Lifestyle Intervention in Prevention of Type 2 Diabetes in Women With a History of Gestational Diabetes Mellitus: One-Year Results of the FIN-D2D Project

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Abstract

Background: Lifestyle interventions are effective in preventing type 2 diabetes (T2D). Women with history of gestational diabetes mellitus (GDM) may have barriers to lifestyle changes, and the previous results of lifestyle interventions are contradictory reporting either favorable outcomes or no significant beneficial effects. Our aim was to compare cardio-metabolic risk profile and responses to a 1-year lifestyle intervention program in women with and without history of GDM.

Methods: The Implementation Project of the Program for Prevention of Type 2 Diabetes (FIN-D2D) was conducted in Finland in five hospital districts. Altogether 1,661 women aged ≤ 45 years participated in the program. One-year follow-up was available for 393 women who did not have screen-detected T2D at baseline, and 265 of them had at least one intervention visit [115 (43.4%) women with history of GDM and 150 (56.6%) without history of GDM].

Results: At baseline, women with GDM had similar baseline glucose tolerance but better anthropometric characteristics, blood pressure, and lipid profile than women without GDM after adjustment for age. Beneficial changes in cardiovascular risk profile existed among women with and without GDM during follow-up and the effect of lifestyle intervention was similar between the groups, except that low-density lipoprotein cholesterol improved only in women with GDM. Altogether, 4.0% of those with GDM and 5.0% of those without GDM developed T2D ($p=0.959$ adjustment for age).

Conclusions: The effect of a 1-year lifestyle intervention in primary healthcare setting was similar regardless of history of GDM, both women with and without GDM benefitted from participation in the lifestyle intervention.

Introduction

GESTATIONAL DIABETES MELLITUS (GDM) is defined as carbohydrate intolerance resulting in hyperglycemia, which occurs during pregnancy.¹ Women with a history of

this condition have an elevated risk for developing type 2 diabetes (T2D).^{2,3} For example, about 10% of women with GDM in Finland will develop diabetes during the next 6 years; about half of them develop T2D.⁴ GDM is also related to worse cardio-metabolic risk profile,^{5,6} metabolic syndrome

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(MetS)^{5,7} and risk for cardiovascular disease, which is partly due to the subsequent development of T2D.⁸

Lifestyle interventions are a successful means of preventing T2D in high-risk individuals for T2D;^{9,10} the effectiveness of lifestyle intervention in women with a history of GDM have also been examined to some extent.^{11–17} In the Tianjin Gestational Diabetes Mellitus Prevention Program, lifestyle intervention yielded beneficial changes in weight, body mass index (BMI), body fat, waist circumference, plasma insulin levels, physical activity and diet in women with prior GDM during the 1-year follow-up.¹⁷ Other studies have also shown that lifestyle intervention reduced weight and BMI,^{13,16} and yielded beneficial changes in diet^{15,16} and leisure time physical activity¹⁶ in women with GDM. In addition, in the Diabetes Prevention Program (DPP), the effect of lifestyle intervention on T2D risk reduction was similar in women with and without a history of GDM, but women without GDM lost more weight during the follow-up.¹²

It has been suggested that women with GDM may have many barriers to lifestyle changes, such as lack of motivation, financial and time constraints, childcare duties, fatigue, and work-related obstacles,¹⁸ and they may not perceive themselves as being at high risk for T2D after delivery.¹⁹ Some studies have already shown that favorable outcomes are difficult to achieve by lifestyle interventions in this population.^{11,14} For example, a web-based pedometer program with education on lifestyle changes did not have an impact on changes in fasting and 2-hour glucose and weight in women with a history of GDM.¹¹ Therefore, it would be important to study further whether the response to lifestyle intervention differs between women with and without a history of GDM.

