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Article

Six-Month Metabolic Outcomes in Newly Diagnosed Type 2 Diabetes Under Multifactorial Management: A Retrospective Cohort Study

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Abstract

Background and Objectives: Newly diagnosed type 2 diabetes mellitus (T2DM) is managed with lifestyle and pharmacological treatment started together. The aim of this study was to evaluate clinical and metabolic outcomes at six months in adults with newly diagnosed T2DM receiving structured therapeutic education, medical nutrition therapy and standard pharmacotherapy. Materials and Methods: In this single-center retrospective cohort, we analyzed 100 adults (aged 21–84 years) newly diagnosed with T2DM in Bucharest, Romania (2024–2025), with complete evaluations at baseline and at six months. Changes in HbA1c, fasting plasma glucose, lipids, body mass index, blood pressure and renal function were assessed with paired tests; secondary analyses were exploratory. Results: Mean age was 58.2±13.87 years; 51% were women. Obesity, hypertension and dyslipidemia were present in 63%, 72% and 63%. Mean HbA1c decreased from 8.43±2.55% to 6.47 ± 1.26% (−1.95%, 95% CI [−2.45; −1.46]), and 88% reached HbA1c <7%. Fasting plasma glucose, body mass index, blood pressure, total and HDL cholesterol, and triglycerides also improved, whereas only 7% reached their LDL cholesterol target. Conclusions: Diabetes self-management education combined with personalized nutritional therapy and standard pharmacological treatment was associated with improved glycemic control and several cardiometabolic parameters over six months. These findings support integrating structured therapeutic education and individualized nutritional interventions into the early management of T2DM.

Keywords: type 2 diabetes mellitus; newly diagnosed; therapeutic education; medical nutrition therapy; real-world data; cardiometabolic risk

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1. Introduction

The management of diabetes continues to be one of the most significant global public health challenges, currently affecting 11.1% of adults aged 20 to 79—or 1 in 9 people—according to data from the 11th edition of the IDF Diabetes Atlas (2025) [1]. In 2024, the number of affected adults was estimated at 589 million, with a projected increase to 853 million by 2050. Microvascular and macrovascular complications are the leading cause of increased morbidity and mortality among patients, with the incidence of comorbidities remaining high despite advances in pharmacological therapy.

The time of diagnosis of type 2 diabetes offers an important opportunity for the early implementation of therapeutic interventions and lifestyle changes, with a potential impact on the long-term course of the disease. Given these considerations, therapeutic education and medical nutritional therapy (MNT) play a central role in the management of diabetes, with demonstrated effects on glycemic control, cardiovascular risk factors, and the progression of complications. Adopting healthy behaviors and maintaining psychological well-being contribute significantly to achieving optimal clinical outcomes [2,3].

Therapeutic education is a continuous process that is essential for achieving optimal glycemic and blood pressure control, improving the lipid profile, and maintaining or achieving an optimal body weight [4].

In this context, numerous dietary patterns have been shown to have beneficial effects on metabolic control in people with diabetes, with the most widely studied including the Mediterranean diet, the Dietary Approaches to Stop Hypertension (DASH) diet, low-carbohydrate diets, and vegetarian or predominantly plant-based diets [5,6]. However, there is no universal dietary model applicable to all patients, and the effectiveness of nutritional interventions depends largely on tailoring recommendations to each person's clinical characteristics, dietary preferences, sociocultural context, and individual capabilities [7].

Consequently, nutritional medical therapy must be individualized, with the goal of increasing treatment adherence, facilitating the adoption and long-term maintenance of healthy behaviors, and optimizing metabolic control and cardiovascular risk factors [8].

The objective of this study was to evaluate changes in clinical and metabolic outcomes at six months in patients with newly diagnosed type 2 diabetes managed with structured therapeutic education, medical nutrition therapy and standard pharmacotherapy. The primary outcome was glycemic control (HbA1c, fasting plasma glucose); secondary outcomes were changes in lipid profile, anthropometric parameters, blood pressure, and renal function from baseline to six months.

2. Materials and Methods

Study Design

This study is a single-center, retrospective study conducted over a two-year period, from January 1, 2024, to December 31, 2025, within the Department of Diabetes, Nutrition, and Metabolic Diseases at the "Nicolae Malaxa" Clinical Hospital in Bucharest. The study is reported in accordance with the STROBE guidelines for observational studies [9].

Participants

The study cohort included 100 patients, aged 21 to 84 years, newly diagnosed with type 2 diabetes. The diagnosis was established according to the criteria of the American Diabetes Association (2024) [10].

Patients who underwent two visits with a complete evaluation were included in the analysis: the first visit at the time of diagnosis and the second at 6 months after the initial evaluation.

Patients with type 1 diabetes, secondary diabetes (pancreatic, drug-induced, or endocrine), type 2 diabetes known prior to the study period, uncontrolled thyroid disease, severe liver disease, active

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neoplasms, chronic systemic corticosteroid therapy, as well as patients who were pregnant or breastfeeding, and cases with incomplete data at either of the two evaluation visits.

Clinical and Biological Assessment

The assessment protocol used at each visit included a detailed medical history, anthropometric measurements (weight, height, and waist circumference), and monitoring of clinical parameters (blood pressure and heart rate). Based on weight and height, body mass index (BMI = kg/m²) was calculated and used to classify patients into body weight categories according to World Health Organization criteria [11].

The biological profile included: glycemic status (glycated hemoglobin—HbA1c—and fasting plasma glucose, FPG), lipid profile (total cholesterol, high-density lipoprotein—HDL-cholesterol, low-density lipoprotein—LDL-cholesterol, and triglycerides), renal function [serum creatinine, estimated glomerular filtration rate (eGFR) calculated using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula, and urinary albumin-to-creatinine ratio (ACR)]; and liver function, assessed by aspartate aminotransferase (AST) and alanine aminotransferase (ALT). In addition, the triglyceride-glucose index (TyG = ln [triglycerides (mg/dL) × FPG (mg/dL) / 2]) was calculated [12], used as a surrogate marker of insulin resistance, with a cutoff value of 8.8 [13].

