type 2 diabetes mellitus is associated with significant premature morbidity and mortality related to micro- and macro-vascular disease. The result is disability and shortened life expectancy, which seriously impact on both social and economic costs in the

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developed and developing country. More than 10% of the total health budget is expensed on the management of diabetes mellitus and its complications in developed countries. In the United State, the diabetes cost had increased rapidly from US$20.4 billion in 1987 to US$90 billion in 1994 and the most recent estimate is around US$100 billion[7].

IGT is an intermediate category between normal glucose tolerance and overt diabetes[8]. It is generally accepted that patients proceed through IGT before progressing to type 2 diabetes mellitus[9,10]. Several studies in adults demonstrated that patients with IGT have a six to tenfold increase in risk of developing type 2 diabetes[11], depending on the population studied[12] and the number of other cardiovascular disease risk factors presented[13]. In addition, IGT has been linked with an increased risk of cardiovascular events and some analyses have demonstrated an increased mortality risk compared with patients with normal glucose tolerance[14]. With lifestyle modification, the risk of type 2 diabetes mellitus in adults with IGT decreased significantly[8,15,16]. However, studies that examined the effect of lifestyle intervention on obese children and adolescents with IGT have been limited[17].

This study attempts to determine whether diet and exercise education with or without metformin therapy in our diabetes clinic can improve metabolic problems in Thai obese children with IGT.

Material and Method

Twenty-six children and adolescents with IGT, who received lifestyle modification training program from our diabetes clinic, were enrolled into the study. These patients were recruited primarily through the OGTT of high-risk obese children and adolescents, defined as those with the body mass index (BMI) [the weight in kilograms (kg) divided by the square of the height in meter (m^2)] for age and sex above 95th percentile plus 2 out of these 3 following criteria; 1) the presence of type 2 diabetes mellitus in the first and/or the second degree relatives, 2) the presence of acanthosis nigricans, and 3) the ethnicity of African-American, Hispanic-American, Native American, Asian-American, Asian or Pacific Islanders. IGT was defined as a 2-hour plasma glucose concentration of 140 to 199 mg/dL (7.8 to 11.0 mmol/L) after the oral administration of 1.75 g/kg (maximum 75 g) of glucose[18,19]. All participants were able to ambulate independently and were not on any medications known to affect glucose metabolism such as glucocorticoids. Patients with a previous diagnosis of DM, chronic illness, or mental abnormalities were excluded.

All patients and their families received individualized dietary education including the recommended daily caloric intake, carbohydrate portion, food exchanges, total and saturated fat restriction to less than 30% and 10% of energy consumption, respectively and an increase in fiber consumption to at least 15 g per 1000 kcal from dietician in our diabetes clinic. The daily caloric intake was calculated by using the ideal body weight for height of each patient in the first visit and decreased 200 kcal every follow up visit if BMI was still increased. Ingestions of whole-grain products (such as brown rice), fiber rich vegetables and fruits, low fat milk and meat products, and vegetable oils rich in monounsaturated fatty acids were also recommended. All fast foods and soda were encouraged to be substituted by low fat Thai food and water or low fat milk. The dietary advice was tailored to each patient on the basis of three-day food records completed every 3 months. All parents were advised to restrict their children's sedentary lifestyles (*i.e.*, watching television and playing video game) to less than 1 hour per day. These patients also attended at least 1-day exercise training program, aiming to increase aerobic exercise, in Physical Medicine and Rehabilitation (PM & R) Department and continued everyday home exercise at least 30 minutes per day. Some patients received metformin depending on the discussion between the physician and family. The dose of metformin was gradually increased from 500 mg/day to 2,000 mg/day within 2-3 months.

All patients and their families visited the diabetes clinic and met with their physicians, nurse educator, nutritionist and psychologist monthly for 3 consecutive month and then every 2 to 3 months afterward. In each visit, the diabetes team did reeducate, adjust the treatment plans for each patient and encourage them to maintain this healthy program regularly.

At least 6 months after initiation the treatment, the patients underwent the 2-hour OGTT. Written informed assent and consent were obtained from participants and parents prior to the test. Plasma glucose, insulin level, HbA_1C and lipid profiles including total cholesterol, triglyceride, high-density lipoprotein-cholesterol (HDL-C), and low-density lipoprotein-cholesterol (LDL-C) were measured. Plasma glucose, insulin and HbA_1C levels were measured using Hexokinase method, electrochemiluminescence immunoassay and Turbidimetric Inhibition

Immunoassay, respectively (Roche Diagnostics, Indianapolis, IN, USA). Total cholesterol, triglyceride, HDL-C and LDL-C were measured via enzymatic method (Roche Diagnostics, Indianapolis, IN, USA). Auxological data including height, weight and BMI were also recorded at the same visit. The results were compared with historical pre-treatment data from the patients' medical records.

