Education and Lifestyle as Elements of Type 2 Diabetes Therapy

Zuzanna Adriana Przybyłek-Stępień, Provincial Multidisciplinary Center of Oncology and Traumatology named after M. Copernicus University: Lodz, PL

https://orcid.org/0009-0002-4857-1315

przybylekstepienzuzanna@gmail.com

Jan Szustak, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0006-0690-7211

j.m.szustak@gmail.com

Ryszard Bartosiński, Provincial Hospital in Bielsko-Biała,

Al. Armii Krajowej 101, 43-316 Bielsko-Biala, Poland

https://orcid.org/0009-0005-3687-015X

rabartosi@gmail.com

Michał Wijata, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0004-0121-2854

wijata.michal@gmail.com

Anna Maria Wijata, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0005-7656-8318

anna.wijata@icloud.com

Justyna Dutkiewicz, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0007-0352-7827

justyna.dutkiewicz96@gmail.comm

Wiktoria Mączyńska, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0008-9833-7598

wika.maczynska@gmail.com

Maria Kąpa, Medical University of Lodz,

al. Tadeusza Kościuszki 4, 90-419 Lodz, Poland

https://orcid.org/0009-0008-5880-2416

maria.kapa.332@gmail.com

Bartosz Szepietowski, Heliodor Swiecicki Clinical Hospital,

ul. Przybyszewskiego 49, 60-355 Poznan, Poland

https://orcid.org/0009-0001-6945-3871

bartosz.szepietowski@gmail.com

Jakub Marek Kaźmierczak, Medical University of Lodz,

al. Tadeusza Kościuszki 4, 90-419 Lodz, Poland

https://orcid.org/0009-0002-0701-7983

jakub.kazmierczak.md@gmail.com

Ewelina Rycerz, Saint Lucas Hospital,

ul. Gimnazjalna 41B, 26-200 Konskie, Poland

https://orcid.org/0009-0006-5749-5720

ewelina.rycerz1@gmail.com

Piotr Pasek, Copernicus Memorial Hospital: Łódź, PL

https://orcid.org/0009-0001-6218-9887

pasek.piotrus@gmail.com

Corresponding author:

Zuzanna Adriana Przybyłek-Stępień, Provincial Multidisciplinary Center of Oncology and Traumatology named after M. Copernicus University: Lodz, PL

https://orcid.org/0009-0002-4857-1315

przybylekstepienzuzanna@gmail.com

Abstract

Introduction
Type 2 diabetes is the most common disorder of carbohydrate metabolism, characterized by high blood glucose levels. This disease has become one of the major global health issues. Treatment of type 2 diabetes involves both pharmacotherapy and lifestyle changes, with patient education playing a key role in the effectiveness of therapy. The goal of treatment is to prevent complications and improve the quality of life for patients.

Aim of the Study
The aim of this paper is to discuss the role of education and lifestyle in the therapy of type 2 diabetes.

Materials and Methods
This work was written based on a review of the current literature available through PubMed

and other databases The following keywords were used for the literature review: "diabetes", "epidemiology", "complications", "lifestyle", and "education". This allowed for an analysis of the pathogenesis, diagnosis, education, and lifestyle as elements of treatment, as well as complications associated with diabetes.

Conclusions

Type 2 diabetes is one of the most prevalent chronic diseases worldwide, with the incidence and prevalence continuously increasing. Early diagnosis and proper patient education are crucial in treatment, as they enable effective lifestyle modification, better disease management, and a reduction in the risk of complications. Diabetes education increases patient engagement in treatment, leading to better metabolic control and improved quality of life. In the future, further promotion of education will be important, as it will help in the earlier diagnosis of diabetes and reduce the number of its complications.