All patients were evaluated for the presence of chronic complications of diabetes mellitus. Microvascular complications—diabetic polyneuropathy, diabetic retinopathy, and chronic kidney disease (CKD)—were assessed according to the criteria of the 2024 ADA guidelines [14,15]. Cardiovascular history—including myocardial infarction, stroke, heart failure, and peripheral arterial disease—was documented based on medical history and a cardiology consultation conducted at the time of study enrollment.

Metabolic Syndrome

Metabolic syndrome has been defined according to the harmonized criteria of the International Diabetes Federation, the American Heart Association, and the National Heart, Lung, and Blood Institute (Joint Interim Statement, 2009) [16], by the presence of at least three of the following five components: central obesity (waist circumference ≥94 cm in men and ≥80 cm in women, according to thresholds for the European population), triglycerides ≥150 mg/dL, HDL -cholesterol <40 mg/dL in men and <50 mg/dL in women, systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg or ongoing antihypertensive treatment in patients with a history of hypertension, and fasting blood glucose ≥100 mg/dL.

The 10-year cardiovascular risk was estimated using the SCORE2-Diabetes algorithm, developed and validated for people with type 2 diabetes in Europe [17] . Patients with documented atherosclerotic cardiovascular disease were directly classified into the very high-risk category, in accordance with the recommendations of the 2021 ESC guidelines [18].

All included patients received a comprehensive therapeutic intervention consisting of structured therapeutic education, personalized nutritional therapy and initiation of pharmacological treatment in accordance with the standard of care during the study period.

Therapeutic Education (TE)

Therapeutic education was provided through individual sessions led by physicians specializing in Diabetes, Nutrition, and Metabolic Diseases, with the support of nurses experienced in caring for patients with diabetes. The physicians coordinated the educational program as a whole, while the nurses provided hands-on training on self-monitoring of blood glucose, insulin injection techniques, and diabetic foot care. The program's content covered the key competencies recommended by the World Health Organization for diabetes management, including: understanding the disease and its basic pathophysiological mechanisms; recognizing, preventing, and managing acute and chronic complications; managing days when feeling unwell; the principles of self-monitoring of blood

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glucose, nutritional management with an emphasis on the distribution of carbohydrates across meals, the importance of regular physical activity, and diabetic foot care. Each patient received individualized counseling tailored to their level of understanding, associated comorbidities, and sociocultural context.

Nutritional Intervention

Medical Nutritional Therapy

At the time of diagnosis, all enrolled patients received individualized medical nutrition counseling tailored to their personal and cultural preferences, access to food, level of health literacy, and individual ability to implement changes [19]. Dietary recommendations were tailored to each patient's clinical characteristics, the type and level of reported physical activity, and associated medical conditions. A balanced dietary model was followed, with a controlled distribution of macronutrients: carbohydrates accounted for 50–60% of daily energy needs, fats 30–35% (saturated fatty acids <7%, trans fatty acids <1%, monounsaturated fatty acids ~10%, polyunsaturated fatty acids 5–10%), and proteins approximately 15%, equivalent to 0.8–1.2 g/kg body weight per day. Consumption of simple sugars was limited to less than 5% of daily caloric intake. Consumption of nutrient-dense foods was encouraged, particularly whole grains, vegetables, and fruits. The goal of the intervention was to achieve and maintain optimal body weight, optimize glycemic and lipid control, normalize blood pressure, and prevent or delay the onset of diabetes complications.

Physical Activity

According to the recommendations of the 2024 ADA guidelines [19,20], each patient was recommended to engage in at least 150 minutes of moderate-intensity physical activity per week—such as brisk walking or cycling—in at least 3 sessions, in the absence of contraindications related to metabolic complications or associated pathologies. Patients who were overweight and/or obese were also instructed to restrict their energy intake by 100–500 kcal/day below their estimated requirements, with the goal of achieving a weight loss of at least 5–10% within 6 months and maintaining that weight loss thereafter.

Statistics

The collected data were analyzed using IBM SPSS Statistics, version 19.0. The statistical analysis included descriptive methods to characterize the study population: normally distributed continuous variables were expressed as mean ± standard deviation; non-normally distributed variables were expressed as median and interquartile range; and categorical variables were expressed as absolute frequencies and percentages. The normality of the distribution was tested using the Shapiro-Wilk test.

To compare values between the two visits, the paired t-test was used for normally distributed variables, and the Wilcoxon Signed-Rank test was used for non-normally distributed variables. Associations between independent categorical variables were assessed using the chi-square test; in cases where expected frequencies were less than 5, Fisher's exact test was used. Changes in paired categorical variables between the two visits were analyzed using the McNemar test.

To identify the therapeutic factors associated with glycemic control, a hierarchical multiple linear regression analysis was performed. The dependent variable was the change in FPG between baseline and six months. Independent variables were entered into four successive blocks using the Enter method. Unstandardized regression coefficients (B), standardized regression coefficients (β), p-values, R^2, adjusted R^2, and overall model F-statistics were reported. The threshold for statistical significance was set at $p < 0.05$.

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3. Results

The study cohort included 100 patients with type 2 diabetes, of whom 49 were men (49.0%) and 51 were women (51.0%), with a mean age of 58.2 ± 13.87 years. The distribution by age group showed that the largest proportion of patients diagnosed with type 2 diabetes was in the 50–59 age group, among both men (36.7%; n = 18) and women (33.3%; n = 17) (Figure 1).

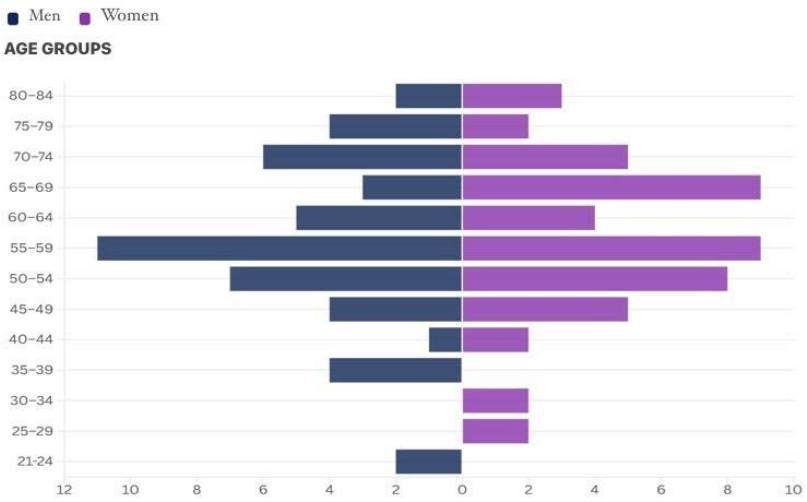

Figure 1. Demographic characteristics of the study group.

