RAP CONFERENCE PROCEEDINGS, VOL. 10, PP. 106–113, 2025
ISSN 2737-9973 (ONLINE) | DOI: 10.37392/RAPPROC.2025.20
RAP-PROCEEDINGS.ORG

THE INFLUENCE OF SELF-CONTROL ON THE QUALITY OF GLUCOREGULATION IN PATIENTS WITH TYPE 2 DIABETES

Tijana S. Jončić[1], Jasmina M. Jovanović Mirković[1*], Nataša K. Rančić[2], Slaviša G. Minić[1], Marija Z. Mikić Mladenović[1], Christos G. Alexopoulos[1]

[1]The Academy of Applied Preschool Teaching and Health Studies, Department of Medical Studies, Ćuprija, Serbia
[2] Faculty of Medicine, University of Niš, Niš, Serbia

Abstract. *Diabetes mellitus or diabetes, as a chronic disease that represents a global problem for the entire world population. Today, diabetes mellitus occupies a leading position in the morbidity and mortality statistics of the population in countries with a high standard of living, the so-called developed countries. Diabetes is a progressive disease. Since all systems of the human body are damaged, the type of manifestation and the severity of complications vary greatly. The treatment of patients with diabetes requires a multidisciplinary approach. Prevention of insulin-dependent diabetes aims to reduce the occurrence of the disease. It refers to improving the nutritional status, physical condition, and emotional state of the individual and society as a whole. This can be achieved by reducing risk factors and population strategies, i.e. by changing established harmful habits and modifying environmental factors. This research* ***aims*** *to determine the prevalence, frequency, and methods of self-control in studied patients with type 2 diabetes mellitus and to determine the most optimal model for planning and implementing a self-control program that provides patients with the best quality of glycoregulation and maintains the best quality of life.* ***Research Methodology.*** *The study was a prospective study involving 100 patients of both sexes suffering from type 2 diabetes mellitus. The study was conducted at the Ćuprija General Hospital within the Diabetes Consultation Center in the period from June 2009 to March 2010.* ***The results and discussion*** *of this study show that patients with type 2 diabetes have a satisfactory level of knowledge about their disease, as evidenced by the implementation of a self-control program, but they ignore the influence of diet and physical activity on the quality of glycaregulation. The cause of this phenomenon most likely lies in the level of education or lack of effort to raise it to a higher level when it comes to diet and physical activity. The modern approach to diabetes management is based on the active involvement of patients and family members, the adoption of healthier lifestyle habits, and the acquisition of new knowledge about diabetes.* ***Conclusion.*** *Self-control as the basis of good glycemic control in patients with type 2 diabetes is all that individuals can do for themselves and their health. Appropriately implemented self-control, based on good education, is the path to active participation in disease management and improved quality of life.*

Keywords: *diabetes mellitus type 2, self-control, glycoregulation, nutrition, physical activity*

1. INTRODUCTION

Diabetes is a progressive disease. As all systems of the human body are damaged, the manifestations and severity of complications are diverse, and the treatment of patients with diabetes requires a multidisciplinary approach. Diabetes mellitus, or diabetes, as a chronic disease, is a global problem for the entire world population. The incidence and prevalence of diabetes are increasing worldwide, especially in developing countries and emerging regions. The disease is lifelong and requires major medical and economic efforts from the entire human race [1].

This is evidenced by a large-scale epidemiological study by Paul Zimmet from Australia, who, together with other epidemiologists from around the world, began a study in 1995 and published it in 2000 [2, 3]. At that time, he pointed out that the number of diabetics would increase considerably and that this number would continue to rise. At that time, it was predicted that there would be 221 million people with diabetes by 2010. However, studies have shown that the number of patients in 2007 was 246 million, exceeding the pre-2010 figure of 221 million [4]. Studies have been carried out in many countries around the world that show an increase in the number of patients [5, 6].

According to the latest estimate by the World Health Organisation (WHO), the number of patients could rise to 366 million by 2030, which is extremely worrying data [7]. For the World Health Organisation, the knowledge of the increase in patient numbers alone indicates that the entire world population is in the grip of a diabetes “pandemic”.

In Serbia today, it is estimated that the number of patients has almost reached the astonishing figure of 500,000, and that the number of patients with type II diabetes is many times higher than those with type I diabetes [2, 8].

Diabetes mellitus today occupies a leading place in the statistics of morbidity and mortality of the population in countries with a high standard of living,

* ninajovanovic.vms@gmail.com

the so-called developed countries. Type II diabetes mellitus is an aetiopathogenetically heterogeneous disease characterized by a permanent disorder of glycoregulation, resulting from changes in the cells of the pancreatic islets and an altered sensitivity of peripheral tissues to insulin, particularly in muscle and adipose tissue [6]. There appears to be a consensus that genetic predisposition, inadequate or insufficient insulin secretion, insulin resistance, increased body weight, and increased hepatic glucose production are the primary factors contributing to the insulin-independent type of diabetes.