Keywords

Diabetes, Epidemiology, Complications, Lifestyle, Education

Introduction

Type 2 diabetes is the most common disorder of carbohydrate metabolism worldwide, characterized by high blood glucose levels. The underlying cause of this disease is insulin resistance, which refers to the increased resistance of tissues, mainly skeletal muscles, liver, and adipose tissue, to insulin. Next, under conditions of insulin resistance, there is a progressive impairment of insulin secretion by the beta cells of the pancreatic islets(1). Type 2 diabetes is one of the most common chronic diseases in society. A continuous increase in its prevalence is observed, which is why the World Health Organization has called it the world's first non-communicable epidemic(2). The treatment of diabetes is based on pharmacotherapy, which is complemented by non-pharmacological treatment, i.e., a health-promoting lifestyle.

The foundation of effective diabetes treatment is the patient's knowledge. Patient education is therefore an integral part of the therapeutic process. The goal of diabetes treatment is to minimize complications, which translates into maintaining a good quality of life for the patient(1). The aim of this paper is to present the elements of therapy used in type 2 diabetes, such as education and lifestyle.

Diagnosis of Diabetes

Early diagnosis of diabetes is crucial as it helps to halt the progression of the disease, which in turn contributes to a certain extent to reducing the occurrence of complications. The presence of diabetes is associated with various symptoms that are linked to hyperglycemia and its effects on specific organ systems. The most common symptoms include:

- Polydipsia – increased thirst
- Polyuria – increased urination
- Weakness and increased drowsiness
- Unintentional weight loss
- Formation of purulent skin lesions
- Recurrent urinary tract infections(3)

When a patient reports such symptoms, diagnostic testing is necessary. The basis for diagnosing diabetes is the measurement of blood glucose from a venous sample. The first test in such cases is the measurement of random blood glucose. A result of ≥ 200 mg/dl (≥ 11.1 mmol/l) in symptomatic patients is sufficient for the diagnosis of diabetes. If the result is < 200 mg/dl (< 11.1 mmol/l) or the patient does not report symptoms, further diagnostics are required:

- Two separate fasting blood glucose measurements, each taken on a different day, are required for a diabetes diagnosis. Diabetes is diagnosed when both fasting glucose levels are ≥ 126 mg/dL (≥ 7.0 mmol/L).
- One-time measurement of glycated hemoglobin (HbA1c) – the threshold for diagnosing diabetes is HbA1c ≥ 6.5% (≥ 48 mmol/mol).

If one or two fasting glucose measurements are within the range of 100-125 mg/dl (5.6–6.9 mmol/l) or the HbA1c level is between 5.7–6.4% (39–46 mmol/mol), an oral glucose

tolerance test (OGTT) should be performed. If the glucose level at the 120-minute mark of the OGTT is ≥ 200 mg/dl (≥ 11.1 mmol/l), this is sufficient to diagnose diabetes(4,5).

Risk Groups for Diabetes

The course of type 2 diabetes is often asymptomatic. Therefore, screening individuals from risk groups is crucial. These groups include:

- Individuals with overweight (BMI 25-29.9 kg/m²) or obesity (BMI ≥ 30 kg/m²), or women with a waist circumference > 80 cm and men with a waist circumference > 94 cm.
- Individuals with a family history of diabetes (parents or siblings diagnosed with diabetes).
- Individuals previously diagnosed with impaired glucose tolerance or impaired fasting glucose.
- Women who have had gestational diabetes.
- Women who have given birth to a child weighing > 4 kg.
- Women with polycystic ovary syndrome.
- Individuals with hypertension.
- Individuals with HDL-C < 40 mg/dl (< 1.0 mmol/l) or triglyceride levels > 150 mg/dl (> 1.7 mmol/l).
- Individuals with atherosclerotic cardiovascular disease.

For individuals in these groups, fasting blood glucose measurement or an oral glucose tolerance test (OGTT) should be performed once a year for screening. Additionally, diagnostic screening tests should be conducted every 3 years for all individuals aged ≥ 45 years(6,7).