Assessment of the End Point

Normal glucose tolerance was defined as a fasting plasma glucose concentration lower than 100 mg/dL (5.6 mmol/L) and a 2-hour plasma glucose concentration less than 140 mg/dL (7.8 mmol/L). Glucose levels considered diagnostic for diabetes mellitus were a fasting plasma glucose level of 126 mg/dL (7.0 mmol/L) or more and a 2-hour post-challenge level of 200 mg/dL (11.1 mmol/L) or more. Intermediate levels of glucose, fasting glucose levels of 100 to 125 mg/dL, were known as impaired fasting plasma glucose (IFG)[18,19], whereas IGT was defined as previously mentioned.

Statistical analysis

All statistical calculations were performed with SPSS for windows version 10 (SPSS Inc, Chicago, Illinois). Results are presented as mean ± standard deviation (SD) unless otherwise stated. The anthropometric variables and biochemical findings of patients with IGT were compared between pre- and post-treatment using the paired t-test. Pearson's correlation was used to examine the correlations between the changes of anthropometric variables and biochemical findings and the changes of 2-hour OGTT plasma glucose levels after the intervention.

Results

Of 26 patients with IGT, 4 patients were excluded from the study because two had Prader-Willi syndrome, one had Down syndrome and the other was on glucocorticoids. The other 3 patients did not return for the OGTT assessment. Therefore, only 19 patients completed the second test.

In these 19 patients (10 females and 9 males with the mean age of 11.7 ± 2.0 years, age range 9.0-15.3 years), all were Asian in heritage. Twelve patients (63.2%) had family history of type 2 diabetes (52.6% in the 2nd degree relatives alone and 10.5% in both the 1st and 2nd degree relatives). Five patients (26.3%) also had impaired fasting plasma glucose (IFG) at the diagnosis of IGT.

The mean duration of lifestyle modification treatment was 1.02 ± 0.33 years. After intervention, the patients' weight SDS, BMI and BMI SDS decreased significantly as compared to the pre-treatment data (ps < 0.05) (Table 1). In addition, the post-treatment 2-hour plasma glucose, fasting insulin, 2-hour insulin, HbA_1C and cholesterol levels were significantly lower than those of the pre-treatment results (ps < 0.05) (Table 2). Significant positive correlations were found between the decreased level of 2-hour plasma glucose and the decreases of weight SDS (r = 0.554, p = 0.014), BMI SDS (r = 0.485, p = 0.035), fasting insulin level (r = 0.585, p = 0.008) and 2-hour insulin level (r = 0.621, p = 0.005).

In this study, we demonstrated that 16 patients (84.2%) successfully reversed from IGT to normal glucose tolerance, whereas three (15.8%) remained to have IGT. Of 5 patients who had IFG together with IGT at pre-treatment, none remained IFG after intervention. Although all of the data of patients in the reversed OGTT and remained IGT groups were not able to

Table 1. The anthropometric variables of 19 patients with IGT at pre- and post-lifestyle modification treatment

	Pre-treatment (n =19)	Post-treatment (n = 19)	p
Age	11.7 ± 2.1	12.7 ± 2.1	0.000*
Weight (kg)	71.4 ± 18.8	69.5 ± 13.1	0.222
Weight SDS	5.0 ± 2.0	4.3 ± 1.4	0.002*
Height (cm)	150.9 ± 11.6	155.6 ± 10.6	0.000*
Height SDS	1.1 ± 1.2	1.1 ± 1.2	0.586
BMI (kg/m^2)	30.9 ± 5.0	28.5 ± 3.0	0.002*
BMI SDS	8.3 ± 4.5	7.2 ± 3.5	0.022*

Values expressed as mean ± SD, p < 0.05 consider statistically significant*

Table 2. Biochemical findings of 19 patients with IGT at pre-and post-lifestyle modification treatment