The insulin gene has been identified on the short arm of chromosome 11, and the insulin receptor gene on the short arm of chromosome 19 is also known, while insulin resistance is associated with a gene on chromosome 4q, more specifically known as FABP2 [9]. It is assumed that predisposed individuals inherit the insulin resistance genotype, the expression of which is exacerbated by obesity [10], and physical inactivity. People without insulin resistance do not develop diabetes, regardless of the presence of obesity [1, 10].

Peripheral insulin resistance, which is associated with impaired glucose transport in adipocytes and skeletal muscle, is a key factor in the pathogenesis of type II diabetes mellitus [10, 11, 12].

Insulin resistance is the inability of peripheral target tissues to respond appropriately to the physiological concentration of insulin present in the bloodstream; therefore, insulin resistance is by definition a defect in signal transduction [13].

Since skeletal muscle absorbs the majority of total glucose, insulin resistance in skeletal muscle is of major importance in the development of T2DM and can occur at three levels: glucose transport, hexokinase (i.e. glucose phosphorylation, and glycogen synthesis [14, 15].

In patients with T2DM, impaired glucose transport upon insulin stimulation in skeletal muscle is associated with decreased levels of insulin receptor and insulin receptor substrate proteins (IRS), decreased tyrosine phosphorylation (TYR) in the insulin receptor and IRS-1, and decreased phosphatidyl inositol 3-kinase (PI-3K) activity [5, 16]. Decreased TYR kinase activity of the insulin receptor and decreased phosphorylation of IRS-1 are not associated with changes in the amount of IRS-1 protein, as IRS-1 expression in patients with DMT2 is the same as in healthy individuals [15, 16].

In the aetiopathogenesis of insulin-independent diabetes, obesity plays an important role as one of the risk factors for the development of the disease, although not all obese individuals develop diabetes [3]. In obese individuals, there is very often insulin resistance, which manifests itself in reduced glucose uptake in peripheral tissues and only to a very small extent in the hepatocytes. A reduction in the number of insulin receptors on the membranes of fat and muscle tissue cells has been demonstrated, and the affinity of the receptor for insulin is also reduced (the activity of the insulin receptor tyrosine kinase is reduced) [17].

The hypothalamus regulates glucose homeostasis by controlling the secretion of insulin and counter-regulating hormones. Dysfunction of the hypothalamus can significantly impair insulin secretion and glucose metabolism through counter-regulating hormones (glucagon, cortisol, catecholamines, and somatotropin) [18, 19]. Various stressful situations (infections, psychological and physical trauma, surgical interventions) as well as lesions of the ventromedial hypothalamus lead to increased activity of the CRF-ACTH-cortisol axis, which causes inhibition of the gonadotropic axis and creates the conditions for the development of central obesity [6, 19, 20]. Cumulative stressful situations can accelerate the onset of diabetes, and the latent form of diabetes becomes manifest.

Considering that diabetes arises from the interaction of hereditary predisposition and environmental factors, which include a range of biological, behavioural, external, and social characteristics, prevention should focus on correcting personal habits to improve quality of life [21].

Prevention of non-insulin-dependent diabetes mellitus aims to reduce the incidence of the disease and relates to improving the nutritional status, physical fitness, and emotional state of the individual and society as a whole. This can be achieved by reducing risk factors and population strategies, i.e., by changing established harmful habits and modifying environmental factors [20, 22]. There is evidence that relatively small improvements in diet, reducing obesity and increasing physical activity, can have a huge impact on rates of diabetes and other chronic diseases that share the same risk factors (such as cardiovascular disease and many cancers) when implemented across the population. Much more attention needs to be paid to how these changes can be achieved in as many people as possible. Implementing a healthy lifestyle (adequate diet, well-dosed physical activity, maintaining ideal body weight, quitting smoking, and reducing alcohol consumption) is a goal that every society should strive for, as it will significantly reduce the incidence of type II diabetes and other chronic diseases [6, 23].

This study aims to determine the prevalence, frequency, and methods of performing self-monitoring in patients with type 2 diabetes mellitus. In addition to the main objective, the study also pursued a broader objective, namely to identify the most optimal model for planning and implementing a self-monitoring programme that enables patients to achieve the best quality of glycoregulation and maintain an optimal quality of life.

2. Methodology of the study

The study is a prospective study in which 100 patients of both sexes with type 2 diabetes mellitus participated. The study was conducted at the Ćuprija General Hospital within the Diabetes Counselling Centre from June 2009 to March 2010.

3. Results and discussion

When analysing the methods used to perform self-monitoring, information was obtained on the quality of self-monitoring of glycoregulation, obesity and dietary habits, as well as on the frequency of use of health services. The quality of self-monitoring of blood glucose levels was assessed according to whether patients had blood glucose metres and how often they used them at home, as well as how often they measured blood glucose and urine in the laboratory. The quality of self-monitoring of obesity and dietary habits was assessed using data on how many patients had a scale to measure

their weight and how often they checked their weight at home [24, 25, 26]. The quality of self-monitoring was also assessed by the number of visits to an endocrinologist.