Goals of Diabetes Treatment

The expectations regarding the outcomes of type 2 diabetes treatment vary depending on the individual patient. The therapeutic goal and choice of strategy depend on factors such as the duration of the disease, the patient's involvement in the treatment process, comorbidities, estimated life expectancy, and the benefits the patient can gain from treatment. The primary goal of type 2 diabetes treatment is the reduction of diabetes-related complications(8).

Achieving this main therapeutic goal is possible through the realization of smaller, intermediate objectives, which form the foundation for success in therapy. In collaboration with the patient, the aim is to normalize glycemia—goal HbA1c ≤ 7%(9,10), normalize body weight, normalize blood pressure—target BP ≤ 130/80 mmHg, normalize the lipid profile depending on cardiovascular risk: for patients with moderate risk—LDL-C < 100 mg/dl; with high risk—LDL-C < 70 mg/dl; with very high risk—LDL-C < 55 mg/dl; and cardiovascular-renal protection. To achieve all these goals, it is crucial to implement lifestyle changes and provide effective diabetes education(9,11).

Complications of Diabetes

Chronic hyperglycemia has an adverse effect on the human body. Even a slight and sustained increase in blood glucose levels can lead to damage, impaired function, and even failure of various organs. The complications of diabetes are divided into two main groups: acute complications and chronic complications(12).

Acute Diabetes Complications

Acute complications of diabetes are conditions that pose an immediate threat to the patient's health and life. These complications typically develop very rapidly and require immediate medical intervention. The acute complications of diabetes include:

- Diabetic Ketoacidosis (DKA) and Coma

  This is an acute disturbance of water-electrolyte balance and acid-base equilibrium. The underlying cause of this complication is the disturbance of carbohydrate, protein, and fat metabolism. The latter undergoes excessive breakdown, leading to the formation of ketone bodies, which are present in both serum and urine(13). A patient with diabetic ketoacidosis presents with the following symptoms: excessive thirst, polyuria, weakness and drowsiness, impaired consciousness, hypotension, tachycardia, Kussmaul breathing, and a fruity acetone odor from the mouth. Diabetic ketoacidosis is a life-threatening condition, with mortality ranging from 0.2% to 2%, and the risk increases with recurrent episodes(14).

- Hyperglycemic Hyperosmolar Syndrome (HHS)

  This condition mainly occurs in patients with undiagnosed or inadequately treated diabetes. It is characterized by extremely high blood glucose levels (>600 mg/dl), high

plasma osmolality (>320 mOsm/kg H2O), and prerenal kidney failure. The clinical presentation of a typical patient with HHS includes altered consciousness leading to coma, tachycardia, hypotension, signs of dehydration, and rapid, shallow breathing. The mortality rate for this syndrome is very high, approximately 15%(15).

- Lactic Acidosis

Lactic acidosis is the least common acute complication of diabetes and results from anaerobic glucose metabolism. It is mainly observed in patients experiencing shock. Clinical symptoms include significant weakness, delirium, coma, hypothermia, hypotension, oliguria, nausea, and vomiting. Historically, the mortality rate of lactic acidosis was nearly 50%(16).

- Hypoglycemia

Hypoglycemia is the most frequently occurring acute complication of diabetes. It is defined as a blood glucose level below 70 mg/dl, regardless of whether symptoms are present. Clinically significant hypoglycemia is defined as a glucose level below 54 mg/dl. The most common cause of hypoglycemia is an excessive dose of hypoglycemic medication relative to physical activity and meals. Characteristic symptoms of hypoglycemia include nausea, headache, anxiety, agitation, palpitations, hunger, trembling, confusion, drowsiness, vision disturbances, and, in severe cases, coma(17,18).

