Effects of Weight Reduction on Body Mass Index, Hemoglobin A1c, and Insulin Concentration among Type 2 Diabetic Obese Palestinian Females

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دراسة تأثير خفض الوزن على مؤشر كتلة الجسم وتركيز الهيموجلوبين السكري والأنسولين لدى الإناث الفلسطينيات البدينات المصابات بالنوع الثاني من مرض السكر

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Abstract

We aimed to investigate the effects of weight reduction on body mass index, hemoglobin A1c, insulin, glucose and lipid profile among type 2 diabetic obese females in Gaza strip, Palestine.

This prospective study included 50 obese type 2 diabetic females (30-60 years old) as cases and 50 apparently healthy age-matched females as controls for baseline comparisons. A low-calorie diet (1200–1500 Kcal/day) and a daily aerobic activity program were prescribed to obese diabetic females for 24 successive weeks. The study variables were measured and statistically compared to those of the controls. At baseline, body mass index, hemoglobin A1c, insulin, glucose, and lipid profiles showed significant differences between cases and controls. After 24 weeks of weight reduction program, there were significant decreases in body mass index, hemoglobin A1c percentage, insulin and glucose concentrations in obese diabetic females compared to their baseline levels ($P < 0.05$). Cholesterol, triglyceride, and low-density lipoprotein levels were significantly decreased among obese females with type 2 diabetes after weight reduction program compared to their baseline levels. Following the 24-week weight loss program, BMI in diabetic obese women showed a statistically significant positive correlation with HbA1c levels, insulin, glucose, cholesterol, triglyceride, and LDL-C levels ($P < 0.01$), while HDL-C) concentrations were non-significantly increased. Weight reduction using a low-calorie diet combined with aerobic exercise improves body mass index, hemoglobin A1c, insulin and lipid profile. This weight reduction program is associated with better glycemic control, which may justify a lower antidiabetic dose in obese diabetic females. Such weight reduction may also decrease cardiovascular complications in individuals with type 2 diabetic.

Keywords: Hemoglobin A1c, Insulin, Body-Mass Index, Weight Reduction, Diabetes, Palestinian females

الملخص:

هدفت الدراسة الى معرفة تأثير خفض الوزن على مؤشر كتلة الجسم، ومستوى الهيموجلوبين السكري، الأنسولين، الجلوكوز، ومستوى الدهون لدى الإناث البدينات المصابات بالنوع الثاني من مرض السكر في قطاع غزة، فلسطين.
تكونت عينة الدراسة من 50 انثى بدينة مصابة بالنوع الثاني من مرض السكر تتراوح أعمارهن بين 30-60 سنة عاماً ليمثلن مجموعة الحالات بالإضافة الى 50 انثى من اللواتي يبدو أنهن يتمتعن بصحة جيدة من نفس العمر كمجموعة ضابطة. تم إعطاء النظام الغذائي منخفض السعرات الحرارية (1200-1500 سعرة حرارية / يوم) متزامن مع برنامج من الأنشطة الهوائية اليومية للإناث البدينات المصابات بداء السكري لمدة 24 أسبوعًا. تم قياس متغيرات الدراسة وتقييمها إحصائيا ومقارنتها مع المجموعة الضابطة. أظهرت نتائج الدراسة اختلافات وفروقات كبيرة في مؤشر كتلة الجسم والهيموجلوبين السكري والأنسولين والجلوكوز والدهون عند مقارنة مجموعة الحالات ومع المجموعة الضابطة. بعد 24 أسبوعًا من المداومة على برنامج خفض الوزن والحمية الغذائية، لوحظ انخفاض كبير في مؤشر كتلة الجسم، ومستوى الهيموجلوبين السكري تركيز الجلوكوز لدى الإناث البدينات المصابات بداء السكري عند مستوى الدلالة $P < 0.05$). بينما انخفض مستوى الكوليسترول والدهون الثلاثية والبروتين الدهني منخفض الكثافة بشكل ملحوظ، بينما شهد مستوى البروتين الدهني عالي الكثافة (HDL) زيادة غير ملحوظة لدى النساء البدينات المصابات بداء السكري من النوع الثاني وذلك بعد المداومة على برنامج إنقاص الوزن مقارنة بما قبل الدراسة. كما ظهرت بعض العلاقات ذات دلالة إحصائية بين متغيرات الدراسة المختلفة. أظهر مؤشر كتلة الجسم لدى النساء البدينات المصابات بالسكري ارتباطًا إيجابيًا كبيرًا مع مستويات الهيموجلوبين السكري، والإنسولين، والجلوكوز، والكوليسترول، والدهون الثلاثية،
($P < 0.01$). خلصت الدارسة الى ان إنقاص الوزن باستخدام نظام غذائي منخفض السعرات الحرارية إلى جانب التمارين الرياضية الهوائية يحسن بشكل كبير مؤشر كتلة الجسم، ومستويات كل من الهيموجلوبين السكري، الأنسولين والدهون. كما خلصت الدراسة أيضا الى ان برنامج إنقاص الوزن له المقدرة على التحكم بشكل جيد في نسبة السكر في الدم، مما قد يبرر تقليل جرعة أدوية مرض السكر، وتقليل مضاعفات القلب والأوعية الدموية لدى الإناث البدينات المصابات بالسكري من النوع الثاني.

