CASE REPORT

Reversal of type 2 diabetes mellitus in an obese man: Role of dietary modification and physical activity

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Abstract

Reversal of Type 2 diabetes mellitus (Type 2 DM) in obese patients with short-term history of diabetes has been seen. However, achieving such reversal in patients with long-term history of diabetes and maintaining long-term metabolic control with dietary modification and physical activity (PA) has not been documented. The aim of this paper is to report a novel case of an obese man (BMI = 43.6 kg/m^2) in his fifties with a 20-year history of Type 2 DM, dyslipidemia and hypertension treated with medication who was able to reverse these disorders and stop all medications after being exposed to a very low-calorie diet (VLCD) for 16 weeks. With this treatment he was able to reduce his weight by 15.3% (BMI = 37.0 kg/m^2) and his laboratory values were normal including a glycated hemoglobin (HbA1c) of 6.0%. Continuing with the combination of low-calorie diets (LCDs) and a supervised moderate-intensity exercise program for a period of 10 months, he reduced his weight by another 12.7% (BMI = 31.4 kg/m^2) and his laboratory values remained normal. At > 3 years of follow-up with the combination of weight-maintenance diet, supervised moderate-intensity exercise program and counselling his BMI is 32.9 kg/m^2 and he maintains adequate metabolic control including an HbA1c that stays $\leqslant$ 6.5%. Although future clinical research is needed to confirm these findings, this case-report demonstrates that dietary modification and PA can reverse Type 2 DM and provide long-term protective effects against obesity-associated disorders in patients with a long-history of Type 2 DM.

Keys words

Type 2 diabetes mellitus, Very-low calorie diet, Low calorie diet, Physical activity.

1 Introduction

Type 2 diabetes mellitus (Type 2 DM) is a highly prevalent chronic disease in obese patients and is characterized by defects in both insulin action and secretion. A recent study demonstrated that, with a very low-calorie diet (VLCD), the twin defects of beta cell failure and insulin resistance that underlie Type 2 DM in obese patients was reversible; the participants selected had a relatively short duration of Type 2 DM (up to 4 years) [1]. However, achieving such reversal in patients with long-term history of diabetes and maintaining long-term metabolic control with dietary modification and physical activity (PA) has not been documented. It is clearly demonstrated that beta cell function declines linearly with time in patients with Type 2 DM in such a way that after 10 years > 50% of these patients require insulin therapy [2]. Therefore, the aim of this paper is to describe the case of an obese patient having a 20-year history of type 2 DM who was

able to reverse his diabetic condition and maintain long-term metabolic control with dietary modification combined with PA.

2 Case report

This case report presents an obese man in his fifties with a 20-year history of Type 2 DM, dyslipidemia and hypertension treated with Rosiglitazone, Glucophage, Glyburide, Atorvastatin, and Hydrochlorothiazide who presented to our clinic for weight loss after being treated at another obesity clinic. He was not presenting with any other comorbid conditions, he was a non-smoker, and reported refraining from alcohol and illicit drugs. At his first visit to the initial clinic, his weight was 130.5 kg, height 173 cm for a BMI of 43.6 kg/m^2, he had a normal blood pressure (< 130/80 mm Hg) and a normal physical exam. His laboratory results were within the recommended values for all metabolic variables [3]. The physician at this first clinic decided to put this patient on a VLCD. A VLCD provides 400-800 kcal/day of high-quality protein (1.2 to 1.5 g/kg of ideal body weight) and carbohydrate (approximately 50g/day) fortified with the recommended daily allowance of vitamins, mineral and trace elements. After 16 weeks of a VLCD, the patient achieved a 15.3% weight loss (130.5 kg to 110.5 kg with a new BMI of 37.0 kg/m^2). The patient stopped all medications six weeks prior to his first visit with us but remained asymptomatic with a normal glycemic control including glycated hemoglobin (HbA1c) of 6.0 %. It should be noted that these changes can only be attributed to the diet, since during that period, the patient remained sedentary (no physical activity), had not taken any drugs promoting weight loss either prescribed or over the counter and was not treated by bariatric surgery.

At his first visit with us, he was presenting with a BMI of 37.0 kg/m^2, with normal blood pressure (< 130/80 mmHg), a normal physical exam (including neurological and eye exam) and his laboratory results were within the recommended values for all metabolic variables [3]. Continuing to follow with a low-calorie diets (LCDs) combined with a supervised moderate-intensity exercise program for a period of 10 months, he reduced his weight by another 12.7% (BMI = 31.4 kg/m^2) and his laboratory values remained normal. Briefly, the LCD consisted of 1000-1200 kcal/day (45%-50% protein, 25%-35% carbohydrates, 15%-20% fat) fortified with the recommended daily allowance of vitamins, minerals, and trace elements. The supervised physical activity program was determined in consultation with an exercise specialist. The program was kept sustainable to help him lose weight and improve his cardiovascular fitness. The program was divided into 2 forms: 1). aerobic exercise, such brisk walking, jogging and stationary biking, to improve endurance capacity; and 2). resistance exercise, such as weight lifting to improve muscular strength and tonus. At the beginning the patient was doing 20 to 30 minutes of aerobic exercise at an intensity level of 50%-70% of maximum heart rate (220 minus age of patient) combined with a 20 to 30 minutes of resistance training 3 times/week that progressively increased to 45 minutes of aerobic exercise combined with 45 minutes of resistance training 5 times/week. During that period, the patient received counseling on dietary and physical interventions as described in a recent evidence-based Continuous Medical Education (CME) article by Plourde and Prud'homme [4].