Chronic Diabetes Complications

Chronic hyperglycemia leads to complications such as macroangiopathies and microangiopathies, which are diseases of the vascular system. Diabetes contributes to early development of atherosclerosis. It is estimated that coronary artery disease occurs twice as frequently in diabetic patients compared to the general population. The risk of death from cardiovascular causes is approximately three times higher in diabetics than in the general population(8,19). Another complication in the group of macroangiopathies is stroke, which occurs 2–3 times more often than in people without diabetes(8,20). Atherosclerosis of the arteries can also lead to ischemia of the lower limbs, which manifests as pain during walking, and in more advanced cases, may result in necrosis of the peripheral parts of the foot(8,19). Microangiopathies are pathologies affecting small capillaries. Among them, we distinguish diabetic retinopathy, diabetic nephropathy, and diabetic neuropathy(8,19). Diabetic

Retinopathy is damage to the retina resulting from vascular changes, leading to visual impairment and eventual loss of vision(8,19,21). Diabetic Nephropathy is damage to the renal glomeruli responsible for blood filtration and the formation of urine, through which metabolic waste products are excreted. It leads to kidney failure(8,19,22). Diabetic Neuropathy is a chronic complication of diabetes caused by pathology in the vessels that nourish the nerves. This results in damage to the central, peripheral, and autonomic nervous systems. It includes chronic sensorimotor polyneuropathy, which manifests as painful muscle cramps, paresthesia, and dysesthesia of the hands and feet, as well as autonomic neuropathy. The most common manifestations of autonomic neuropathy are in the cardiovascular, gastrointestinal, and genitourinary systems(8,19,23). Diabetic Foot Syndrome is a specific complication of diabetes is diabetic foot syndrome, where infection or ulceration occurs in the tissues of the foot, potentially accompanied by destruction of deeper tissues, such as bones. Diabetic foot syndrome can be classified as neuropathic, vascular, or mixed. It can be caused by nerve damage (neuropathic diabetic foot), vascular damage (vascular/ischemic diabetic foot), or both (Neuroischemic diabetic foot)(8,24).

Patient Education

Behavioral therapy is a key component of the therapeutic process for patients diagnosed with diabetes. Its goal is to increase patient self-awareness and self-management. Educating patients with type 2 diabetes presents a significant challenge, especially because the disease primarily affects older individuals. To facilitate this difficult process, it is beneficial for the patient to be accompanied by close family members, as this increases the likelihood that the theoretical knowledge provided will translate into practical application. The best outcomes in diabetes education are achieved through a multi-stage approach. The first stage, also known as the survival level, provides essential information that helps avoid acute complications of diabetes. The second stage — basic education — provides knowledge that enables the patient to consciously participate in the therapeutic process in order to prevent chronic complications. The education of the patient should make them aware of the importance of a healthy lifestyle, which will be reflected in modifications to their behavior(25). There are various forms of education that address the individual needs of patients. One of them is individual therapy, which focuses on discussing the patient's personal issues and preferences. The goal of individual education is not only to provide knowledge about diabetes but also to equip the

patient with skills that allow them to independently monitor their glucose levels, manage insulin therapy (if applicable), follow proper nutrition guidelines, engage in physical activity, and cope with the stress and emotions related to the disease. In individual education, meetings with the patient may include discussions with the physician, dietitian, nurse, and even a psychologist, who can help the patient deal with the challenges of long-term management of a chronic illness. The patient is the central figure of the therapeutic team and must be an active member in order for the knowledge gained during education to be applied in real life(26,27). Another type of education is group therapy, which aims to provide mutual support and motivation for patients in adopting a healthier lifestyle. In group therapy, patients participate in educational sessions where they can share their experiences, ask questions, learn from each other, and receive support from specialists(27,28). The result of effective, comprehensive education is raising the patient's awareness of their responsibility for their own health through self-care and self-monitoring. These actions lead to the practice of a health-promoting lifestyle. Regardless of the type of education, it should always be a continuous process, encompassing both medical and psychological aspects, to support the patient, motivate them, and maintain the highest possible quality of life for the patient(26–28).