الكلمات المفتاحية: الهيموجلوبين السكري، الأنسولين، مؤشر كتلة الجسم، إنقاص الوزن، السكري

Introduction

Obesity is a chronic, multifactorial disease, its prevalence continues to increase in both developing and developed countries (Haidar & Cosman, 2011). The increasing prevalence of obesity has been also reported in Palestine in general (Abdeen et al., 2012) and Gaza strip in particular (El Kishawi et al., 2016). Type 2 diabetes (T2D) is strongly associated with obesity (Powers et al., 2020; Vázquez et al., 2023), and increased cardiovascular risk (ElSayed et al., 2023; Zatterale et al., 2020). Obesity is thought to be responsible for about 80–85% of T2D risks (Ortega et al., 2020). Obesity is related to T2D by a number of pathways, including adipose tissue remodeling as a result of unhealthy behaviors (Carbone et al., 2019). The most effective nutritional intervention is a dietary program that promotes weight reduction while maintaining the required nutrition. Several studies have shown that low carbohydrate diets may help people lose weight, especially those who are obese or overweight (Goldenberg et al., 2021; Kelly et al., 2020; Mwafy et al., 2018). Low carbohydrate diet combined with aerobic exercise were found to be a promising strategy for controlling metabolic variables (Macedo et al., 2020).

Insulin is the key hormone that stimulate glucose and fatty acid storage following meal intake, while exercise is a state in which energy reserves must be mobilized (Al-Ibraheem et al., 2024; Morigny et al., 2021). In this study, we aimed to evaluate the effects of weight reduction on body mass index, HbA1c, insulin, glucose, and lipid profile concentrations before and after weight reduction, based on low calorie diet and aerobic exercise among Palestinian obese type 2 diabetic females. To the best of our knowledge, and based on our search of scientific literature, the current study may be the first to specifically examine the relationship between Body mass index (BMI), hemoglobin A1c (HbA1c), insulin, glucose, and lipid profile concentrations in obese diabetic Palestinian females after programmed weight reduction and aerobic exercise.

Methods

Study population and Study design

This prospective study includes 100 samples based on evaluation of obesity among type 2 diabetic females aged (30-60) years in Gaza strip. Cases comprised of 50 obese diabetic females having BMI >30 kg/m^2, a fasting blood glucose level >150 mg/dl, and receiving daily hypoglycemic drugs all over the period of the study (Rochester & Akiyode, 2014; Zhang et al., 2010). In addition, an equal number of apparently healthy females have BMI 18.5-24.9 kg/m^2 and fasting glucose level <90.0 mg/dl were selected as a control group. The sample size was calculated using EPI-INFO statistical package version 3.5.1 that was used with 95% CI, 80% power and 50% proportion as conservative and OR>2. The sample size is in a case of 1:1 ratio of case to control was 46. For a no-response expectation, the sample size was increased to 50 females in the case group and 50 females in the control group.

Study variables: Diagnosis of T2D was in accordance with the criteria of the World Health Organization: fasting plasma glucose ≥ 126 mg/dl, 2-hr glucose ≥ 200 mg/dl and HbA1c of 5.7%-6.4% (WHO, 2006). Before and after the 24-week weight reduction program, all individuals had anthropometric measurements and blood samples for biochemical evaluations. The study was conducted under physician supervision at private nutritional centers in Gaza strip. Exclusion criteria were including a pregnant or lactating women and female with severe hepatic or renal diseases, and subjects taking medications that might affect body weight or glucose metabolism.

Ethical considerations: All study participants completed and signed the informed consent form of the study. This study was approved by the Gaza Strip's Helsinki Committee under ethical approval number PHRC/HC/301/17.