The implementation program of the national diabetes prevention program (FIN-D2D) conducted in primary health care in Finland showed that lifestyle intervention was effective in prevention of T2D in high-risk individuals for T2D.²⁰ In order to examine the impact of history of GDM on the success of lifestyle counselling in FIN-D2D, we compared the baseline cardio-metabolic risk profile and responses to a 1-year lifestyle intervention programme in women aged ≤ 45 years with and without a history of GDM.

Material and Methods

According to the high-risk strategy of the FIN-D2D program, men and women who were at high risk for T2D were identified between 2003 and 2008 in the area of five hospital districts in Finland.^{21–23} Approximately 400 primary healthcare centers and occupational healthcare clinics were involved in the program; after identification, the activities included health check-ups, laboratory examinations, visits to doctor's appointments, if needed, lifestyle interventions, and follow-up visits.^{20,21,23} Permission for data collection for evaluation purposes from these healthcare units concerning high-risk women for T2D was given to the National Public Health Institute by the Ministry of Social Affairs and Health. Because all the activities of the program were included in daily routines in primary healthcare and the women received written information about the project, there was no need to collect informed consent.

Women were considered to be at high risk for T2D if they had had GDM based on their medical history or a history of impaired fasting glucose (IFG), impaired glucose tolerance

(IGT) or coronary heart disease.²¹ In addition, women who scored at least 15 points in the modified Finnish diabetes risk score test (FINDRISC),^{20,24} which was available at pharmacies and public events and via a nationwide advertising campaign and the Internet along with primary healthcare, were considered to be at high risk for T2D.²⁰ All women who had a positive history of GDM were classified as GDM positive. Women who entered the project based on reasons other than the history of GDM were combined as having no history of GDM.

Measures of weight in light clothing without shoes (kg), height (cm), waist circumference (cm), systolic and diastolic blood pressure (mmHg), and short counselling for lifestyle modifications were included in health check-ups conducted by local nurses. Sitting position was used when measuring blood pressure from the right arm.²² BMI was calculated as weight (kg) divided by the height (m) squared. Laboratory examinations included total cholesterol (mmol/L), high-density lipoprotein (HDL) cholesterol (mmol/L) and triglycerides (mmol/L), which were analyzed in local laboratories using enzymatic methods.²⁰ Low-density lipoprotein (LDL) cholesterol (mmol/L) was calculated by using Friedewald's formula.²⁵ The main outcome measure was glucose tolerance. The oral glucose tolerance test (OGTT) was started in the morning after overnight fasting. A glucose load of 75 g was used in the test, and fasting and 2-hour samples were collected either from venous or capillary samples according to local routines. Because of changes during the 1-year follow-up in the methodology of measuring fasting and 2-hour glucose levels,²⁶ we only used information from tests using identical methods at baseline and follow-up. In the definition of glucose tolerance status, classes of normal glucose tolerance (NGT), IFG, IGT, and T2D were used based on the World Health Organization (WHO) 1999 criteria.¹ Glucose tolerance status was considered to deteriorate during the follow-up if the status changed from NGT to IFG, IGT or T2D, or from IFG or IGT to T2D, or to improve if the status improved from IFG or IGT to NGT.²⁷ MetS was defined by using the International Diabetes Federation 2005 criteria.²⁸

The questionnaire included questions on changes in lifestyle (physical activity and diet), and information from the 1-year follow-up was used. The question on physical activity was as follows: "Have you increased your physical activity during the past year?" Questions concerning diet were the following: "Have you reduced fat intake in your diet during the past year?" (For example, switched from semi-skimmed to skimmed milk, reduced the amount of fat on bread, or tried to choose low-fat foods or products); "Have you changed the quality of fat to softer during the past year?" (For example, changed from butter-vegetable oil mixture to soft margarine, begun to use oil in cooking, or increased the number of fish meals); and "Have you increased the use of vegetables, fruits, and berries during the past year?" The response options to these four questions were as follows: (1) No, and I do not intend to increase/decrease/change; (2) No, but I intend to increase/decrease/change in the near future; (3) I have tried to increase/decrease/change; (4) I have clearly increased/decreased/changed; and (5) I have already previously been highly physically active/My diet was already previously low-fat/I have already previously used mainly soft fats/a lot of vegetables, fruits, and berries.²⁶ Response options 1–3 and 5 were combined in the question on physical activity, as well as

dietary habits as having no change. Furthermore, questions on diet were combined, and if a woman had change in one of these three domains of diet, she was considered to have a dietary change in a healthier direction.