Diet

Over the past few decades, dietary recommendations for diabetic patients have undergone modifications. Currently, it is believed that the diet of a person with diabetes does not differ from the general principles of healthy eating. When planning a diet, an individualized approach should be taken for each patient, considering their food preferences, coexisting conditions, age, gender, level of physical activity, and economic factors(29). The diet should focus on minimizing the intake of highly processed foods, increasing vegetable consumption, and limiting added sugars. The goal of nutritional education for people with type 2 diabetes is to achieve and maintain metabolic control and reduce body weight, as most patients suffer from overweight or obesity. Education mainly focuses on teaching patients how to assess the caloric value of meals and control portion sizes. For patients with excess body weight, introducing calorie deficit is recommended, aiming for a weight reduction of approximately 0.5-1 kg per week(30). People with type 2 diabetes should have knowledge of the sources of carbohydrates, proteins, and fats. In a properly balanced diet, energy is obtained from 45-50% carbohydrates, 30-35% fats, and 15-20% proteins(31). To achieve metabolic control, patients

must monitor the amount of carbohydrates consumed in each meal and throughout the day. Carbohydrate exchange lists are helpful for this. One carbohydrate exchange (1 CHO) is the amount of a product that provides 10 g of glucose. This allows patients to consume a variety of meals while maintaining a consistent level of carbohydrate intake. An educated patient is able to recognize and consciously avoid foods that contain easily absorbed carbohydrates and added sugars(32). Meals for patients with type 2 diabetes should be consumed regularly, which helps maintain stable blood glucose levels. Depending on the individual needs of the patient, it is recommended to have 3 meals per day for patients treated with diet and hypoglycemic medications. Patients on insulin therapy should consume 5-6 meals per day. Irregularity and an improper number of meals can lead to greater fluctuations in blood glucose levels throughout the day(33). Alcohol consumption carries the risk of hypoglycemia and is therefore not recommended for people with type 2 diabetes. Alcohol inhibits gluconeogenesis, which reduces glucose production and release from the liver. Additionally, alcohol is high in calories, which may contribute to weight gain and the development of obesity(34).

Physical Activity

Regular physical activity is an essential component of effective treatment for type 2 diabetes. The type, duration, and intensity of exercise should be tailored to the individual's capabilities, taking into account their physical condition and the stage of the disease. According to recommendations, the minimum amount of activity is 30 minutes of brisk walking three times a week(35). Physical activity brings a range of metabolic benefits. During exercise, glycogen synthesis increases, hexokinase activity is enhanced, and the number of capillaries in muscles rises, which ultimately improves glucose transport into muscle tissues(36). Additionally, regular physical activity helps lower blood pressure and improve lipid profiles(37). Individuals with type 2 diabetes who do not use insulin or sulfonylurea derivatives have a minimal risk of hypoglycemia. For this group, the recommended form of exercise is aerobic training, supplemented with strength training 2-3 times a week. Regular physical activity increases tissue sensitivity to insulin, potentially delaying the need for insulin therapy. However, these patients should periodically monitor their blood glucose during exercise. On the other hand, individuals using insulin are at risk of hypoglycemia, especially during prolonged aerobic activity. In such cases, insulin dosage should be adjusted, and additional carbohydrates should be consumed to prevent excessive glucose drops. Regular glucose

monitoring during exercise is crucial to ensure the safety of insulin-treated patients(38). It is important to emphasize that the benefits of physical activity are independent of the type of diabetes therapy. Regular exercise not only improves glycemic control but also helps in weight reduction, which is key in managing type 2 diabetes. Recent studies highlight that long-term physical activity has a positive impact on reducing the risk of cardiovascular complications and improving the quality of life in patients with diabetes. Regular exercise, properly tailored to the patient's needs, can thus form the foundation of effective therapy for this disease(39,40).