After the LCD, the patient was put on a weight maintenance diet and continued to be involved in a supervised moderate-intensity physical activity program as described above. The weight maintenance diet was determined based on a balance between energy intake and energy expenditure to maintain desirable body weight and prevent weight regain. The diet consisted of 50% to 60% of total calories from carbohydrates preferably in the form of slowly absorbed sugars such as cereals and whole-grain bread; 20% to 30% of fat, but <7% saturated fat; and the rest as protein ($\approx$15% of total calories). The diet was rich in fiber (20-30 g/day), to help control appetite. The diet was monitored on a regular basis by a nutritionist. The patient also received counseling on strategies for maintaining long-term weight loss and preventing weight regain [4]. Three years after his first visit with us, his BMI is 32.9 kg/m^2, he has normal blood pressure and physical exam, and his laboratory tests remain below the target level including an HbA1c that stays $\leqslant$ 6.5%.

3 Discussion

VLCD is known to induce rapid weight loss and the metabolic benefits occur quickly with only modest (6.5%) weight reduction [5]. A recent study [1] demonstrated that, with an acute low energy balance alone (600 kcal/day), the twin defects of beta cell failure and insulin resistance that underlie Type 2 DM are reversed. Similarly, a recent Pro/Con article comparing between the role of gastrointestinal factors and those from food restriction to understand the mechanism involved in the reversal of Type 2 DM in obese patients after bariatric surgery concluded that an acute negative caloric restriction is all that is needed to reverse Type 2 DM [6].

Multiple mechanisms are involved in the improvement of glycemic control with VLCD to include reduced hepatic glucose output; increased insulin action in the liver and peripheral tissues; and enhanced insulin secretion [5]. VLCD also permits a significant improvement in obesity-associated comorbidities, particularly hypertension and dyslipidemia, reducing the development of diabetes-associated cardiovascular complications [1, 5]. Our case report provides case-based evidence that Type 2 DM, hypertension and dyslipidemia can be reversed by a sudden negative energy balance induced by a VLCD [1].

In an article by Taylor [7] it has been hypothesized that the abnormalities in insulin secretion and resistance in obese patients with Type 2 DM is related to an excess lipid accumulation in the liver and pancreas. Intrahepatic lipid content plays a central role in insulin resistance [8, 9]. As liver fat increases, the process of glucose production by the liver becomes less sensitive to insulin suppression resulting in an increase in plasma glucose and in basal insulin secretion [8, 9]. Simultaneously, the secretion of triglycerides (TRG) from the liver is increased [7]. As a result, all tissues will be exposed to a higher amount of TRG than necessary for normal body functions. Because, pancreatic islets are susceptible to local TRG accumulation [7], this leads to a desensitization of pancreatic beta cells resulting in a decrease in insulin secretion [10, 11].

Recent evidence demonstrated that reversal of Type 2 DM and restoration of normal beta cell function is simply due to a reduction in intra-organ fat in the liver and pancreas; interestingly, this can be produced by dietary modifications alone due to change in basal hepatic glucose production [1, 6]. Although not measured, it is possible that the initial 20 kg of weight lost, observed in our patient, was sufficient to remove fat from the liver and pancreas, allowing the return of normal liver glucose production, and improved insulin secretion [7].

Reversal of Type 2 DM has also been observed with moderate hypocaloric diet (≈1200 kcal/day) and after moderate weight losses (8 kg) [12]. A small reduction in intrahepatic lipids was observed, which reversed hepatic insulin resistance and normalized rates of basal glucose production. This occurred independently of any changes in insulin-mediated peripheral glucose metabolism [12]. It was documented that moderate caloric restriction (≈1100 kcal/day) [13] causes sequential changes in liver and skeletal muscle metabolism in obese individuals; both metabolisms being improved within few days of caloric restriction and with moderate weight loss (7%). Similarly, exercise training alone [14] can improve several metabolic syndrome components including: fasting plasma glucose, lipid profile, blood pressure and waist circumference (all $P < 0.001$). Adding PA to hypocaloric diets, highly improves these components compared with diet alone (adjusted odds ratio, 3.68) [15]. A meta-analysis by Duclos et al. [16], has clearly demonstrated the benefits of PA in patients with Type 2 DM. Supervised exercise interventions of $\geqslant$ 8 weeks duration have been shown to lower HbA1c by an average of 0.6% and resulted in improvements of cardiovascular risk factors independent of any change in BMI or fat mass [16]. They have confirmed the benefits of exercise training in Type 2 DM management and provided strong evidence that moderate-intensity physical activity (feasible for most patients) is sufficient to induce sustained positive change for 2 years. Here, with the combination weight maintenance diet (≈1800 kcal/day) and moderate-intensity physical activity, we have extended the reversal of Type 2 DM at > 3 years.

To further assist the patient in his long-term maintenance of weight loss, we have used the strategies from the National Weight Control Registry (NWCR) discussed in our recent CME [4]. The NWCR includes information from more than 5000

obese people who have lost, 31.8 kg on average, and kept it off for ⩾ 6 years. Among these strategies, it is reported that engaging patients in a high level of moderate-intensity physical activity and eating a diet low in calories and fat, as performed here, are strong correlates of long-term weight loss maintenance [4]. Therefore, we can deduce that the combination of all these elements has contributed to maintain and promote long-term metabolic control in our patient.

In conclusion, although, future clinical research is needed to confirm these findings, this case report demonstrated that dietary modification and PA can reverse Type 2 DM and provide protective effects against obesity-associated disorders in a patient with a long-history of Type 2 DM at > 3 years of follow-up. This supports a role of dietary modifications and physical activity as a tool to be considered in the long-term management of type 2 diabetes and other obesity-associated comorbidities.

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Conflicting interest

The author declared no conflict of interest.

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