The basis of every solution to every problem is education. The concept of education is not new in the treatment of diabetes. Even before the discovery of insulin, the close relationship between good health and physical activity, as well as its influence on the course and outcome of diseases, was observed. Over time, based on experimental research and empirical findings, a great deal of interest has developed in the implementation of training programmes for patients with type II diabetes mellitus. Targeted education is needed for both healthcare professionals and individuals with diabetes. In addition, training is needed to help them integrate new knowledge and change old practises. Changing old practises and applying new knowledge is crucial if clinical outcomes for patients with diabetes are to be improved. Today, in the world of rapid technological development and electronic information transfer, it is possible to integrate education into type II diabetes mellitus therapy on a large scale, thereby preventing the development of chronic complications and improving the quality of life [27, 28].

Today, self-monitoring through education is widely recognised as an integral part of diabetes treatment. A modern educational approach to implementing effective self-control requires significant effort and time from both the individual and the medical staff as a whole. However, in this complex system of mutual interactions, the environment in which the patient lives and works [29, 30].

The conclusions of numerous studies support the view of the influence of education on self-control, emphasising that self-control only has a positive effect on the metabolic control of the disease if the patient adapts his diet and physical activity according to the results of his self-measured control. In order to achieve good self-control, the patient's awareness must be focused on acquiring new knowledge and applying it in daily life [31].

A well-trained patient performs self-monitoring several times a day, keeps an independent self-monitoring diary and receives information about the appropriateness of their self-monitoring and the need to adapt it to their general state of health at each visit to the doctor. Self-monitoring of blood glucose levels is carried out using a device - a self-monitoring glucose metre [32].

The ease of use, the accuracy of the results and the relatively affordable price have led to their widespread use, which contributes significantly to improving the quality of life of people with diabetes [32]. To gain a proper insight into the development of blood glucose levels, continuous monitoring is usually required. In this way, hypo- and hyperglycaemia states can be prevented, which can disrupt the course of the disease and potentially endanger the patient's life if they are not recognised in time. Motivating the patient to self-monitor blood glucose levels at home, together with proper diet, moderate physical activity and regular intake of the suggested therapy, is the basis for good control of one's disease [33, 34].

New research has shown that a more successful regulation of blood glucose levels and a better knowledge of one's disease have a positive effect on the patient's psychological state. When they learn to control their disease, they become more self-confident and take more responsibility for their health. A slightly smaller number of patients show extreme anxiety. They should be involved in group work as soon as possible so that they understand that diabetes affects them, but not alone; they can share their problems with their peers [31, 33].

Although the role of proper diet, physical activity and reduction of excess weight with the use of medication and/or insulin therapy is a widely recognised strategy in the management of type 2 diabetes mellitus, the impact of self-monitoring and education on the quality of glycoregulation in patients with type 2 diabetes and thus reducing the risk of developing chronic complications is not yet well understood [34, 35].

The general characteristics of the patients are listed in Table 1.

Table 1. General characteristics of the patients studied

Gender	Number/%	Age	BMI (kg/m²)	sysTA (mmHg)	diaTA (mmHg)
Women	55/55%	60.1±8.3	28.7±6.02	133.8±17.2	82.5±8.9
Men	45/45%	58.6±8.3	29.4±5.0	137.8±23.1	83±10.7
Total	100/100%	59.4±8.2	29.1±5.6	135.6±20.1	82.7±9.7

NS for all parameters

Data are expressed as number/% and mean ± standard deviation

BMI - body mass index;

sysTA - systolic blood pressure (mmHg);

diaTA - diastolic blood pressure (mmHg).

Statistical analysis using Student's t-test showed a difference in the degree of obesity, but no difference in mean age and systolic and diastolic blood pressure values between the sexes of the patients studied (Table 1).

Dietary characteristics and adherence to dietary therapy recommendations are shown in Table 2.

Table 2. General characteristics of the patients studied

Gender	Unbalanced	Diet
Women	32/58%	23/42%
Men	27/60%	18/40%
Total	59/59%	41/41%

Slightly more than half of the women and men studied had an unbalanced diet, although statistical analysis using the chi-square test revealed no significant difference between the sexes (Table 2).

The prevalence of the individual types of physical activity is shown in Figure 1.

Among patients with type II diabetes mellitus, it is noticeable that almost half regularly go for a brisk walk, while sports and combined physical activity occur much less frequently. It is worrying that almost a quarter of patients do not engage in regular physical activity and fall into the inactive category (Figure 1).