Sleep

Adhering to proper sleep hygiene is crucial for maintaining appropriate blood glucose levels, and therefore, plays a significant role in metabolic control. Studies show that sleep disturbances, such as sleep apnea, insomnia, or insufficient sleep, can lead to poorer glycemic control, increased insulin resistance, and a higher risk of cardiovascular complications, which are common in individuals with diabetes(40). People with type 2 diabetes should aim for an average of 7-9 hours of sleep per day. This sleep should be regular and uninterrupted. An important aspect is also the quality of sleep—avoiding distractions, such as using electronics before bedtime, and ensuring proper conditions in the bedroom. Proper sleep hygiene helps stabilize glucose levels, improve insulin sensitivity, and reduce stress, all of which are important in the management of type 2 diabetes. Additionally, individuals with diabetes should seek medical advice if they suspect sleep disorders, such as sleep apnea, which may require specialized treatment(41–43).

Combating Nicotinism

In patients with type 2 diabetes, nicotine addiction is one of the major factors contributing to the development of cardiovascular diseases. Smoking increases insulin resistance, worsens microcirculation, and promotes the development of vascular complications. Quitting smoking is a crucial element of therapy that can significantly improve the prognosis and quality of life for patients with type 2 diabetes(44).

Conclusions

Type 2 diabetes is one of the most common chronic diseases and one of the biggest challenges in modern medicine. There is a continuous upward trend in the number of new diagnoses, both in Poland and globally. When diagnosed too late and treated improperly, this disease leads to a range of complications that negatively affect the patient's quality of life. Therefore, early diagnosis and proper education are key in treatment, as they translate into lifestyle modifications for the patient. Managing type 2 diabetes is not just about pharmacotherapy. An essential element of comprehensive therapy is patient education, which provides them with the tools to manage the disease independently. Well-educated patients are more engaged in their treatment and can make informed decisions about diet, physical activity, and monitoring their health. An informed patient adopts a healthy lifestyle, which leads to better metabolic control. Properly managed disease reduces the occurrence of complications, thus improving both the length and quality of life. In the future, it is crucial to continue promoting diabetes education, both among patients and in society, which will enable early diagnosis, better disease control, and a reduction in complications.

Not applicable.

References:

1. Scheen AJ. Pathophysiology of type 2 diabetes. Acta Clin Belg. 2003 Nov;58(6):335–41.

2. WHO. World Health Organization. (2016). Physical activity strategy for the WHO European Region 2016–2025. WHO Regional Office for Europe.

3. Chung WK, Erion K, Florez JC, Hattersley AT, Hivert MF, Lee CG, et al. Precision medicine in diabetes: a Consensus Report from the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetologia. 2020 Sep;63(9):1671–93.

4. De Franco E, Flanagan SE, Houghton JAL, Lango Allen H, Mackay DJG, Temple IK, et al. The effect of early, comprehensive genomic testing on clinical care in neonatal diabetes: an international cohort study. Lancet. 2015 Sep 5;386(9997):957–63.

5. Genuth S, Alberti KGMM, Bennett P, Buse J, Defronzo R, Kahn R, et al. Follow-up report on the diagnosis of diabetes mellitus. Diabetes Care. 2003 Nov;26(11):3160–7.

6. Haw JS, Galaviz KI, Straus AN, Kowalski AJ, Magee MJ, Weber MB, et al. Long-term sustainability of diabetes prevention approaches: A systematic review and meta-analysis of randomized clinical trials. JAMA Intern Med. 2017 Dec 1;177(12):1808–17.

7. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med. 2002 Feb 7;346(6):393–403.

8. Stratton IM, Adler AI, Neil HA, Matthews DR, Manley SE, Cull CA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ. 2000 Aug 12;321(7258):405–12.

9. Battelino T, Danne T, Bergenstal RM, Amiel SA, Beck R, Biester T, et al. Clinical targets for continuous glucose monitoring data interpretation: Recommendations from the international consensus on time in range. Diabetes Care. 2019 Aug;42(8):1593–603.