Comorbidities associated with diabetes were common in the study population. Hypertension was the most prevalent associated condition, identified in 72.0% of patients (n=72), followed by metabolic syndrome, present in 67.0% (n=67), obesity in 63.0% (n=63), and dyslipidemia in 63.0% (n=63). No statistically significant differences were observed between the sexes for any of these comorbidities.

Among microvascular complications, chronic kidney disease was the most common condition identified, present in 14.0% of patients (n=14), with no significant differences between men and women (12.2%, n=6 versus 15.7%, n=8; p=0.620). Diabetic polyneuropathy was diagnosed in 6.0% of participants (n=6), with a numerically higher prevalence among men compared to women (8.2%, n=4 versus 3.9%, n=2) (p=0.430). Diabetic retinopathy was present in 4.0% of patients (n=4), with a similar distribution between the two sexes (2 cases in men and 2 cases in women; p=1.000) (Table 1).

Table 1. Clinical characteristics, metabolic comorbidities, chronic complications, and initial medication of patients included in the study, by sex.

Parameter	Male (n=49)	Female (n=51)	Total (n=100)	p
Age (years), mean ± SD	57.8 ± 14.41	58.59 ± 13.48	58.2 ± 13.87	0.777
Metabolic comorbidities				
Hypertension, n (%)	37 (75.5)	35 (68.6)	72 (72.0)	0.443*
Obesity, n (%)	31 (63.3)	32 (62.7)	63 (63.0)	0.950*
Dyslipidemia, n (%)	32 (65.3)	31 (60.8)	63 (63.0)	0.640*
Hepatic steatosis, n (%)	8 (16.3)	7 (13.7)	15 (15.0)	0.716*
Metabolic syndrome, n (%)	33 (67.3)	34 (66.7)	67 (67.0)	0.122*
Diabetic polyneuropathy, n (%)	4 (8.2)	2 (3.9)	6 (6.0)	0.430**
Diabetic retinopathy, n (%)	2 (4.1)	2 (3.9)	4 (4.0)	1.000**
Chronic kidney disease, n (%)	6 (12.2)	8 (15.7)	14 (14.0)	0.620*
Heart failure, n (%)	3 (6.1)	5 (9.8)	8 (8.0)	0.710**
Ischemic heart disease, n (%)	13 (26.5)	2 (3.9)	15 (15.0)	**0.002***
Myocardial infarction, n (%)	6 (12.2)	0 (0.0)	6 (6.0)	**0.012****

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Stroke, n (%)	3 (6.1)	0 (0.0)	3 (3.0)	0.114**
Peripheral arterial disease, n (%)	2 (4.1)	4 (7.8)	6 (6.0)	0.678**
Major above-knee amputation, n (%)	1 (2.0)	—	1 (1.0)	0.490**
Initiated medication				
Metformin n, (%)	43 (87.8)	36 (70.6)	79 (79.0)	**0.035***
SGLT2 inhibitors n, (%)	12 (24.5)	6 (11.8)	18 (18.0)	0.098*
DPP-4 inhibitors n, (%)	1 (2.0)	2 (3.9)	3 (3.0)	1.000**
Oral semaglutide n, (%)	1 (2.0)	0 (0.0)	1 (1.0)	0.490**
Basal insulin n, (%)	8 (16.3)	10 (19.6)	18 (18.0)	0.669*
Rapid-acting insulin n,(%)	2 (4.1)	5 (9.8)	7 (7.0)	0.437**
Tirzepatide n, (%)	1 (2.0)	2 (3.9)	3 (3.0)	1.000**
Gliclazide n,(%)	6 (12.2)	3 (5.9)	9 (9.0)	0.313**

SD = standard deviation. p-values < 0.05 were considered statistically significant.* Pearson's chi-square test.** Fisher's exact test.

With regard to macrovascular complications, ischemic heart disease was the most common cardiovascular condition identified, present in 15.0% of patients (n=15). Its prevalence was significantly higher in men than in women (26.5%, n=13 versus 3.9%, n=2; p=0.002). Furthermore, a history of myocardial infarction was reported exclusively in male patients (12.2%, n=6 versus 0%; p=0.012). Heart failure was present in 8.0% of patients (n=8), and peripheral arterial disease in 6.0% (n=6), with no significant differences between the sexes. Stroke was identified in 3.0% of patients (n=3), exclusively among men (6.1%, n=3 versus 0%; p=0.114). In the analyzed cohort, a single case of major thigh amputation was recorded (1.0%; n=1), in a male patient (Table 1). Regarding antidiabetic treatment, at the first visit, the most commonly used medication was metformin (n = 79; 79%), followed by sodium-glucose cotransporter-2 (SGLT2) inhibitors (n = 18; 18%), gliclazide (n = 9; 9%), dipeptidyl peptidase-4 inhibitors (iDPP-4) (n = 3; 3%), tirzepatide (n = 3; 3%), and oral semaglutide (n = 1; 1%).

Basal insulin therapy was initiated in 18 (18%) patients, and rapid-acting insulin in 7 (7%) of them. When comparing the distribution of treatments by sex, metformin use was significantly more common in men than in women (87.8% vs. 70.6%; p=0.035), whereas for the other therapeutic classes (iSGLT2, iDDP-4, gliclazide, oral semaglutide, tirzepatide, basal insulin, and rapid-acting insulin), no statistically significant differences were identified between the sexes (Table 1).