The women were given the opportunity to participate in lifestyle intervention visits. Group interventions were default based on the principles of empowerment. They were mainly exercise or weight maintenance groups, also including lectures on diabetes and related topics.^{20,23} The other alternative was individual counselling, the topics being healthy diet, physical activity, smoking, and alcohol intake, depending on the women's needs,^{20,23} and more emphasis on encouraging the women to participate in the activities of other local organizations supporting prevention of T2D.²³ Local circumstances of the health care units, as well as resources had an influence on the frequency of individual visits and group interventions.²⁰

In total, 1,661 women participated in baseline examinations between January 17, 2004 and August 28, 2007 (Fig. 1). Of these women, 793 made follow-up visits; 507 of them had visits between January 17, 2005 and June 12, 2008, i.e., 9–18 months after the baseline examination, and this was consid-

ered a 1-year follow-up.²⁰ Of these women, 393 did not have screen-detected T2D (ST2D) based on the OGTT at baseline,²⁰ and 265 of them made at least one intervention visit and comprised the study population of this study, with 115 (43.4%) women with a history of GDM and 150 (56.6%) without a history of GDM.

Statistical analyses were performed by using SAS 9.2 for Windows (SAS Institute). Cross-tabulation, chi-square test, and independent sample *t*-test were used to investigate the differences in baseline cardio-metabolic risk profile and changes in profile during the 1-year follow-up between women with and without a history of GDM. Logarithmic transformation was used for serum triglycerides at baseline. Analysis of covariance was used to study the differences between baseline cardio-metabolic risk profile and changes in profile during the 1-year follow-up between women with and without GDM after adjustment for age as a continuous variable, respective outcome variable and BMI at baseline. Logistic regression analyses were used when studying baseline MetS and incidence of T2D during the follow-up according to GDM after adjustment for age. Paired samples *t*-test was used when examining changes in cardio-metabolic risk profile

FIG. 1. Flowchart of women aged ≤ 45 years at high risk for type 2 diabetes (T2D) in the Finnish diabetes prevention program (FIN-D2D). ST2D, screen-detected T2D.

during the 1-year follow-up within women with and without GDM. Independent sample *t*-test was used to study differences in age and cardio-metabolic risk factor profile at baseline between women who had participated in the follow-up visit (including also participation beyond the 1-year follow-up) and those who had not, and also between women who had participated in the 1-year follow-up visit and those who had participated in another follow-up visit beyond the 1-year follow-up visit. Furthermore, women who comprised the study group were compared to women who had a follow-up visit, but who had no lifestyle intervention visits (see Fig. 1).

Results

Age and the cardio-metabolic risk profile at baseline did not differ between women who participated in the follow-up visit and those who did not. Women who participated in the 1-year follow-up were older (mean age 38.4 years, SD 5.8) than women who had a follow-up visit beyond the 1-year follow-up (mean 37.6 years, SD 5.8, $p=0.05$). Similarly, women without screen-detected T2D who participated in the 1-year follow-up were older (mean 38.2 years, SD 5.7) than women who had a follow-up visit beyond the 1-year follow-up (mean 37.2 years, SD 5.7, $p<0.05$). There were no differences in age and cardio-metabolic risk profile at baseline

between women in the final study group compared with women who had a follow-up visit, but no lifestyle intervention visit.