10. Vijan S, Sussman JB, Yudkin JS, Hayward RA. Effect of patients' risks and preferences on health gains with plasma glucose level lowering in type 2 diabetes mellitus. JAMA

Intern Med. 2014 Aug;174(8):1227–34.

11. Cosentino F, Grant PJ, Aboyans V, Bailey CJ, Ceriello A, Delgado V, et al. 2019 ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD. Eur Heart J. 2020 Jan 7;41(2):255–323.

12. Czech A, Tatoń J. Definition, Epidemiometry, and Indicators of the Development of Diabetes Epidemic, Diabetes, ed. ed.CA, Tatoń J, Elamed W, editors. 2009;17–27.

13. Chua HR, Schneider A, Bellomo R. Bicarbonate in diabetic ketoacidosis - a systematic review. Ann Intensive Care. 2011 Jul 6;1(1):23.

14. Dhatariya KK, Joint British Diabetes Societies for Inpatient Care. The management of diabetic ketoacidosis in adults-An updated guideline from the Joint British Diabetes Society for Inpatient Care. Diabet Med. 2022 Jun;39(6):e14788.

15. Dhatariya KK, Vellanki P. Treatment of diabetic ketoacidosis (DKA)/hyperglycemic hyperosmolar state (HHS): Novel advances in the management of hyperglycemic crises (UK versus USA). Curr Diab Rep. 2017 May;17(5):33.

16. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes. Diabetes Care. 2009 Jul;32(7):1335–43.

17. Seaquist ER, Anderson J, Childs B, Cryer P, Dagogo-Jack S, Fish L, et al. Hypoglycemia and diabetes: a report of a workgroup of the American Diabetes Association and the Endocrine Society. J Clin Endocrinol Metab. 2013 May;98(5):1845–59.

18. Abraham SB, Arunachalam S, Zhong A, Agrawal P, Cohen O, McMahon CM. Improved real-world glycemic control with continuous glucose monitoring system predictive alerts. J Diabetes Sci Technol. 2021 Jan;15(1):91–7.

19. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clin Diabetes. 2008 Apr 1;26(2):77–82.

20. Capes SE, Hunt D, Malmberg K, Pathak P, Gerstein HC. Stress hyperglycemia and prognosis of stroke in nondiabetic and diabetic patients: A systematic overview. Stroke. 2001 Oct;32(10):2426–32.

21. Bragge P, Gruen RL, Chau M, Forbes A, Taylor HR. Screening for presence or absence of diabetic retinopathy: a meta-analysis: A meta-analysis. Arch Ophthalmol. 2011 Apr;129(4):435–44.

22. de Boer IH, Khunti K, Sadusky T, Tuttle KR, Neumiller JJ, Rhee CM, et al. Diabetes Management in Chronic Kidney Disease: A consensus report by the American Diabetes Association (ADA) and Kidney Disease: Improving Global Outcomes (KDIGO). Diabetes Care. 2022 Dec 1;45(12):3075–90.

23. Martin CL, Albers JW, Pop-Busui R, DCCT/EDIC Research Group. Neuropathy and related findings in the diabetes control and complications trial/epidemiology of diabetes

interventions and complications study. Diabetes Care. 2014;37(1):31–8.

24. Senneville É, Albalawi Z, van Asten SA, Abbas ZG, Allison G, Aragón-Sánchez J, et al. Diagnosis of infection in the foot of patients with diabetes: A systematic review. Diabetes Metab Res Rev. 2024 Mar;40(3):e3723.

25. Otto-Buczkowska E, Marciniak-Brzezińska M. Specyficzne problemy edukacji diabetologicznej. Forum Medycyny Rodzinnej. 2016;10(4):212–8.

26. Funnell MM, Anderson RM. Empowerment and self-management of diabetes. Clin Diabetes. 2004 Jul 1;22(3):123–7.

27. American Diabetes Association. Standards of care in diabetes-2023 abridged for primary care providers. Clin Diabetes. 2022 Dec 12;41(1):4–31.