	Pre-treatment (n =19)	Post-treatment (n = 19)	p
Fasting PG (mg/dL)	90.5 ± 11.3	86.6 ± 5.9	0.064
2-hr PG (mg/dL)	161.1 ± 17.4	123.9 ± 19.6	0.000*
Fasting insulin(μU/mL)	32.2 ± 14.0	20.8 ± 10.1	0.001*
2-hr insulin (μU/mL)	257.1 ± 113.9	126.6 ± 80.2	0.002*
HbA_1C (%)	6.0 ± 0.6	5.5 ± 0.4	0.006*
Cholesterol (mg/dL)	196.0 ± 31.1	176.3 ± 42.3	0.035*
Triglyceride (mg/dL)	101.7 ± 39.9	120.1 ± 76.7	0.129
HDL-C (mg/dL)	51.1 ± 15.5	50.1 ± 16.9	0.677
LDL-C (mg/dL)	117.6 ± 30.4	104.0 ± 34.6	0.101

Values expressed as mean ± SD, $p < 0.05$ consider statistically significant*

Table 3. Data of patients in reversed OGTT and remained IGT groups

	Pre-treatment		Post-treatment	
	Reversed OGTT (n = 16)	Remained IGT (n = 3)	Reversed OGTT (n = 16)	Remained IGT (n = 3)
Age	11.7 ± 2.1	11.7 ± 2.5	12.7 ± 2.1	12.9 ± 2.7
Weight SDS	5.0 ± 1.8	4.9 ± 3.4	4.3 ± 1.3	4.3 ± 2.4
Height SDS	1.4 ± 1.2	-0.1 ± 0.7	1.3 ± 1.2	0.2 ± 0.7
BMI (kg/m^2)	30.5 ± 4.2	34.6 ± 8.5	28.3 ± 2.6	29.5 ± 5.4
BMI SDS	7.8 ± 3.3	11.2 ± 8.2	6.8 ± 2.6	9.1 ± 7.2
FPG (mg/dL)	91.5 ± 11.0	85.0 ± 14.4	87.1 ± 5.7	84.3 ± 7.8
2-hr PG (mg/dL)	159.4 ± 17.2	170.0 ± 19.5	117.9 ± 14.8	155.7 ± 5.5
Fasting insulin	32.9 ± 14.8	28.4 ± 9.1	20.4 ± 11.0	32.1 ± 2.1
2-hr insulin	259.9 ± 119.7	241.7 ± 93.8	119.0 ± 84.4	167.5 ± 37.9
HbA_1C (%)	6.0 ± 0.6	6.2 ± 0.6	5.4 ± 0.3	5.7 ± 0.7
Cholesterol (mg/dL)	192.8 ± 30.9	213.3 ± 32.0	171.6 ± 44.2	201.7 ± 18.9
TG (mg/dL)	101.5 ± 43.4	103.0 ± 13.7	116.8 ± 78.9	137.7 ± 77.5
HDL-C (mg/dL)	50.2 ± 15.1	56.0 ± 20.5	48.4 ± 14.5	58.7 ± 29.7
LDL-C (mg/dL)	115.4 ± 26.0	129.5 ± 55.0	102.1 ± 34.3	116.2 ± 43.9

compared statistically due to small numbers of patients who remained IGT (Table 3 and 4), it seems that the patients in the reversed IGT group had the BMI, BMI SDS, HbA_1C, cholesterol, triglyceride and LDL-C levels less than the patients in the remained IGT group both pre- and post-intervention periods as shown in Table 3. Interestingly, both fasting and 2-hour insulin levels in the reversed IGT group, which were higher at diagnosis, became lower than the remained IGT group after the intervention. The percentage of changes of auxological and biochemical data of the patients in the reversed IGT group and those who remained IGT are also given in Table 4. The decreases of fasting insulin, 2-hour insulin and cholesterol in the reversed group were more than those in the remained IGT group.

Of 19 patients who underwent the second OGTT, 13 received treatment with lifestyle modification alone whereas 6 received both lifestyle modification and metformin. As demonstrated in Fig. 1, the success outcome in converting IGT to normal glucose tolerance

by treatment with lifestyle modification alone was not different from the combined treatment between lifestyle modification and metformin (84.6% vs. 83.3%). In addition, the post-intervention anthropometric variables and biochemical findings were not significantly different between these two treatment groups. However, the treatment with metformin tended to improve the BMI, BMI SDS, insulin resistance and lipid profiles more than treatment with lifestyle modification alone (Table 5).