Women with a history of GDM were younger and had a better cardio-metabolic risk profile at baseline than women without a history of GDM (Table 1). After adjustment for age, the differences between women with and without GDM in fasting ($p=0.084$) and 2-hour glucose ($p=0.173$) were not statistically significant. Overall, 51.3% of the women with a history of GDM had MetS at baseline compared to 64.7% of those without a history of GDM ($p=0.086$ after adjustment for age). Of women with a history of GDM, 70.3% had NGT, 8.1% IFG, and 21.6% IGT at baseline; the corresponding proportions for women without a history of GDM were 55.8%, 14.3%, and 29.9%, respectively ($p=0.053$). Women with a history of GDM had a lower mean FINDRISC score (14.4, SD 3.74) than women without a history of GDM (16.3, SD 2.33, $p<0.001$).

During the 1-year follow-up, only 26.8% ($n=26$) and 31.5% ($n=39$) of the women with a history of GDM and of those without a history of GDM, respectively, reported an increase in physical activity ($p=0.452$, between the groups). With regard to dietary habits, 55.7% ($n=54$) of women with a history of GDM and 63.2% of those without a history of GDM ($n=79$) reported dietary changes in a healthier direction ($p=0.256$, between the groups).

TABLE 1. BASELINE CARDIO-METABOLIC RISK PROFILE AND CHANGES IN RISK PROFILE DURING THE ONE-YEAR FOLLOW-UP IN WOMEN AGED ≤ 45 YEARS WITH AND WITHOUT A HISTORY OF GESTATIONAL DIABETES MELLITUS

	<i>Gestational diabetes mellitus</i>										
	<i>Yes</i>				<i>No</i>						
	<i>Baseline</i>		<i>Change</i>		<i>Baseline</i>		<i>Change</i>		<i>Baseline</i>	<i>Change</i>	
	<i>n</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>p^a</i>	<i>n</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>p^a</i>	<i>p^b</i>	<i>p^c</i>	<i>p^d</i>
Age	115	35.7 (5.95)			150	39.9 (4.81)			<0.001		
Fasting glucose (mmol/L)	86	5.41 (0.47)	0.04 (0.48)	0.490	109	5.70 (0.64)	-0.11 (0.55)	0.038	<.001	0.052	0.734
2-hour glucose (mmol/L)	86	6.41 (1.87)	-0.03 (1.52)	0.871	109	6.94 (1.81)	-0.39 (1.83)	0.029	0.045	0.144	0.179
Weight (kg)	115	82.5 (19.4)	-0.61 (5.39)	0.226	150	90.8 (18.0)	-2.4 (9.99)	0.003	<.001	0.077	0.877
BMI (kg/m ²)	114	30.3 (6.64)	-0.27 (1.96)	0.147	149	33.7 (6.30)	-0.90 (3.58)	0.003	<.001	0.091	0.862
Waist (cm)	107	96.2 (15.6)	-1.6 (7.07)	0.018	146	103 (12.9)	-1.6 (6.65)	0.004	<.001	0.978	0.311
Systolic BP (mmHg)	109	125 (12.7)	-0.70 (8.61)	0.397	149	134 (15.7)	-1.5 (13.8)	0.193	<.001	0.605	0.149
Diastolic BP (mmHg)	109	80 (10.2)	-0.22 (7.42)	0.752	149	87 (9.65)	-1.4 (8.00)	0.004	<.001	0.247	0.577
Total cholesterol (mmol/L)	94	4.75 (0.77)	-0.07 (0.65)	0.284	137	5.04 (0.84)	-0.11 (0.62)	0.045	0.009	0.680	0.256
HDL cholesterol (mmol/L)	93	1.44 (0.40)	0.08 (0.33)	0.025	137	1.32 (0.31)	0.02 (0.18)	0.124	0.013	0.110	0.084
LDL cholesterol (mmol/L)	93	2.76 (0.70)	-0.21 (0.69)	0.004	137	3.04 (0.78)	-0.09 (0.56)	0.058	0.006	0.153	0.014
Triglycerides (mmol/L)	93	1.24 (0.61)	0.12 (0.70)	0.115	137	1.49 (0.66)	-0.09 (0.58)	0.081	0.003	0.018	0.853

^a*p*-value for paired samples *t*-test.