Primary Outcome—Changes in Glycemic Control

Six months after the start of treatment, a significant improvement in glycemic control was observed. Fasting plasma glucose (FPG) decreased from 177.38 ± 77.79 mg/dL to 129.07 ± 34.87 mg/dL, corresponding to a mean reduction of 48.32 mg/dL (95% CI: [−63.72; −32.92] mg/dL, p<0.001). Similarly, HbA1c levels decreased significantly, from 8.43 ± 2.55% to 6.47 ± 1.26%, with a mean difference of −1.95% (95% CI: [−2.45; −1.46], p<0.001). At the follow-up evaluation, 88.0% of patients (n=88) achieved the recommended therapeutic target of HbA1c <7%, and 47.0% (n=47) had FPG levels below 126 mg/dL (Table 2).

Table 2. Changes in clinical and laboratory parameters between the initial visit and the follow-up visit.

Variable	Visit 1	Visit 2	Difference	p
Glycemic parameters				
FPG (mg/dL)	177.38 ± 77.79	129.07 ± 34.87	−48.32 ± 77.60 (95% CI: [−63.72; −32.92])	<0.001
HbA1c (%)	8.43 ± 2.55	6.47 ± 1.26	−1.95 ± 2.49 (95% CI: [−2.45; −1.46])	<0.001
Lipid profile				
Total cholesterol (mg/dL)	207.36 ± 58.38	184.57 ± 38.19	−22.79 ± 67.75 (95% CI: [−36.23; −9.35])	<0.001
LDL cholesterol (mg/dL)*	122.62 ± 34.54	103.28 ± 29.07	−19.34 ± 38.40 (95% CI: [−26.96; −11.72])	<0.001

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HDL cholesterol (mg/dL)	48.70 ± 11.89	52.68 ± 12.59	+3.98 ± 15.33 (95% CI: [0.94; 7.02])	0.008
Triglycerides (mg/dL)	206.00 (95.83)	151.93 (47.68)	−19.10 (96.69) (95% CI: [−88.90; −19.23])	<0.001
Renal function				
Creatinine (mg/dL)*	0.889 ± 0.260	0.855 ± 0.302	−0.034 ± 0.23 (95% CI: [−0.08; 0.01])	0.140
eGFR (mL/min/1.73 m²)*	87.72 ± 20.13	91.56 ± 20.63	+3.84 ± 18.37 (95% CI: [0.19; 7.48])	0.039
Anthropometric parameters				
BMI (kg/m²)	32.69 ± 6.90	31.98 ± 6.99	−0.71 ± 2.26 (95% CI: [−1.16; −0.26])	<0.001
Blood pressure values				
SBP (mmHg)*	143.06 ± 23.56	125.31 ± 13.16	−17.75 ± 19.87 (95% CI: [−21.69; −13.81])	<0.001
DBP (mmHg)*	91.66 ± 13.80	80.73 ± 6.49	−10.93 ± 12.99 (95% CI: [−13.51; −8.35])	<0.001
Insulin resistance				
TyG index	9.51 (0.95)	9.06 (0.61)	−0.36 (0.94) (95% CI: [−0.66; −0.35])	<0.001

SD = standard deviation; FPG = fasting plasma glucose; HbA1c = glycated hemoglobin; LDL = low-density lipoprotein; HDL = high-density lipoprotein; eGFR = estimated glomerular filtration rate; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; TyG = triglyceride-to-glucose index. Statistical tests were selected based on the data distribution, as assessed by the Shapiro-Wilk test: for variables with a non-normal distribution, the Wilcoxon Signed-Rank test (Z) was used; for variables with a normal distribution, the t-test for paired samples (T) was used, marked with *. Values of $p < 0.05$ were considered statistically significant.

Secondary Objectives

Changes in the Lipid Profile

Six months after the start of the therapeutic intervention, the lipid profile showed favorable changes. Total cholesterol decreased by an average of 22.79 mg/dL (95% CI [−36.23; −9.35] mg/dL; $p < 0.001$), and LDL cholesterol by 19.34 mg/dL (95% CI [−26.96; −11.72] mg/dL; $p < 0.001$). Triglycerides decreased by 19.1 mg/dL (95% CI [−88.90; −19.23] mg/dL; $p < 0.001$). At the same time, HDL cholesterol increased by 3.98 mg/dL (95% CI [0.94; 7.02] mg/dL; $p = 0.008$) (Table 2).

With regard to the therapeutic targets recommended by the 2021 ESC guidelines, 76 patients (76.0%) were classified as being at very high cardiovascular risk, with a target LDL-cholesterol level of <55 mg/dL, while 24 patients (24.0%) were classified as having high cardiovascular risk, with an LDL-cholesterol target of <70 mg/dL. Although LDL-cholesterol levels decreased significantly after intervention, most patients did not achieve the treatment goals corresponding to their cardiovascular risk category.

Analysis of the transition between LDL-cholesterol categories at the two visits revealed a predominance of stability, with 90 patients (90.0%) maintaining their initial classification. A favorable outcome, defined as a shift from values above the therapeutic target to achieving the individual therapeutic goal, was observed in 7 patients (7.0%), while 3 patients (3.0%) experienced an unfavorable outcome. Although the number of patients who improved was higher than the number of patients whose condition worsened, the difference did not reach statistical significance (according to the exact McNemar test, p=0.344).

The categorical analysis of triglycerides also revealed a favorable trend. A total of 26 patients (26.0%) progressed from hypertriglyceridemia to normal triglyceride levels, compared with 14 patients (14.0%) who showed the opposite trend. At the same time, 20 patients (20.0%) maintained normal levels at both evaluations, while 40 patients (40.0%) had triglyceride levels ≥150 mg/dL at both visits. Although the number of patients who achieved normal triglyceride levels was higher

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than that of those whose levels worsened, the difference was not statistically significant according to the exact McNemar test (p=0.081).

At the 6-month follow-up, 46 patients (46.0%) achieved the therapeutic target for triglycerides, defined as a level <150 mg/dL. In contrast, the proportion of patients who achieved the therapeutic targets for LDL cholesterol was low. Of the 24 patients with high cardiovascular risk, only one patient (4.2%) achieved the LDL-cholesterol target of <70 mg/dL. Of the 76 patients with very high cardiovascular risk, 6 patients (7.9%) achieved the LDL-cholesterol target of <55 mg/dL.

Overall, the degree to which therapeutic goals were achieved varied depending on the parameter analyzed (Table 3).