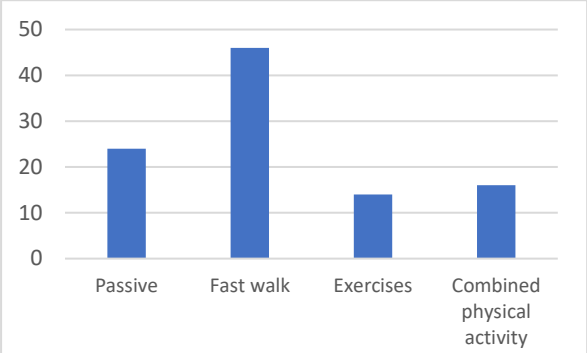

Figure 1. Type of physical activity in the patients analysed

The prevalence of the individual forms of therapy for type II diabetes mellitus is shown in Figure 2.

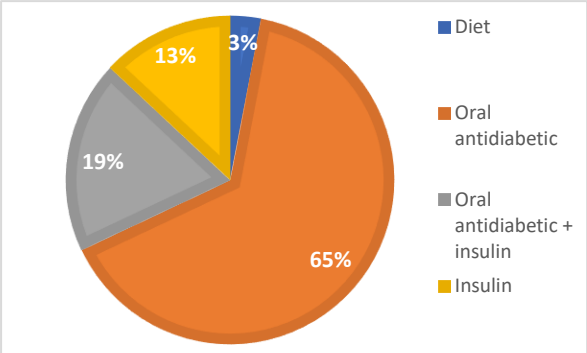

Figure 2. Prevalence of individual types of type 2 DM therapy

The highest percentage of patients with type II diabetes mellitus studied were taking oral antidiabetics in addition to the hygiene and dietary recommendations, while only 3% were without medication or insulin therapy (Figure 2).

The quality of glycaemic control in the patients studied, as assessed by morning glycaemia, postprandial glycaemia and glycosylated haemoglobin A1c concentration, is shown in Table 3.

Table 3. Quality of glycoregulation in relation to the gender of the subjects

	HbA1c (%)	Fasting blood glucose (mmol/l)	Postprandial blood glucose (mmol/l)
Women	8.9±2.4	8.24±2.3	12.7±2.93
Men	9.2±2.02	8.66±2.3	13.5±3.12
Total	9.06±2.2	8.42±2.3	13.07±3.03

HbA1c-Glycosylated haemoglobin A1c; NS for all parameters

Analysis using Student's T-test shows that there are no significant statistical differences in the quality of glycoregulation between the sexes (Table 3).

The characteristics of the self-monitoring programme in relation to the use of self-measurement are shown in Figure 3.

In the analysed sample of patients with type II diabetes mellitus, approximately 66% have a self-monitoring device, with this percentage being slightly higher in male patients (77.8%) than in female patients (56.7%). An analysis using the chi-square test shows that this difference is not statistically significant, but is on the borderline of significance (chi=3.3, p=0.055) (Figure 3).

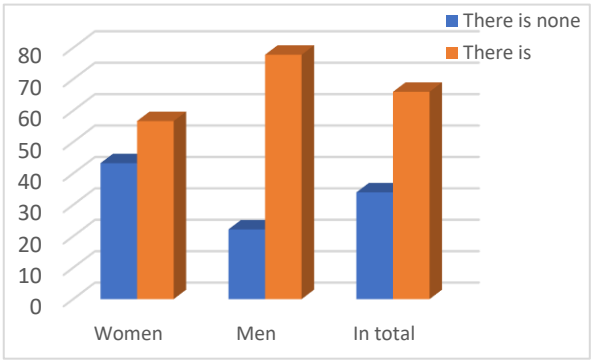

Figure 3. Percentage of patients with a self-monitoring device for blood sugar (NS for all parameters)

For patients who have a blood glucose metre, the quality of self-monitoring is determined by the frequency of blood glucose measurements. The results are shown in Figure 4.

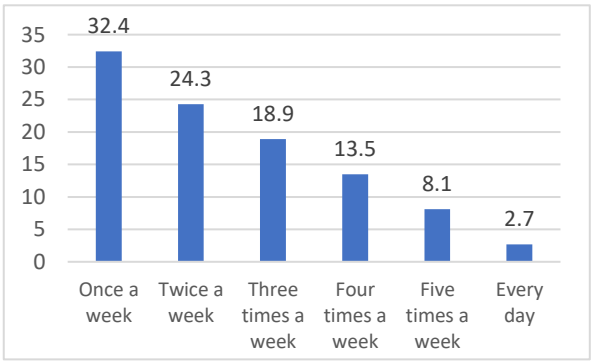

Figure 4. Frequency of measuring glycaemia with a self-monitoring device

Figure 4 shows that the largest percentage of patients use the metre once a week, and only 2.7% of patients use the metre daily (Figure 4).

The quality of self-control of the disease was also determined based on the frequency of glycemia control in laboratory conditions. The results are shown in Figure 5.