^b*p*-value for independent sample *t*-test comparing differences at baseline characteristics between gestational diabetes mellitus (GDM) groups.

^c*p*-value for independent sample *t*-test comparing differences in changes of characteristics during the follow-up between GDM groups.

^d*p*-value for analysis of covariance comparing changes in cardio-metabolic characteristics after adjusting for age, outcome variable and BMI at baseline.

BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD, standard deviation.

Table 1 shows changes in cardio-metabolic risk profile during the 1-year follow-up within and between women with and without GDM with adjustments for age, outcome variable of interest, and BMI at baseline. Within women with GDM, waist circumference and LDL cholesterol decreased and HDL cholesterol increased during the follow-up. Instead, within women without history of GDM, there was a reduction in fasting and 2-hour glucose, weight, BMI, waist circumference, diastolic blood pressure, and total cholesterol. However, bivariate analyses showed that changes in cardio-metabolic risk profile were not different between women with and without a history of GDM, the only exception being LDL cholesterol; i.e., the reduction was greater in women with GDM after adjustment for age, outcome variable, and BMI at baseline, $p=0.014$ (Table 1).

Among women with a history of GDM glucose tolerance status deteriorated in 9.3%, remained unchanged in 75.3%, and improved in 15.5%. The corresponding proportions for women without a history of GDM were 13.6%, 66.1%, and 20.3% ($p=0.338$), respectively. During the 1-year follow-up, T2D developed in 4.0% ($n=4$) of the women with a history of GDM and in 5.0% ($n=6$) of those without a history of GDM ($p=0.959$ after adjustment for age).

Discussion

Our study showed that 43.4% of the Finnish women at high risk for T2D aged ≤ 45 years participating in the FIN-D2D program had a history of GDM. The women with a history of GDM had a similar glucose tolerance status and prevalence of MetS, but a better cardio-metabolic risk profile at baseline than women without a history of GDM after adjustment for age. Among women with a history of GDM, beneficial changes in waist circumference and in LDL and HDL cholesterol were observed during the 1-year follow-up, and among women without GDM, beneficial changes were seen in fasting and 2-hour glucose, anthropometric characteristics, diastolic blood pressure, and total cholesterol. The effect of lifestyle intervention on cardio-metabolic risk profile and incidence of T2D during the 1-year follow-up did not differ between women with and without a history of GDM.

While some studies have shown that women with a history of GDM tend to have a worse cardio-metabolic risk profile than women without GDM,^{5,6} our study showed that women with a history of GDM had, in general, a better cardio-metabolic risk profile at baseline than those women without a history of GDM, but who were at high risk for T2D. We did not have information on pregnancies; thus, we cannot speculate about the time elapsed since the last pregnancy. Women with a history of GDM may have received lifestyle advice earlier and adhered to a healthier lifestyle due to GDM diagnosis during their pregnancy. In Finland, practically all pregnant women visit maternity welfare clinics about 12–15 times where they receive free-of-charge health counselling and health care.²⁹ Women with GDM are treated more intensively and most of them receive dietary and other lifestyle advice.³⁰ It has been also shown that women's smoking and intake of alcohol and caffeinated drinks are decreased during pregnancy.³¹

Routine OGTT is also performed in all pregnant women for screening of GDM between the 24th and 28th weeks of pregnancy, and if the risk is high, the test is performed earlier, between the 12th and 16th weeks.³⁰ Today, diagnostic limits

for GDM in fasting glucose are ≥ 5.3 mmol/L, after 1 hour ≥ 10.0 mmol/L, and after 2 hours ≥ 8.6 mmol/L.³⁰ However, during the time when women with GDM were referred to the FIN-D2D program, diagnostic limits for GDM were ≥ 4.8 mmol/L, ≥ 10.0 mmol/L, and ≥ 8.7 mmol/L for fasting, 1-hour, and 2-hour glucose, respectively.³² As the diagnostic cutoff value for GDM in fasting glucose is now higher, our study may also include women in the GDM group who would not today be classified as having GDM.