Weight reduction program and dietary intervention: The weight reduction program consisted of individual intervention sessions designed to implement behavior strategies related to eating and physical activity, with the goal of achieving and maintain wight reduction. The participants were maintained on low calorie diet (1200-1500 Kcal) and regular aerobics exercise (30-50 min/day, 4-5 days/week). The subjects performed these daily exercises for 24 weeks and visited the clinic every month for consultations. Physicians, who took full medical histories, conducted physical examinations and medically evaluated all the individuals. In every visit, participants have been asked about health and/or any problem that they may have or encountered during the study.

Body mass index measurements: Measurements to calculate BMI were taken for each participant in light clothing and without shoes. Height and weight were measured by automatic height-weight scale (Detecto DR400C, USA), to the nearest 0.1 cm and 0.1 kg, respectively. Weight (kg) divided by height (m^2) was used to compute BMI (kg/m^2).

Specimen collection and processing: Blood samples were collected in the morning after 12 hours of overnight fasting in a lavender top tube. The serum was immediately separated by centrifugation for 10 minutes at 2500 rpm. Whole blood HbA1c was determined by immunoturbidity method (Weykamp et al., 1995). Insulin was determined by a solid phase enzyme-linked immune sorbent assay (MacDonald & Gapinski, 1989). Glucose, cholesterol and triglycerides were measured by enzymatic colorimetric method (Fossati & Prencipe, 1982; Lott & Turner, 1975; Richmond, 1973). Liquid HDL-C precipitant for the measurement of HDL-C using Diasys Diagnostic Systems, Germany, while LDL-C was calculated using the empirical relationship of Friedewald (Grove, 1979).

Data analysis: The IBM SPSS program for Windows, version 21.0, was used to tabulate, and statistically analyze the data. Frequency and proportions were used to express qualitative data, and the Chi-square test was used to determine how the proportions differed. The percentage change and independent-samples t-test were also used to calculate the variance in means across groups. *P*-values less than 0.05 were considered as the statistically significant limit.

Results

Table 1 displays the sociodemographic data of the study participants. The age of the study population ranged from 30-60 years with mean of 33.3±5.9 years for obese diabetic females and 32.7±7.1 years for controls (χ^2= 0.43 and *P*=0.9). A greater percentage of participants female (36.0%) among obese diabetic females and among non-obese females (38.0%) were in the younger age group (30-40 years). Most of obese diabetic females (54%) were single and46% were married. Forty two percent of obese diabetic females were employee and 58% were non-employee. Baseline comparisons before weight reduction program are shown in Tables 2 and 3. BMI in obese diabetic group before weight reduction was significantly higher compared to non-obese females (36.6±5.1 vs 22.0±2.0 kg/m^2, *P*<0.001). The mean levels of HbA1c (7.8±1.1% vs 4.5±0.55%), insulin levels (24.1±6.5 µIU/ml vs 14.9±5.2 µIU/ml) and glucose (201.2±37.6 mg/dl vs 80.0±7.1 mg/dl) were significantly elevated in obese female with T2D compared to control group. Table 4 revealed that cholesterol, triglyceride, and low-density lipoprotein (LDL-C) concentrations were significantly increased in obese diabetic group before weight reduction compared to non-obese group (*P*<0.05). High-density lipoprotein (HDL-C) concentrations were non significantly increased in obese diabetic group before weight reduction compared to non-obese group (*P*>0.05).

After 24 weeks of weight reduction program (Tables 2, 3), the BMI in diabetic obese females were markedly decreased from baseline with percentage change (-17.2, *P*<0.001). The mean levels of HbA1c (6.7±0.56% vs 7.8±1.1%), insulin (16.8±4.8 vs 24.1±6.5 µIU/ml, *P*<0.001) and glucose (148.8 ±18.9 mg/dl vs 201.2±37.6 mg/dl) concentrations showed a significant decrease in obese diabetic females after applying low-carbohydrate diet program compared to baseline, with percentage change -14.1, -30.3 and -26.0 respectively, *P*<0.001. The mean levels of cholesterol, triglyceride and low-density lipoprotein were significantly decreased in obese diabetic females after weight reduction program compared to their levels before weight reduction with percentage of change (-17.5%, -34.7% and -21.6%, respectively, *P*<0.001).

Analyses using Pearson correlation coefficient revealed significant correlations between BMI and study parameters (Table 5). Statistically significant positive correlations were found between BMI with HbA1c (r = 0.75, *P<0.001*), insulin (r = 0.55, *P≤0.05*) and glucose (r = 0.78, *P<0.001*), cholesterol, triglyceride and LDL-C (*P<0.01*) concentrations.