Table 3. Achievement of therapeutic targets at 6 months of follow-up.

Therapeutic target	Women n (%)	Men n (%)	Total n (%)	p
Fasting blood glucose	27 (52.9)	20 (40.8)	47 (47)	0.225*
HbA1c	41 (80.4)	47 (95.9)	88 (88)	0.017*
Weight loss ≥5%	14 (27.5)	11 (22.4)	25 (25.0)	0.564*
Weight loss ≥10%	5 (9.8)	1 (2.0)	6 (6.0)	0.205**
Weight loss ≥15%	2 (3.9)	0 (0.0)	2 (2.0)	0.495**
Triglycerides <150 mg/dL	21 (41.2)	25 (51.0)	46 (46.0)	0.323*
SBP <130 mmHg	40 (78.4)	42 (85.7)	82 (82.0)	0.343*
LDL <70 mg/dL[1]	0 (0.0)	1 (11.1)	1 (4.2)	0.375**
LDL <55 mg/dL[2]	0 (0.0)	6 (15.0)	6 (7.9)	0.026**

* p calculated using the Pearson χ^2 test. ** p calculated using Fisher's exact test. 1 Assessed in patients with high cardiovascular risk (n = 24). 2 Assessed in patients with very high cardiovascular risk (n = 76).

Changes in Body Weight

Six months after the start of treatment, a significant improvement in body weight was observed. Body weight decreased by an average of 2.0 ± 6.19 kg (95% CI: [-3.23; -0.77 kg], p<0.001), and body mass index (BMI) decreased significantly, with a mean change of -0.71 kg/m² (95% CI: [-1.16; -0.26], p<0.001). The reduction in BMI was observed in both women and men, with no notable differences between the sexes.

Analysis of the transition between weight categories revealed a shift in patient distribution toward lower BMI categories. An improvement in weight status was observed in 16.0% of participants (n=16), compared with 6.0% (n=6) who experienced a worsening of their weight classification. The most common favorable transition was from Class I obesity to overweight (n=8), followed by the transition from Class II obesity to Class I obesity (n=5). In contrast, the most common unfavorable outcome was the transition from Class I obesity to Class II obesity (n=3).

The McNemar-Bowker test revealed a statistically significant change in the distribution of patients across BMI categories between the two assessments (χ^2=11.770; df=4; p=0.019), suggesting an overall shift toward lower weight categories and a significant improvement in weight status following the therapeutic intervention (Table 2).

Exploratory analysis based on the treatment administered did not reveal any statistically significant differences in the magnitude of BMI reduction between the treatment groups (p=0.183). Thus, the observed weight loss can be interpreted as a favorable effect of the overall therapeutic intervention, without being able to be attributed with certainty to a specific treatment.

At the 6-month follow-up, 25 patients (25%) achieved a weight loss of at least 5% from their baseline weight. Of these, 6 patients (6%) achieved a weight loss of at least 10%, and 2 patients (2%) achieved a reduction of at least 15% (Table 3).

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Changes in Renal Function

Renal function remained stable throughout the follow-up period. Serum creatinine levels did not show significant changes between the initial visit and the follow-up visit, and the estimated glomerular filtration rate (eGFR) showed a slight improvement (Table 2).

Changes in Blood Pressure

The therapeutic intervention was associated with improved blood pressure control. Systolic blood pressure decreased significantly, from 143.06 ± 23.56 mmHg to 125.31 ± 13.16 mmHg, corresponding to a mean reduction of 17.75 (95% CI: [−21.69; −13.81]) mmHg ($p<0.001$). Diastolic blood pressure also showed a reduction of 10.93 (95% CI: [−13.51; −8.35]) mmHg ($p<0.001$) (Table 2). Regarding systolic blood pressure control, 82 (82%) had blood pressure readings <130 mmHg at visit 2 (Table 3).

Changes in Insulin Resistance — TyG Index

At the initial visit, 86.0% of patients (n = 86) had elevated TyG index values (≥8.8) (85.7% men and 86.3% women). These patients had significantly higher levels of fasting blood glucose, HbA1c, and triglycerides (all $p < 0.001$), as well as significantly lower levels of HDL cholesterol ($p = 0.004$); with regard to BMI, blood pressure, total cholesterol, LDL cholesterol, creatinine, or eGFR, there were no statistically significant differences (all $p > 0.05$) (Table A1). Six months after the start of the intervention, this proportion decreased to 74.0% (n=74), reflecting a trend toward improved insulin resistance as metabolic control was optimized. Comparison of the TyG index between visits revealed a significant reduction in the index at 6 months ($Z = −5.835$, $p < 0.001$). Furthermore, analysis of changes in patient proportions showed a significant decrease in the prevalence of pathological TyG index values ($p = 0.017$).

Therapeutic Determinants of Glycemic Change

To identify factors associated with glycemic changes at 6 months, a multiple linear regression analysis was performed with the successive inclusion of predictors, using the difference in glycemic values between the two visits as the dependent variable.

The first model, which included antidiabetic treatment, was statistically significant ($F [8,91] = 7.963$; $p < 0.001$; $R^2 = 0.412$; adjusted $R^2 = 0.360$), explaining 41.2% of the variation in blood glucose levels. The greatest reduction was observed with basal insulin ($B = −92.09$; 95% CI [−132.56; −51.18]; $p<0.001$), followed by gliclazide ($B=−56.25$; 95% CI [−100.51;−11.98]; $p=0.013$).

Model 2 included demographic characteristics such as age and sex, while Model 3 focused on clinical parameters such as BMI and eGFR. No significant improvement was observed in any of the models. The final model included baseline blood glucose, which increased the explanatory power to 83% of the variation ($R^2 = 0.830$; adjusted $R^2 = 0.805$). After final adjustment, baseline blood glucose remained the only independent predictive factor, with none of the initially analyzed therapies showing statistical associations, except for rapid-acting insulin, which was borderline significant ($p=0.053$) (Table A2).

4. Discussion

In the analyzed cohort, which included patients recently diagnosed with type 2 diabetes, early initiation of multifactorial management was associated, after six months, with a significant improvement in glycemic control, weight loss, and improvements in certain metabolic parameters. These results are consistent with data in the literature regarding the efficacy of early multifactorial interventions in type 2 diabetes, with relevant implications from both a clinical and public health perspective.