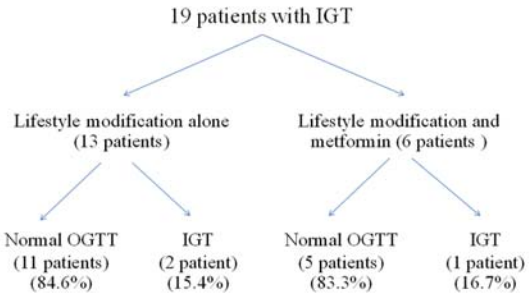

Fig. 1 The comparison of the treatment outcome between lifestyle modification alone versus lifestyle modification and metformin

Table 4. The percentage of changes of auxological and biochemical data of the patients in the reversed IGT group and those who remained IGT after intervention

	Reversed OGTT (n = 16)	Remained IGT (n = 3)
% Weight SDS change	-10.7 ± 16.2	-7.2 ± 11.3
% BMI SDS change	-9.1 ± 21.1	-10.0 ± 7.7
% Fasting insulin change	-32.5 ± 28.8	-10.7 ± 38
% 2-hr insulin change	-37.1 ± 55.6	-22.4 ± 40.5
% Cholesterol change	-10.4 ± 21.3	-4.9 ± 6.5
% Triglyceride change	11.1 ± 41.4	29.5 ± 58.2
% HDL-C change	-0.3 ± 25.1	-1.9 ± 15.7
% LDL-C change	-8.6 ± 29.9	-9.2 ± 3.9

Discussion

Our study demonstrated that lifestyle modification significantly improved metabolic parameters including 2-hour plasma glucose, fasting and 2-hour insulin levels, HbA_1C and cholesterol level of obese youth with IGT. The improvement of these metabolic derangements after lifestyle intervention in our study is similar to previous studies in both children[17] and adults[20]. Moreover, diet and exercise education provided by a multidisciplinary team in our diabetes clinic were able to reverse IGT to normal glucose tolerance in a majority of our obese youth. This finding is similar to a large, randomized controlled trial involving 3,234 overweight adults with IGT in the United State[15] suggesting that intensive lifestyle modification is the recommended treatment of patients with IGT in all ages.

Our lifestyle intervention was intensive and systematic, with the study participants receiving individualized education having details as similar as patients with diabetes mellitus. The study, however, was not designed to test the relative contributions of dietary changes and increased physical activity on the improvement of glucose tolerance, and the effects of these components remain to be determined.

In consistent with previous pediatric weight management programs[17,21], our patients' BMI SDS decreased significantly after lifestyle intervention. BMI and BMI SDS rather than the absolute change in weight

Table 5. The percentage of changes of parameters in patients with lifestyle modification alone and a combined therapy

	Life style alone (n = 13)	Lifestyle & metformin (n = 6)	p
% BMI change	-5.1 ± 7.9	-12.9 ± 7.2	0.055
% BMI SDS change	-21.7 ± 19.5	-34.4 ± 7.8	0.059
% Fasting insulin change	-24.5 ± 33.0	-38.9 ± 22.8	0.35
% 2-hr insulin change	-29.8 ±	-45.6 ± 48.8	0.545
% Cholesterol change	-3.6 ± 13.1	-22.4 ± 26.2	0.05
% TG change	21.0 ± 45.6	-1.1 ± 35.8	0.313
% HDL change	3.8 ± 24.0	-7.9 ± 22.2	0.329
% LDL-C change	0.7 ± 17.7	-29.1 ± 34.8	0.09

were analyzed because our patients still were growing in height. In our study, although the patients did not have significant weight loss, they had significant improvement in BMI and BMI SDS because they also grew in height during the 1 year intervention. The significant correlation between the decreased BMI, BMI SDS and the improvement of the metabolic derangement in this study lead us to closely follow the patients' BMI and BMI SDS instead of their actual weight to monitor the outcome of lifestyle intervention.

The significant positive correlations between the decreased level of 2-hour plasma glucose and the decreases of insulin levels are consistent with Sinha et al[22] study which found that insulin resistance is a strong predictor of the two-hour plasma glucose levels in obese children and adolescents, suggesting that insulin resistance may play an important part in the transition from normal to impaired glucose tolerance.