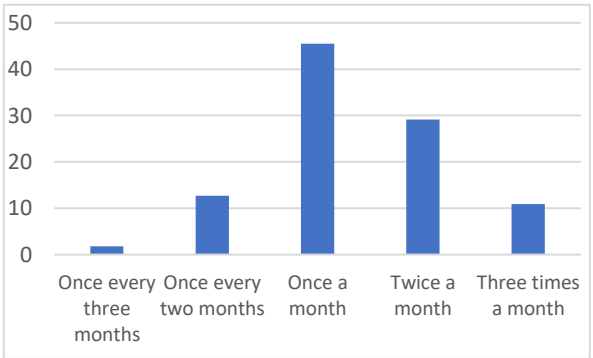

Figure 5. Frequency of glycaemia control in laboratory conditions

The quality of self-control was also observed through the number of visits to the endocrinologist during the year. Based on the frequency of visits to the endocrinologist, an appropriate graphic display was constructed (Figure 6).

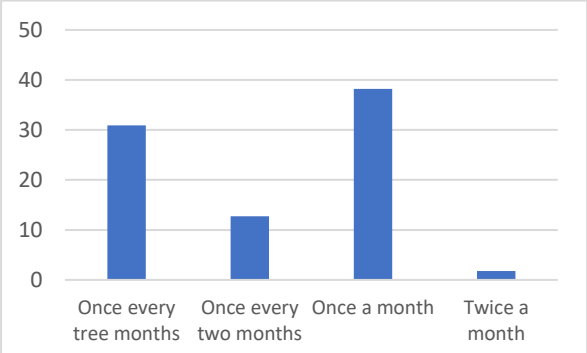

Figure 6. Frequency of visits to an endocrinologist

The quality of glycoregulation observed through the values of glycosylated hemoglobin A1c, morning and postprandial glycemia values in relation to the possession of a self-meter is shown in Table 4.

Table 4. Quality of glycoregulation and possession of a self-monitoring

	Fasting blood glucose (mmol/l)	Postprandial blood glucose (mmol/l)	HbA_1c (%)
Has a self-meter	8.2±2.2	12.4±2.2	8.8±1.6
Does not have a self-meter	8.6±2.35	13.8±3.5*	9.3±2.7#
Total	8.4±2.3	13.07±3.03	9.06±2.3

Data are presented as mean value ± standard deviation *p<0.05; #p<0.1

Table 4 shows that the possession of a self-meter has a significant impact on the quality of glycoregulation. It is noticeable that all parameters of glycoregulation in patients with a self-meter are better than those without a self-meter, but Student's t test showed the significance of this difference only for postprandial glycemia values ($p<0.05$), while for glycosylated hemoglobin A1c it was at the threshold of statistical significance ($p<0.1$).

Industrialisation in the modern world, which in itself forces a fast pace of life and thus the consumption of high-calorie foods, is one of the reasons for the increasing incidence of type II diabetes mellitus. Modern diabetes therapy has set very difficult targets in terms of blood glucose levels, blood lipids, and blood pressure, which should be brought to certain limits in each patient, and large deviations from these should not be allowed in order to prevent the development of acute and chronic complications [36, 37]. To achieve these goals, new therapeutic approaches were sought and existing ones improved. Today, very effective drugs are available for the therapeutic management of this disease, but the success of the therapy depends on adopting a healthier lifestyle, which includes maintaining healthy eating habits and engaging in moderate physical activity. The implementation of the principle of self-control as well as continuous patient education, forms the basis of the therapeutic approach to this global medical problem [38, 39].

A progressive increase in the prevalence of obesity with age was observed, with the lowest prevalence between 18 and 29 years at 9.5 % and the highest prevalence over 60 years at 26.6 %. This significant result suggests the need for even more demanding development of specific obesity prevention programs. More than half of the respondents had an unbalanced diet, indicating an urgent need to educate these patients. Physical activity was more pronounced in men, although there were differences in the type of physical activity. Half of the respondents engaged in brisk walking, while active exercise and a combined type of physical activity were undertaken by a much smaller number of respondents. Of concern is the fact that a quarter of respondents did not engage in any type of physical activity other than that which met daily living needs [40, 41].

Self-monitoring included the use of a self-monitoring device to determine blood glucose levels, body weight control, physical activity in the form of brisk walking, sports, and a combined type of physical activity, lipid status control, blood pressure, visits to the endocrinologist and glycosylated haemoglobin HbA1c, and laboratory determination of blood glucose [42, 43]. At the beginning of the study, the largest percentage of patients with type II diabetes owned a self-monitoring device, but only a small percentage of them used the self-monitoring device daily, while most of them used it once a week, indicating a lower level of education of the subjects about the importance of blood glucose self-monitoring. It has also been shown that ownership of a self-monitoring device correlates with the quality of blood glucose control and that its absence has an impact on poorer blood glucose levels over time, as well as on blood pressure and lipid status.

The influence of weight control also showed an effect on the subjects' glycoregulation, with better regulation observed in subjects with monthly weight control. Visiting an endocrinologist to monitor one's own health and gain insight into diabetes regulation showed better glycoregulation and a reduction in blood pressure levels in subjects who made this visit once a month compared to those who did so every 2 ~ 3 months [44]. Since education and self-monitoring are an integral part of diabetes mellitus therapy, their impact on the course of the disease and the patient's quality of life is crucial to prevent the onset of chronic complications and the early disability that they inevitably bring [45].