STENO-2, a landmark study in this field, highlights the importance of this approach in a prospective randomized trial conducted over a period of 7.8 years that enrolled 160 patients with

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type 2 diabetes and microalbuminuria [21]. The intervention combined lifestyle modification, behavioral support, and intensive pharmacological treatment, resulting in significant improvements in clinical parameters—blood pressure—and biological parameters—HbA1c, LDL cholesterol, total cholesterol, triglycerides, and microalbuminuria [21].

The benefits of the multifactorial intervention persisted even after the intensive treatment period ended. In the extended follow-up of the STENO-2 study, with a mean total follow-up duration of 13.3 years, the intensive intervention was associated with a 57% reduction in cardiovascular mortality (HR=0.43; 95% CI: [0.19; 0.94]; p=0.04), a 46% reduction in all-cause mortality (HR=0.54; 95% CI: [0.32; 0.89]; p=0.02), and a 59% reduction in the risk of cardiovascular events (HR=0.41; 95% CI: [0.25; 0.67]; p<0.001). Furthermore, the need for retinal photocoagulation was significantly lower in the intervention group (RR = 0.45; 95% CI: [0.23; 0.86]; p = 0.02) [22]. After 21.2 years of follow-up, all-cause mortality remained significantly lower in the group that had initially received intensive multifactorial intervention (HR = 0.55; 95% CI: [0.36; 0.83]; p = 0.005). At the same time, median survival was prolonged by at least 7.9 years, and the first cardiovascular event occurred, on average, 8.1 years later than in the conventionally treated group. These data confirm that the benefits of intensive intervention are sustained over the long term, both in terms of survival and in terms of reducing cardiovascular risk [23].

The UKPDS study, which established the standards for glycemic control in patients with newly diagnosed type 2 diabetes, demonstrated that intensive targeted therapy reduces HbA1c levels from 7.9% in the conventional group to 7.0% in the intervention group, with a reduction in the rate of microvascular complications of up to 25% [24] .Long-term analysis showed that the benefits of early and sustained glycemic control are sustained over time—a phenomenon known as "metabolic memory"—with a significant reduction in both microvascular complications (RR=0.76; 95% CI [0.64; 0.89]; p=0.001), as well as significant reductions in the risk of myocardial infarction (RR=0.85; 95% CI [0.74; 0.97]; p=0.01) and all-cause mortality (RR=0.87; 95% CI [0.79; 0.96]; p=0.007) [25].

In our study, early initiation of therapeutic intervention was associated with a significant improvement in glycemic control after six months. HbA1c decreased by 1.95% (95% CI [1.46; 2.45]), from 8.43% to 6.47%, and fasting blood glucose decreased by an average of 48.3 mg/dL (95% CI [32.9; 63.7]). Beyond statistical significance, the clinical relevance of these results is supported by the fact that 88% of patients achieved an HbA1c level <7%, the recommended target for most adults with diabetes, given the individualization of therapeutic goals [26].

The reduction in HbA1c observed in our study is greater than the effect generally attributed to interventions when considered in isolation. A meta-analysis focusing on patients with newly diagnosed type 2 diabetes (12 studies, 2,386 patients diagnosed within the past 12 months) showed that education and self-management support programs were associated with an additional reduction in HbA1c of 0.21% compared with usual care (mean difference: −0.21%; 95% CI [−0.38; −0.04]) [27]. Another meta-analysis confirmed the benefits of self-management education programs, showing that, after six months, they were associated with an additional reduction in HbA1c of 0.44% compared with usual care (95% CI [−0.69; −0.19]) [28]. These results support the role of structured educational interventions in improving glycemic control.

The importance of intervention as early as the first few months after diagnosis is also highlighted by the randomized Early ACTID study, which included 593 patients with newly diagnosed type 2 diabetes. At six months, intensive dietary counseling resulted in an additional reduction in HbA1c of 0.28 percentage points compared with usual care (95% CI [−0.46; −0.10]; p=0.005), an effect that was maintained at 12 months [29]. The period immediately following diagnosis represents a critical window for adopting behavioral changes and establishing effective therapeutic management.

The magnitude of the glycemic response in our cohort must also be analyzed in relation to the elevated baseline values. In the final multivariate model, after adjusting for treatment, age, sex, BMI, and renal function, baseline blood glucose was the only significant predictor of the change in blood glucose at six months (B=−0.947; β=−0.949; p<0.001). Patients with more severe baseline hyperglycemia, therefore, experienced the greatest reductions. After including the baseline value in

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the model, the previously observed associations for basal insulin and gliclazide were no longer significant, which limits the attribution of the response to a specific therapeutic class.

The TyG index, used as an indirect marker of insulin resistance, has been associated in numerous studies with the risk of type 2 diabetes, the development of microvascular complications, and an increased cardiovascular risk [30,31]. In our cohort, the TyG index decreased significantly after six months of intervention, suggesting an improvement in insulin resistance and the overall metabolic profile. However, in the absence of a control group, the change cannot be attributed separately to therapeutic education, nutritional intervention, or pharmacological treatment.

Weight management is an essential component in patients with newly diagnosed T2DM. Modest reductions in body weight are associated with improved glycemic control and the overall cardiometabolic profile. The results of our study are consistent with those of the meta-analysis published by Møller et al., which included five randomized trials involving a total of 912 participants with type 2 diabetes. Individualized MNT, coordinated by a dietitian, was associated, during the first year of intervention, with an additional reduction in body weight of 2.1 kg and in BMI of 0.55 kg/m² [32]. The magnitude of weight loss is similar to that observed in our study. In a prospective analysis of Early ACTID data involving 242 participants, body weight decreased by 2.3 kg (95% CI [−2.7; −1.8]) during the first six months, and BMI decreased by 0.8 kg/m² (95% CI [−0.9; −0.6] [33]. These results are similar to those observed in our cohort, in which the mean decrease was 2.0 kg (95% CI [−3.23; -0.77]), and the body mass index (BMI) decreased by 0.71 kg/m² (95% CI [-1.16; -0.26]).