Table 1. Socio-demographic characteristics of the study population

Character	Non-Obese female		Obese female		*P*-value
	No.	%	No.	%	
Age (Years)					0.90
30-40	19	38	18	36	
41-50	16	32	16	32	
51-60	15	30	16	32	
Mean±SD	32.7±7.1		33.3±5.9*		
Marital status					0.67
Single	29	58	27	54	
Married	21	42	23	46	
Employee status					0.68
Employment	19	38	21	42	
Unemployment	31	62	29	58	
Education					0.89
Primary	10	20	9	18	
Secondary	12	24	14	28	
University or Diploma	28	56	27	54	

Each reading represents Mean ±SD of 50 subjects.
*The significant of difference was checked by chi square test, significant at $P < 0.05$.

Table 2. Anthropometric measurements before and after weight reduction

Anthropometric measurement	Non-Obese female	Obese female		% Change	*P*-value
		Before weight reduction	After weight reduction		
Weight (kg)	55.4±5.6	92.9±15.1[a]	76.9±8.7 [a, b]	67.7 -17.2	0.001
Height (cm)	158.8±3.9	159.2±4.9	159.2±4.9	0.25 0.0	0.87
BMI (kg/m²)	22.0±2.0	36.6±5.1[a]	30.3±3.2 [a, b]	66.4 -17.2	0.001

Kg: kilogram, cm: centimeter, BMI: Body mass index: People with BMI=18.5.24.9 were considered to have normal weight and people with BMI ≥ 30.0 were classified obese.
Each reading represents Mean ±SD of 50' subjects.
[a] The significant of difference was checked by one-way ANOVA test (compare all vs. control), significant at $P<0.05$.
[b] The difference in obese before and after weight reduction were checked by one-way ANOVA was significant at $P<0.05$.

Table 3. Hemoglobin A1c, Insulin and Glucose levels before and after weight reduction

Parameter	Non-Obese female	Obese female		% Change	*P*-value
		Before weight reduction	After weight reduction		
HbA1C (%)				73.3	0.001

	4.5±0.55	7.8±1.1 [a]	6.7±0.56 [a, b]	-14.1	
Insulin (µIU/ml)	14.9±5.2	24.1±6.5 [a]	16.8±4.8 [a, b]	61.7 -30.3	0.001
Glucose (mg/dl)	80.0±7.1	201.2±37.6 [a]	148.8±18.9 [a, b]	151.5 -26.0	0.001

HbA1c: hemoglobin A1c.
Each reading represents Mean ±SD of 50 subjects.
[a] The significant of difference was checked by one-way ANOVA test (compare all vs. control), significant at $P < 0.05$.
[b] The difference in obese before and after weight reduction were checked by one-way ANOVA was significant at P<0.05.

Table 4. Lipid profile before and after weight reduction

Parameter	Non-Obese female	Obese female		% Change	*P*-value
		Before weight reduction	After weight reduction		
Cholesterol (mg/dl)	150.8±28.3	214.3±41.5 [a]	176.7±32.4 [a, b]	42.1 -17.5	0.001
Triglyceride (mg/dl)	82.5±44.6	156.5±43.1 [a]	102.2±50.7 [b]	89.7 -34.7	0.001
HDL-C (mg/dl)	52.9±8.1	54.1±8.9	55.2±9.8	2.3 2.0	0.46
LDL-C (mg/dl)	81.4±20.4	128.9±40.3 [a]	101.1±26.5 [a, b]	58.4 -21.6	0.001

LDL-C: Low density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol.
Each reading represents Mean ±SD of 50 subjects.
[a] The significant of difference was checked by one-way ANOVA test (compare all vs. control), significant at $P < 0.05$.
[b] The difference in obese before and after weight reduction were checked by one-way ANOVA was significant at P<0.05.

Table 5. The correlation of BMI with study parameters

Parameters	BMI (Kg/m^2)	
	Pearson correlation (r)	*P*-value
HbA1C (%)	0.75**	0.001
Insulin (µIU/ml)	0.55*	0.05
Glucose (mg/dl)	0.78**	0.001
Cholesterol (mg/dl)	0.51**	0.001
Triglyceride (mg/dl)	0.46**	0.001
LDL-C (mg/dl)	0.47**	0.001

HbA1c: hemoglobin A1c, LDL-C: Low-density lipoprotein cholesterol.
** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Discussion