The results and discussion of this study suggest that patients with type 2 diabetes have a satisfactory level of knowledge about their own disease, as evidenced by their implementation of a self-control programme, but neglect the effects of diet and physical activity on the quality of glycaemic regulation. The cause of this phenomenon most likely lies in the level of education or a slightly lower commitment to raising it to a higher level when it comes to diet and physical activity. The modern approach to diabetes management is based on the active involvement of patients and family members, the adoption of healthier lifestyle habits and the acquisition of new knowledge about diabetes. Conclusion: Self-control as the basis of good glycaemic control in patients with type 2 diabetes means everything that individuals can do for themselves and their health [46, 47]. Adequately implemented self-

control, based on good education, is the way to actively participate in the fight against disease and to improve one's own quality of life.

4. Conclusion

Self-control and education as the basis of good glycaemic control in patients with type II diabetes represent all that individuals can do for themselves and their health. Appropriately implemented self-control, based on good education, is the path to active participation in disease control and improving one's quality of life. The results of this study indicate that type II diabetes patients have a satisfactory level of knowledge about their own disease, which is reflected in the implementation of a self-control programme, but neglect the influence of diet and physical activity on the quality of glycoregulation. The cause of this phenomenon most likely lies in the level of education or a slightly lower commitment to raising it to a higher level in terms of diet and physical activity. By implementing the principles of education and self-control, we have enabled people with type II diabetes to integrate the disease into their own personality, change their behaviour and accept all the limitations that such a life entails. The treatment itself requires a multidisciplinary approach in which the principles of self-control and education are adapted to the individual.

References

1. American Diabetes Association, "Diagnosis and classification of diabetes mellitus," *Diabetes Care*, vol. 37, suppl. 1, pp. S81 – S90, Jan. 2014. DOI: 10.2337/dc14-S081 PMid: 24357215
2. *IDF Diabetes Atlas*, 10th ed., IDF, Brussels, Belgium, 2021.
3. *Global report on diabetes*, WHO, Geneva, Switzerland, 2016. Retrieved from: https://www.who.int/publications/i/item/9789241565257 Retrieved on: Mar. 31, 2026
4. *International Textbook of Diabetes Mellitus*, vol. 2, R. A. DeFronzo, E. Ferrannini, P. Zimmet, K. G. M. M. Alberti, Eds., 4th ed., Chichester, UK: Wiley-Blackwell, 2015.
5. Y. Zheng, S. H. Ley, F. B. Hu, "Global aetiology and epidemiology of type 2 diabetes mellitus and its complications," *Nat. Rev. Endocrinol.*, vol. 14, no. 2, pp. 88 – 98, Feb. 2018. DOI: 10.1038/nrendo.2017.151 PMid: 29219149
6. М. М. Јовановић, "Етиопатогенеза инсулин-независног дијабетеса," у *Шећерна болест*, М. М. Јовановић, Б. С. Метиљевић, Уредници, Крагујевац, Србија: Призма, 1998, стр. 81 – 106. (M. M. Jovanović, "Etiopathogenesis of insulin-independent diabetes," in Diabetes, M. M. Jovanović, B. S. Metiljević, Eds., Kragujevac, Serbia: Prizma, 1998, pp. 81 – 106.)