Our results are also consistent with those reported by Gortzi et al. in an interventional study that included 88 patients with newly diagnosed type 2 diabetes. After three months of nutrition education, an individualized meal plan, and recommendations regarding physical activity, the authors observed an average weight reduction of 4 kg and a reduction in BMI of 1.7 kg/m², as well as improvements in blood glucose levels and lipid profile [34].

The Look AHEAD study, one of the largest trials to evaluate the effects of lifestyle modification in patients with type 2 diabetes and excess weight, followed 5,145 participants for a median period of 9.6 years. The intervention, based on calorie restriction and increased physical activity, was associated with improved glycemic control, quality of life, and reduced healthcare costs, supporting the role of structured behavioral interventions in the long-term management of the disease. Although participants in the intervention group showed improvements in most cardiovascular risk factors—with the exception of LDL cholesterol—during the first part of the study, these benefits did not translate into a significant reduction in the incidence of major cardiovascular events [35–37]. All of these data support the value of early initiation of therapeutic education and personalized medical nutritional therapy.

The comorbidity profile identified in our cohort highlights the clinical complexity of patients with type 2 diabetes from the moment of diagnosis. Metabolic syndrome was present in 67% of patients, hypertension in 72%, and obesity and dyslipidemia in 63% each. Comparable prevalences have also been reported in other studies conducted in Romania [38,39] and in Europe [40,41] . The frequent co-occurrence of these conditions creates a complex cardio-renal-metabolic profile that requires an early intervention strategy simultaneously aimed at weight loss, blood pressure and lipid profile control, protection of renal function, and reduction of overall cardiovascular risk.

At 6 months, achievement of lipid goals remained low. Only 7% of patients reached their individual LDL cholesterol target, compared with approximately 18% of patients with very high cardiovascular risk included in the DA VINCI study [42]. In the SANTORINI study, the proportion of patients achieving their LDL-C target increased from 21.2% to 30.9% after one year of follow-up [43]. The lower percentage observed in our study can be partially explained by the follow-up duration of only 6 months and by the high proportion of patients with very high cardiovascular risk. Regarding triglycerides, 46% of patients had levels <150 mg/dL at reevaluation.

The prevalence of chronic complications already present at the time of diagnosis, observed in our cohort (ischemic heart disease 15.0%, chronic kidney disease 14.0%, diabetic polyneuropathy 6.0%, diabetic retinopathy 4.0%), falls within the range reported by other studies published in Europe

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or Romania. In a Danish cohort of 6,958 patients newly diagnosed with type 2 diabetes (the DD2 study), 35% already had at least one chronic complication at the time of enrollment—12% exclusively microvascular, 17% exclusively macrovascular, and 6% both types—with macrovascular complications being more common than microvascular ones, a pattern similar to that observed in our cohort [40]. In the Italian Verona Newly Diagnosed Type 2 Diabetes Study cohort, a systematic evaluation of 806 patients identified clinical or subclinical cardiovascular disease in 18.9%, chronic kidney disease in 8.8%, polyneuropathy in 21.2%, and retinopathy in 4.9% of participants. Differences in reported prevalences can be explained, at least in part, by the methods and intensity of screening used to identify complications [41]. Comparable data also come from the UKPDS, where, among 2,337 newly diagnosed patients, 33% already had either retinopathy or ECG changes suggestive of cardiovascular involvement at the time of study enrollment, highlighting a prolonged asymptomatic period prior to clinical recognition of the disease [44]. These data support the importance of active screening and early therapeutic intervention, immediately following diagnosis.

Nutritional therapy, through the promotion of healthy eating patterns—incorporating elements of the Mediterranean diet and the DASH diet—is an essential component of therapeutic education in type 2 diabetes. A longitudinal study conducted between 2016 and 2020 that included 22,187 patients with both type 1 and type 2 diabetes concluded that greater adherence to the Mediterranean diet was inversely associated with the incidence of cardiovascular disease (type 1: OR = 0.53, 95% CI [0.37; 0.75], $p < 0.001$) and type 2: OR = 0.61, 95% CI [0.57; 0.89], $p < 0.001$), with statistically significant protective effects against microvascular complications [45]. Thus, the importance of individualized nutritional intervention as the first step in therapy is reaffirmed.

Calorie restriction recommended for overweight patients, while necessary for optimizing metabolic control, nevertheless carries a nutritional risk. Unbalanced or inadequately supervised low-calorie diets may be associated with an inadequate intake of vitamins and minerals, which can negatively impact the patient's overall nutritional status. Low-calorie diets may be associated with a reduction in the intake of certain essential micronutrients—including magnesium, iron, and calcium—along with a decrease in total caloric intake, which underscores the need for targeted nutritional assessment and monitoring during restrictive dietary interventions [46].

This study has several important limitations. First, its retrospective, single-arm design without a control group precludes causal inference: the observed changes reflect the combined effect of structured education, nutritional counseling, pharmacological treatment started at diagnosis, resolution of glucotoxicity, regression to the mean and spontaneous behavioral change, which cannot be separated. Second, the exposure itself was not measured: the content, intensity and adherence to the educational and nutritional components were not recorded, and dietary intake and physical activity were not assessed. Third, concomitant antihypertensive and lipid-lowering therapy was not analyzed and may have contributed to the changes observed in blood pressure and lipid levels. Fourth, only patients with complete evaluations were included, which may introduce selection bias and overestimate the proportion of patients reaching treatment targets. Fifth, blood pressure and laboratory measurements were obtained in routine clinical care rather than under a standardized research protocol. Sixth, multiple outcomes were tested without correction for multiplicity, and all secondary analyses should be regarded as exploratory. Finally, follow-up was limited to six months, so the durability of the effects, hypoglycemia and long-term outcomes were not assessed, and the single-center setting and wide age range (21–84 years) limit generalizability.

5. Conclusions

In this single-center retrospective cohort of adults with newly diagnosed type 2 diabetes who received structured therapeutic education, medical nutrition therapy and standard pharmacological treatment, HbA1c, fasting glucose, blood pressure and body weight were lower at six months, whereas most patients did not reach their LDL cholesterol targets. Because of the uncontrolled design, these changes cannot be attributed specifically to education or nutrition. Prospective, controlled studies with measured intervention exposure and adherence are needed.