28. Odgers-Jewell K, Ball LE, Kelly JT, Isenring EA, Reidlinger DP, Thomas R. Effectiveness of group-based self-management education for individuals with Type 2 diabetes: a systematic review with meta-analyses and meta-regression. Diabet Med. 2017 Aug;34(8):1027–39.

29. Bell KJ, Smart CE, Steil GM, Brand-Miller JC, King B, Wolpert HA. Impact of fat, protein, and glycemic index on postprandial glucose control in type 1 diabetes: implications for intensive diabetes management in the continuous glucose monitoring era. Diabetes Care. 2015 Jun;38(6):1008–15.

30. Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. J Acad Nutr Diet. 2015 Sep;115(9):1447–63.

31. American Diabetes Association, Bantle JP, Wylie-Rosett J, Albright AL, Apovian CM, Clark NG, et al. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. Diabetes Care. 2008 Jan;31 Suppl 1(Supplement_1):S61–78.

32. Medrela-Kuder E. Proper diet in type 2 diabetes as a means of patients' rehabilitation. Rocz Panstw Zakl Hig. 2011;62(2):219–23.

33. Kołpa M, Grochowska A, Kubik B, Stradomska K. Lifestyle, metabolic compensation in patients with type 2 diabetes mellitus and the risk of chronic disease complications. Clinical Diabetology. 2018;7(3):151–8.

34. Cryer PE, Davis SN, Shamoon H. Hypoglycemia in diabetes. Diabetes Care. 2003 Jun;26(6):1902–12.

35. Czarnecki D, Skalski DW, Kowalski D, Vynogradskyi B, Grygus I. AKTYWNOŚĆ FIZYCZNA SENIORÓW WARUNKIEM ZDROWIA I DOBREJ JAKOŚCI ŻYCIA. Реабілітаційні та фізкультурно-рекреаційні аспекти розвитку людини (Rehabilitation & recreation). 2022 Oct 12;(12):105–12.

36. Journal of physical education and sport [Internet]. Vol. 21. Physical Education and Sport Faculty; 2021. Available from: http://dx.doi.org/10.7752/jpes.2021.02093

37. Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, et al. Exercise and type 2 diabetes: the American College of Sports Medicine and the American Diabetes Association: joint position statement. Diabetes Care. 2010 Dec;33(12):e147–67.

38. Jelleyman C, Yates T, O'Donovan G, Gray LJ, King JA, Khunti K, et al. The effects of high-intensity interval training on glucose regulation and insulin resistance: a meta-analysis: The effects of HIIT on metabolic health. Obes Rev. 2015 Nov;16(11):942–61.

39. Kanaley JA, Colberg SR, Corcoran MH, Malin SK, Rodriguez NR, Crespo CJ, et al. Exercise/physical activity in individuals with type 2 diabetes: A consensus statement from the American College of Sports Medicine. Med Sci Sports Exerc. 2022 Feb 1;54(2):353–68.

40. Knutson KL, Van Cauter E. Associations between sleep loss and increased risk of obesity and diabetes. Ann N Y Acad Sci. 2008;1129(1):287–304.

41. Lee DY, Jung I, Park SY, Yu JH, Seo JA, Kim KJ, et al. Sleep duration and the risk of type 2 diabetes: A community-based cohort study with a 16-year follow-up. Endocrinol Metab (Seoul). 2023 Feb;38(1):146–55.

42. Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: A systematic review and meta-analysis. Sleep Med Rev. 2017 Feb;31:91–101.

43. Ohkuma T, Fujii H, Iwase M, Kikuchi Y, Ogata S, Idewaki Y, et al. Impact of sleep duration on obesity and the glycemic level in patients with type 2 diabetes: the Fukuoka Diabetes Registry. Diabetes Care. 2013 Mar;36(3):611–7.

44. Eliasson B. Cigarette smoking and diabetes. Prog Cardiovasc Dis. 2003 Mar;45(5):405–13.