Metformin, the only oral medication approved by FDA for the treatment of adolescents with type 2 diabetes mellitus, acts preferentially to decrease hepatic glucose production by reducing the rate of gluconeogenesis. A previous randomized double-blind placebo-controlled trial demonstrated that 6 months treatment with metformin without specific dietary restriction significantly decreased BMI, fasting glucose, serum insulin and lipid levels in 14 nondiabetic obese adolescents with fasting hyperinsulinemia and a family history of type 2 diabetes as compared to controls[23]. In addition, the Diabetes Prevention Program (DPP) Research Group[15] demonstrated that long-term treatment with metformin significantly reduced the incidence of type 2 diabetes mellitus in 1,073 overweight adults with IGT as compared to the placebo group indicating that metformin is also effective and may be the treatment of choice in these high risk patients. Combined treatment of metformin and lifestyle intervention in our study, however, was not different from lifestyle intervention alone in normalizing fasting and 2 hour plasma glucose levels. Although part of this indifference may be due to a small number of patients in our study, the previous randomized control trials support our findings[15,23]. The DPP study showed the indifference of fasting and post-load glucose levels between the placebo group and metformin treatment group, whereas lifestyle intervention alone was more effective in normalizing the glucose levels than metformin and placebo[15,24].

In conclusion, impaired glucose tolerance in Thai obese youth can be reversed by lifestyle modification. Intensive individualized dietary education together with exercise training program should be recommended in this high risk group of patients.

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References

1. Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Zeitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. J Pediatr 1996; 128: 608-15.
2. Fagot-Campagna A, Pettitt DJ, Engelgau MM, Burrows NR, Geiss LS, Valdez R, et al. Type 2 diabetes among North American children and adolescents: an epidemiologic review and a public health perspective. J Pediatr 2000; 136: 664-72.
3. Likitmaskul S, Kiattisathavee P, Chaichanwatanakul K, Punnakanta L, Angsusingha K, Tuchinda C. Increasing prevalence of type 2 diabetes mellitus in Thai children and adolescents associated with increasing prevalence of obesity. J Pediatr Endocrinol Metab 2003; 16: 71-7.
4. Mo-suwan L, Junjana C, Puetpaiboon A. Increasing obesity in school children in a transitional society and the effect of the weight control program. Southeast Asian J Trop Med Public Health 1993; 24: 590-4.
5. 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: 1448-53.
6. Keamseng C, Likitmaskul S, Kiattisakthavee P, Weerakulwatana L, Nimkarn S, Sawathiparnich P, et al. Risk of metabolic disturbance and diabetes development in Thai obese children [database on

the Internet]. ISPAD 2003 [cited 2010 Apr 9]: P-90. Available from: http://www.ispad.org/2003-st.malo/2003 posters-90.pdf
7. American Diabetes Association. Economic consequences of diabetes mellitus in the U.S. in 1997. Diabetes Care 1998; 21: 296-309.
8. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Engl J Med 2001; 344: 1343-50.
9. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998; 15: 539-53.
10. Tuomilehto J, Knowler WC, Zimmet P. Primary prevention of non-insulin-dependent diabetes mellitus. Diabetes Metab Rev 1992; 8: 339-53.
11. Saad MF, Knowler WC, Pettitt DJ, Nelson RG, Charles MA, Bennett PH. A two-step model for development of non-insulin-dependent diabetes. Am J Med 1991; 90: 229-35.
12. Alberti KG. The clinical implications of impaired glucose tolerance. Diabet Med 1996; 13: 927-37.
13. Haffner SM, Stern MP, Hazuda HP, Mitchell BD, Patterson JK. Cardiovascular risk factors in confirmed prediabetic individuals. Does the clock for coronary heart disease start ticking before the onset of clinical diabetes? JAMA 1990; 263: 2893-8.
14. Petersen JL, McGuire DK. Impaired glucose tolerance and impaired fasting glucose-a review of diagnosis, clinical implications and management. Diab Vasc Dis Res 2005; 2: 9-15.
15. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med 2002; 346: 393-403.
16. Mensink M. Lifestyle intervention, glucose tolerance, and risk of developing type 2 diabetes mellitus. Metab Syndr Relat Disord 2005; 3: 26-34.
17. Monzavi R, Dreimane D, Geffner ME, Braun S, Conrad B, Klier M, et al. Improvement in risk factors for metabolic syndrome and insulin resistance in overweight youth who are treated with lifestyle intervention. Pediatrics 2006; 117: e1111-8.
18. Rodbard HW, Blonde L, Braithwaite SS, Brett EM, Cobin RH, Handelsman Y, et al. American Association of Clinical Endocrinologists medical guidelines for clinical practice for the management of diabetes mellitus. Endocr Pract 2007; 13(Suppl 1): 1-68.
19. American Diabetes Association. Standards of medical care in diabetes-2008. Diabetes Care 2008; 31(Suppl 1): S12-54.
20. Lindstrom J, Eriksson JG, Valle TT, Aunola S, Cepaitis Z, Hakumaki M, et al. Prevention of diabetes mellitus in subjects with impaired glucose tolerance in the Finnish Diabetes Prevention Study: results from a randomized clinical trial. J Am Soc Nephrol 2003; 14(7 Suppl 2): S108-13.
21. Rosenbaum M, Nonas C, Weil R, Horlick M, Fennoy I, Vargas I, et al. School-based intervention acutely improves insulin sensitivity and decreases inflammatory markers and body fatness in junior high school students. J Clin Endocrinol Metab 2007; 92: 504-8.
22. Sinha R, Fisch G, Teague B, Tamborlane WV, Banyas B, Allen K, et al. Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. N Engl J Med 2002; 346: 802-10.
23. Freemark M, Bursey D. The effects of metformin on body mass index and glucose tolerance in obese adolescents with fasting hyperinsulinemia and a family history of type 2 diabetes. Pediatrics 2001; 107: E55.
24. Lehtovirta M, Forsen B, Gullstrom M, Haggblom M, Eriksson JG, Taskinen MR, et al. Metabolic effects of metformin in patients with impaired glucose tolerance. Diabet Med 2001; 18: 578-83.