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Appendix A

Table A1. Clinical, metabolic, and therapeutic characteristics of patients based on the TyG index at the initial visit and at the follow-up visit.

Variable	Visit 1			Visit 2		
	TyG <8.8 (n=14)	TyG ≥8.8 (n=86)	p	TyG <8.8 (n=26)	TyG ≥8.8 (n=74)	p
Glycemic parameters						
FPG (mg/dL)	118.25 ± 22.23	187.01 ± 79.38	<0.001	116.62 ± 22.35	133.44 ± 37.46	0.034
HbA1c (%)	6.70 ± 0.71	8.71 ± 2.63	<0.001	6.16 ± 0.55	6.58 ± 1.41	0.064
Lipid profile						
Total cholesterol (mg/dL)	171.45 ± 29.47	186.71 ± 39.16	0.227	166.84 ± 33.98	190.80 ± 37.84	0.003
LDL cholesterol* (mg/dL)	111.26 ± 29.55	124.47 ± 35.09	0.186	93.02 ± 29.94	106.88 ± 28.08	0.036
HDL cholesterol (mg/dL)	59.26 ± 16.18	46.98 ± 10.17	0.004	54.11 ± 13.83	52.17 ± 12.18	0.334
Triglycerides (mg/dL)	87.40 (51.65)	206.00 (82.69)	<0.001	90.00 (28.00)	151.93 (39.05)	<0.001
Renal function						
Creatinine* (mg/dL)	0.86 ± 0.24	0.89 ± 0.26	0.634	0.84 ± 0.24	0.86 ± 0.32	0.768
eGFR* (mL/min/1.73 m²)	91.34 ± 17.37	87.14 ± 20.58	0.471	92.67 ± 17.29	91.17 ± 21.78	0.750
Anthropometric parameters						
BMI (kg/m²)	32.97 ± 7.17	32.64 ± 6.89	0.846	30.26 ± 5.20	32.58 ± 7.45	0.291
Blood pressure values						
SBP* (mmHg)	146.64 ± 28.25	142.48 ± 22.84	0.542	127.00 ± 14.54	124.72 ± 12.69	0.449
DBP* (mmHg)	93.29 ± 16.13	91.40 ± 13.46	0.637	79.58 ± 6.43	81.14 ± 6.50	0.294
Medication, n (%)			p (Fisher)		p (Fisher)	
Metformin	7 (50.0)	72 (83.7)	0.009	20 (76.9)	59 (79.7)	0.783
Gliclazide	0 (0.0)	9 (10.5)	0.352	1 (3.8)	8 (10.8)	0.439
Basal insulin	1 (7.1)	17 (19.8)	0.455	6 (23.1)	12 (16.2)	0.553
Rapid-acting insulin	0 (0.0)	7 (8.1)	0.589	2 (7.7)	5 (6.8)	1.000
SGLT2 inhibitors	0 (0.0)	18 (20.9)	0.068	3 (11.5)	15 (20.3)	0.388

SD = standard deviation; FPG = fasting plasma glucose; HbA1c = glycated hemoglobin; LDL = low-density lipoprotein; HDL = high-density lipoprotein; eGFR = estimated glomerular filtration rate; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; iSGLT2 = type 2 sodium-glucose

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cotransporter inhibitor. Comparisons between the TyG <8.8 and TyG ≥8.8 groups were performed using the t-test for independent samples (normally distributed variables, marked with *) or the Mann-Whitney U test (non-normally distributed variables), and the chi-square test or Fisher's exact test for categorical variables (medication). Note: The number of patients in each TyG category differs between visit 1 (n=14/86) and visit 2 (n=26/74) due to some patients transitioning between categories during the intervention. p-values <0.05 were considered statistically significant.

Table A2. Hierarchical multiple linear regression models for identifying factors associated with changes in blood glucose levels at 6 months.

Predictor	Model 1 B (β), p	Model 2 B (β), p	Model 3 B (β), p	Model 4 B (β), p
Metformin	−33.03 (−0.174), 0.056	−33.21 (−0.175), 0.069	−35.72 (−0.188), 0.052	13.42 (0.071), 0.206
SGLT2 inhibitors	0.93 (0.005), 0.955	0.62 (0.003), 0.971	7.73 (0.038), 0.660	−0.07 (0.000), 0.994
DPP-4 inhibitors	−17.96 (−0.040), 0.629	−17.76 (−0.039), 0.638	−28.43 (−0.063), 0.458	−8.2 (−0.018), 0.696
Oral semaglutide	1.68 (0.002), 0.979	−0.82 (−0.001), 0.990	−31.75 (−0.041), 0.677	42.79 (0.055), 0.312
Basal insulin	−92.09 (−0.458), <0.001	−92.40 (−0.460), <0.001	−91.10 (−0.453), <0.001	−17.67 (−0.088), 0.163
Rapid-acting insulin	−55.08 (−0.182), 0.074	−53.74 (−0.178), 0.089	−49.24 (−0.163), 0.119	35.68 (0.118), 0.053
Tirzepatide	17.91 (0.040), 0.648	19.83 (0.044), 0.638	20.87 (0.046), 0.625	6.69 (0.015), 0.775
Gliclazide	−56.25 (−0.208), 0.013	−56.93 (−0.211), 0.014	−53.15 (−0.197), 0.022	17.04 (0.063), 0.208
Age	—	0.08 (0.014), 0.873	0.71 (0.126), 0.263	0.03 (0.004), 0.943
Sex	—	−3.02 (−0.020), 0.821	−2.89 (−0.019), 0.829	5.46 (0.035), 0.460
BMI	—	—	0.80 (0.071), 0.478	−0.84 (−0.075), 0.184
Baseline eGFR	—	—	0.62 (0.161), 0.125	0.27 (0.069), 0.230
Baseline blood glucose	—	—	—	−0.947 (−0.949), <0.001
R^2	0.412	0.412	0.429	0.830
Adjusted R^2	0.360	0.346	0.351	0.805
F	7.963	6.243	5.452	32.341
p	<0.001	<0.001	<0.001	<0.001

B = unstandardized regression coefficient; β = standardized coefficient; R^2 = coefficient of determination.

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