After 24 weeks of a low-calorie diet and aerobic activity regimen, baseline comparisons indicated that BMI in obese diabetic females is significantly decreased. These findings concurred with those of other authors (Wang et al., 2018; Zubrzycki et al., 2018). The BMI of obese females with T2D may be improve by dietary interventions using a low-calorie diet and aerobic exercise (Memelink et al., 2023). According to Fortin et al., in 2018, people with diabetes and metabolic syndrome may benefit from a six-month non-restrictive dietary intervention for weight management (Fortin et al., 2018). Exercise plus a low-calorie diet can effectively reduce body weight, fat mass, and waist size (Arrebola et al., 2011; Gitsi et al., 2024). Maintaining a healthy lifestyle results in weight reduction and improving nutrition while engaging in at least 30 minutes of daily physical exercise may help prevent cardiovascular disease in obese people (Gaesser et al., 2011). Significant positive correlations were found between BMI with HbA1c, insulin and glucose concentrations. Two ways in which exercise has the potential to promote body weight reduction: the energy used in exercise contributes to the negative energy balance and exercise lead weight reduction following calorie restriction to a satisfactory composition (Philippou et al., 2012). This shows that exercise as part of a weight reduction program can have positive impacts on body composition.

Our results demonstrated that the mean levels of HbA1c, insulin, and glucose in obese females with T2D decreased significantly after six-month of applying low-carbohydrate diet program combined with aerobic exercise compared to their pre-study values. These results are coinciding with previous ones (Unwin & Unwin, 2014; Wang et al., 2018). According to Yamada et al., HbA1c levels dramatically decreased in the low carbohydrate diet group by 7.9%and only 2.6% in the calorie-restricted group (Yamada et al., 2014). The dietary carbohydrates stimulates insulin secretion, which, then promotes glucose oxidation, inhibit lipid oxidation, enables lipogenesis, and promotes fat storage while also leading to insulin resistance, inflammation, and oxidative stress (Magkos et al., 2010; Zheng et al., 2023). Hyperinsulinemia and insulin resistance together impair lipid metabolism and raise the risk of cardiovascular disease, the leading cause of death in people with T2D. (Morrish et al., 2001). Low carbohydrate diet decreases insulin secretion, metabolic processes changes to better lipid oxidation over lipid storage. The consequence is an improvement in the lipid profile, and lipotoxic processes that impair pancreatic β-cell function and insulin action resolve (Brun et al., 2022). Some studies have shown how low carbohydrate diets can enhance metabolic health and reduce medication use in type 2 diabetic patients as well as help healthy people lose weight and improve their metabolic health (Hussain et al., 2012; Mayer et al., 2014). Decrease in body fat led to decrease in the fat in both liver and pancreas, and release from the fat-induced metabolic inhibition leads to resumption of regular activity (Taylor, 2013). Weight reduction program is associated with better glycemic control that may justifies a lower antidiabetic dose in the obese diabetic females. Such weight reduction may also decrease the type 2 diabetic cardiovascular complications.

The findings show that cholesterol, triglyceride, and low-density lipoprotein levels dramatically decreased in obese diabetic females following weight reduction programs when compared their levels before the study. Our results are concomitant with other findings (Chen et al., 2020; Mwafy et al., 2018). The pathophysiology of obesity dyslipidemia is multifactorial because obesity increases cardiovascular risk as result to increased fasting plasma triglycerides, high LDL cholesterol, low HDL cholesterol, elevated blood glucose and insulin levels, and high blood pressure (Klop et al., 2013). Positive correlations were obtained between BMI with cholesterol, triglyceride and LDL-C. Similar results were previously obtained (Mwafy et al., 2020). Restricting carbohydrates lowers insulin production, which may help mobilize fat, especially from the intraabdominal region, a depot implicated to metabolic disorders that is increased in type 2 diabetics (Fisher et al., 2011; Zheng et al., 2023). Our nutritional intervention is built around a weight reduction program that combines aerobic activity, better eating habits, and a reduction in overall calorie consumption. Changes in lifestyle can improve both insulin resistance and dyslipidemia, so therapeutic options for treating dyslipidemia brought on by obesity should include weight reduction, exercise, and a balanced diet. Dietary carbohydrate restriction also produced beneficial changes in body composition, fat distribution, and glucose metabolism that may reduce the risk of T2D.

Conclusions

In obese diabetic females, glycemic control was correlated with weight reduction via a low-calorie diet and aerobic activity. The body mass index, HbA1c, insulin concentrations, and lipid profiles of obese diabetic females can be significantly improved. A weight loss program has been correlated with improved glycemic control in female obese diabetics, which may enable a lower antidiabetic regimen. weight loss could may help to reduce the cardiovascular complications associated with type 2 diabetes.

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