7. P. Zimmet, K. G. M. M. Alberti, J. Shaw, "Global and societal implications of the diabetes epidemic," *Nature*, vol. 414, no. 6865, pp. 782 – 787, Dec. 2001. DOI: 10.1038/414782a PMid: 11742409
8. *Национални водич добре клиничке праксе код Diabetes Mellitus-a*, Министарство здравља Републике Србије, Београд, Србија, 2022. (*National Guide for Good Clinical Practice in Diabetes Mellitus*, Ministry of Health of the Republic of Serbia, Belgrade, Serbia, 2022.)
9. P. Z. Zimmet, D. J. McCarty, M. P. de Courten, "The global epidemiology of non-insulin-dependent diabetes mellitus and the metabolic syndrome," *J. Diabetes Complications*, vol. 11, no. 2, pp. 60 – 68, Mar.–Apr. 1997. DOI: 10.1016/s1056-8727(96)00090-6 PMid: 9101389
10. S. Wild, G. Roglic, A. Green, R. Sicree, H. King, "Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030," *Diabetes Care*, vol. 27, no. 5, pp. 1047 – 1053, May 2004. DOI: 10.2337/diacare.27.5.1047 PMid: 15111519
11. *IDF Diabetes Atlas*, 4th ed., IDF, Brussels, Belgium, 2009.
12. G. Williams, J. Pickup, "Pathogenesis of NIDDM," in *Handbook of Diabetes*, 1st ed., Oxford, UK: Blackwell Science, 1992, ch. 21, pp. 150 – 154.
13. J. E. Pessin, A. R. Saltiel, "Signaling pathways in insulin action: molecular targets of insulin resistance," *J. Clin. Invest.*, vol. 106, no. 2, pp. 165 – 169, Jul. 2000. DOI: 10.1172/JCI10582 PMid: 10903329 PMCid: PMC314316
14. K. F. Petersen, G. I. Shulman, "Pathogenesis of skeletal muscle insulin resistance in type 2 diabetes mellitus," *Am. J. Cardiol.*, vol. 90, no. 5, pp. 11G – 18G, Sep. 2002. DOI: 10.1016/s0002-9149(02)02554-7 PMid: 12231074
15. J. R. Zierath, A. Krook, H. Wallberg-Henriksson, "Insulin action in skeletal muscle from patients with NIDDM," *Mol. Cell. Biochem.*, vol. 182, no. 1–2, pp. 153 – 160, May 1998. DOI: 10.1023/A:1006861628496 PMid: 9609124
16. R. A. DeFronzo et al., "Type 2 diabetes mellitus," *Nat. Rev. Dis. Primers*, vol. 1, 15019, Jul. 2015. DOI: 10.1038/nrdp.2015.19 PMid: 27189025
17. S. Chatterjee, K. Khunti, M. J. Davies, "Type 2 diabetes," *Lancet*, vol. 389, no. 10085, pp. 2239 – 2251, Jun. 2017. DOI: 10.1016/S0140-6736(17)30058-2 PMid: 28190580
18. M. A. Atkinson, G. S. Eisenbarth, A. W. Michels, "Type 1 diabetes," *Lancet*, vol. 383, no. 9911, pp. 69 – 82, Jan. 2014. DOI: 10.1016/S0140-6736(13)60591-7 PMid: 23890997 PMCid: PMC4380133
19. American Diabetes Association, "Standards of medical care in diabetes—2023," *Diabetes Care*, vol. 46, suppl. 1, pp. S1–S290, Jan. 2023. DOI: 10.2337/dc23-SINT
20. J. A. Bluestone, K. Herold, G. Eisenbarth, "Genetics, pathogenesis and clinical interventions in type 1 diabetes," *Nature*, vol. 464, no. 7293, pp. 1293 – 1300, Apr. 2010. DOI: 10.1038/nature08933 PMid: 20432533 PMCid: PMC4959889
21. *Здравствено статистички годишњак Републике Србије 2023*, Београд, Србија: Институт „Батут," 2024. (*Health Statistical Yearbook of the Republic of Serbia 2023*, Belgrade, Serbia: Batut Institute, 2024.) Retrieved from: https://www.batut.org.rs/download/publikacije/pub2023v4.pdf Retrieved on: Mar. 31, 2026
22. G. Williams, J. Pickup, "Diagnostic and classification of diabetes," in *Handbook of Diabetes*, 1st ed., Oxford, UK: Blackwell Science, 1992, ch. 7, pp. 45 – 48.