ผลของการเปลี่ยนแปลงพฤติกรรมการบริโภค และการออกกำลังกายของเด็ก และวัยรุ่นอ้วนต่อความผิดปกติของระดับน้ำตาลในเลือด

นวพร นำเบญจพล, สุภาวดี ลิขิตมาศกุล, ไพรัลยา นาควัชระ, จีรันดา สันติประภพ, พรพิมล เกียรติศักดิ์ทวี, เรณู วงษ์อาน

ภูมิหลัง: *โรคอ้วนในเด็กกำลังเป็นปัญหาสำคัญของประเทศไทย การศึกษาของเราก่อนหน้านี้พบว่า 1 ใน 3 ของเด็กอ้วนมี impaired glucose tolerance (IGT) และร้อยละ 2.6 ของเด็กอ้วนเป็นโรคเบาหวานชนิดที่ 2*

วัตถุประสงค์: *เพื่อศึกษาถึงผลของการให้ความรู้ทางโภชนาการและการออกกำลังกาย ร่วมกับการให้และไม่ให้ยาลดระดับน้ำตาลในเลือดชื่อ เมทฟอร์มิน ในการแก้ไขภาวะ IGT ในเด็กอ้วน*

วัสดุและวิธีการ: *เด็กอ้วนที่มี IGT ที่ได้รับการรักษาโดยการให้ความรู้เพื่อปรับพฤติกรรมการบริโภคและการออกกำลังกาย ร่วมกับการให้และไม่ให้ยาเมทฟอร์มิน เข้ารับการทดสอบ oral glucose tolerance test และตรวจเลือดหาระดับน้ำตาลกลูโคส อินสุลิน น้ำตาลเฉลี่ย 3 เดือน และไขมัน หลังการรักษา แล้วนำผลที่ได้ไปเปรียบเทียบกับผลเลือดก่อนการรักษา*

ผลการศึกษา: *หลังให้การรักษานาน 1 ปี ร้อยละ 84.2 ของผู้ป่วยมีระดับน้ำตาลในเลือดเป็นปกติ ในขณะที่ร้อยละ 15.8 ยังคงมี IGT ผู้ป่วยที่ระดับน้ำตาลในเลือดกลับมาเป็นปกตินั้น มีค่าดัชนีมวลกาย ระดับน้ำตาลในเลือด 2 ชั่วโมงหลังรับประทานน้ำตาลกลูโคส และระดับอินสุลินในเลือดต่ำกว่าผู้ป่วยที่ยังคงมี IGT อย่างมีนัยสำคัญทางสถิติ การใช้ยาเมทฟอร์มินร่วมกับการปรับพฤติกรรมไม่มีผลแตกต่างจากการปรับพฤติกรรมแต่เพียงอย่างเดียวในการแก้ไขความผิดปกติของระดับน้ำตาลในเลือด*

สรุป: *ความผิดปกติของระดับน้ำตาลในเลือดในระยะ IGT สามารถแก้ไขให้กลับเป็นปกติได้โดยการเปลี่ยนแปลงพฤติกรรมการบริโภคและการออกกำลังกายอย่างสม่ำเสมอ ซึ่งอาจจะให้ยาเมทฟอร์มินร่วมด้วยหรือไม่ก็ได้*