Our finding that lifestyle intervention yielded only modest improvements in cardio-metabolic risk profile within women with a history of GDM is in line with the results of an earlier lifestyle intervention study that reported reduction in waist circumference along with other anthropometric measures during the follow-up in women with previous GDM.¹⁷ The reason why only modest improvements were seen in our study in women with GDM may be that these women may not perceive themselves as being at high risk for T2D after delivery. It has been shown, for example, that only 16% of women with previous GDM believed themselves to be at high risk for T2D, and women with greater perceptions of risk intended more often to change their lifestyle in a healthier direction.¹⁹ Common barriers to lifestyle changes in women with GDM have been child care duties, fatigue, work-related obstacles, and lack of time and motivation¹⁸ and—for example, in a behavioral intervention study among women with GDM—an increase in physical activity targets was not attained.¹⁴ Our result of the effect of lifestyle intervention on the incidence of T2D between women with and without GDM is in line with the results of the DPP trial.¹² However, the results are difficult to compare due to differences in study designs. We cannot analyze in detail the true effectiveness of our intervention due to the lack of counselling data collected. We suggest that novel approaches, such as Internet-based lifestyle interventions,¹⁸ may also be useful in order to benefit more from lifestyle interventions in women with GDM. An interesting finding was also that a high number of women at risk did not participate in the program at all after the baseline, reflecting the situation “in real life.”

Our study has its limitations. It was conducted in a real-life setting and was not a randomized controlled trial; thus, no formal control group existed. In addition, the study was based on the secondary analyses of the data of the FIN-D2D. Therefore, we do not know whether women with a history of GDM were treated with diet or insulin during their pregnancy. Furthermore, there was no information as for how many pregnancies with or without GDM they had had and how much time had passed since their last delivery with GDM. What is more, we do not know whether the women without a history of GDM had ever been pregnant and whether they have had for example polycystic ovarian syndrome, which can cause infertility and is related to a worse cardio-metabolic risk profile.³³ In addition, it should be noted when interpreting the results of changes in glucose tolerance that the glucose tolerance status is not stable over time. Worsening insulin resistance and β cell dysfunction are well-known reasons for glucose intolerance during gestation.³⁴ Because about one in ten Finnish women with a history of GDM will develop diabetes in the near future, and about half of them will develop type 1 diabetes,⁴ our study may also include women, who were developing type 1 diabetes, which may also affect the current results. In our study, 5% of women

developed diabetes during the 1-year follow-up, which shows that they truly were at increased risk.

The strength of this study was that this was the first national effort to implement prevention of T2D in a primary health care setting, which gave us the opportunity to study the effect of lifestyle intervention in women with and without GDM.

Conclusions

We conclude that women at high risk of T2D benefitted from the participation in the 1-year lifestyle intervention conducted in a primary healthcare setting regardless of a history of GDM. The effect of lifestyle intervention did not differ between women with and without a history of GDM in terms of changes in glucose tolerance, incidence of T2D and changes in cardio-metabolic risk profile, except lowering of LDL-cholesterol in women with GDM. Surprisingly, a relatively small proportion of the women screened were willing to participate in the 1-year program. Therefore, in the future, motivation and more intensive lifestyle interventions and new approaches to lifestyle interventions in women with GDM are needed in order to benefit more from interventions in this particular risk group. In addition, the effect of lifestyle intervention in women with and without a history of GDM should be examined by using larger datasets and in controlled study design settings.

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Disclosure Statement

No competing financial interests exist.

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