23. B. B. Kahn, J. S. Flier, "Obesity and insulin resistance," *J. Clin. Invest.*, vol. 106, no. 4, pp. 473 – 481, Aug. 2000.
DOI: 10.1172/JCI10842
PMid: 10953022
PMCid: PMC380258
24. *Obesity and overweight*, WHO, Geneva, Switzerland, 2021.
Retrieved from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
Retrieved on: Mar. 31, 2026
25. M. Ng et al., "Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013," *Lancet*, vol. 384, no. 9945, pp. 766 – 781, Aug. 2014.
DOI: 10.1016/S0140-6736(14)60460-8
PMid: 24880830
PMCid: PMC4624264
26. F. B. Hu, *Obesity Epidemiology*, Oxford, UK: Oxford University Press, 2008.
27. M. W. Schwartz et al., "Cooperation between brain and islet in glucose homeostasis and diabetes," *Nature*, vol. 503, no. 7474, pp. 59 – 66, Nov. 2013.
DOI: 10.1038/nature12709
PMid: 24162835
28. S. E. Kahn, M. E. Cooper, S. Del Prato, "Pathophysiology and treatment of type 2 diabetes: Perspectives on the past, present, and future," *Lancet*, vol. 383, no. 9922, pp. 1068 – 1083, Mar. 2014.
DOI: 10.1016/S0140-6736(13)62154-6
PMid: 24315620
PMCid: PMC4226760
29. G. P. Chrousos, "Stress and disorders of the stress system," *Nat. Rev. Endocrinol.*, vol. 5, no. 7, pp. 374 – 381, Jul. 2009.
DOI: 10.1038/nrendo.2009.106
PMid: 19488073
30. F. B. Hu, "Globalization of diabetes: The role of diet, lifestyle, and genes," *Diabetes Care*, vol. 34, no. 6, pp. 1249 – 1257, Jun. 2011.
DOI: 10.2337/dc11-0442
PMid: 21617109
PMCid: PMC3114340
31. M. A. Powers et al., "Diabetes Self-management Education and Support in Type 2 Diabetes: A Joint Position Statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics," *Diabetes Educ.*, vol. 41, no. 4, pp. 417 – 430, Aug. 2015.
DOI: 10.1177/0145721715588904
PMid: 26047627
32. R. W. Beck et al., "Effect of continuous glucose monitoring on glycemic control in adults with type 1 diabetes using insulin injections: The DIAMOND randomized clinical trial," *JAMA*, vol. 317, no. 4, pp. 371 – 378, Jan. 2017.
DOI: 10.1001/jama.2016.19975
PMid: 28118453
33. S. L. Norris, M. M. Engelgau, K. M. Narayan, "Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials," *Diabetes Care*, vol. 24, no. 3, pp. 561 – 587, Mar. 2001.
DOI: 10.2337/diacare.24.3.561
PMid: 11289485
34. N. A. ElSayed et al., "Glycemic targets: Standards of Care in Diabetes—2023," *Diabetes Care*, vol. 46, suppl. 1, pp. S97 – S110, Jan. 2023.
DOI: 10.2337/dc23-S006
PMid: 36507646
PMCid: PMC9810469
35. D. E. Warburton, C. W. Nicol, S. S. Bredin, "Health benefits of physical activity: The evidence," *CMAJ*, vol. 174, no. 6, pp. 801 – 809, Mar. 2006.
DOI: 10.1503/cmaj.051351
PMid: 16534088
PMCid: PMC1402378
36. F. W. Booth, C. K. Roberts, M. J. Laye, "Lack of exercise is a major cause of chronic diseases," *Compr. Physiol.*, vol. 2, no. 2, pp. 1143 – 1211, Apr. 2012.
DOI: 10.1002/cphy.c110025
PMid: 23798298
PMCid: PMC4241367
37. R. A. DeFronzo, E. Ferrannini, "Insulin resistance. A multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease," *Diabetes Care*, vol. 14, no. 3, pp. 173 – 194, Mar. 1991.
DOI: 10.2337/diacare.14.3.173
PMid: 2044434
38. M. Stumvoll, B. J. Goldstein, T. W. van Haeften, "Type 2 diabetes: Principles of pathogenesis and therapy," *Lancet*, vol. 365, no. 9467, pp. 1333 – 1346, Apr. 2005.
DOI: 10.1016/S0140-6736(05)61032-X
PMid: 15823385
39. J. Tuomilehto et al., "Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance," *N. Engl. J. Med.*, vol. 344, no. 18, pp. 1343 – 1350, May 2001.
DOI: 10.1056/NEJM200105033441801
PMid: 11333990
40. W. C. Knowler et al., "Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin," *N. Engl. J. Med.*, vol. 346, no. 6, pp. 393 – 403, Feb. 2002.
DOI: 10.1056/NEJMoa012512
PMid: 11832527
PMCid: PMC1370926
41. C. L. Gillies et al., "Pharmacological and lifestyle interventions to prevent or delay type 2 diabetes in people with impaired glucose tolerance: Systematic review and meta-analysis," *BMJ*, vol. 334, no. 7588, 299, Jan. 2007.
DOI: 10.1136/bmj.39063.689375.55
PMid: 17237299
PMCid: PMC1796695
42. G. Li et al., "The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: A 20-year follow-up study," *Lancet*, vol. 371, no. 9626, pp. 1783 – 1789, May 2008.
DOI: 10.1016/S0140-6736(08)60766-7
PMid: 18502303
43. *Use of glycated haemoglobin (HbA1c) in the diagnosis of diabetes mellitus*, WHO, Geneva, Switzerland, 2011.
Retrieved from: https://www.who.int/publications/i/item/use-of-glycated-haemoglobin-(-hba1c)-in-diagnosis-of-diabetes-mellitus
Retrieved on: Apr. 1, 2026
44. International Expert Committee, "International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes," *Diabetes Care*, vol. 32, no. 7, pp. 1327 – 1334, Jul. 2009.
DOI: 10.2337/dc09-9033
PMid: 19502545
PMCid: PMC2699715
45. D. M. Nathan et al., "Translating the A1C assay into estimated average glucose values," *Diabetes Care*, vol. 31, no. 8, pp. 1473 – 1478, Aug. 2008.
DOI: 10.2337/dc08-0545
PMid: 18540046
PMCid: PMC2742903
46. N. G. Boulé, E. Haddad, G. P. Kenny, G. A. Wells, R. J. Sigal, "Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: A meta-analysis of controlled clinical trials," *JAMA*, vol. 286, no. 10, pp. 1218 – 1227, Sep. 2001.
DOI: 10.1001/jama.286.10.1218
PMid: 11559268

47. I. M. Stratton et al., "Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): Prospective observational study," *BMJ*, vol. 321, no. 7258, pp. 405 – 412, Aug. 2000.
DOI: 10.1136/bmj.321.7258.405
PMid: 10938048
PMCid: PMC27454