Ashdin Publishing
Journal of Drug and Alcohol Research
Vol. 14 (2025), Article ID 170472, 13 pages
DOI: 10.4303/JDAR/236452

Review Article

Transforming Diabetes Care in Older Adults: A Review of Epidemiology, Challenges, and Personalized Management

Anastasia V. Poznyak[1*], Sergey Kozlov[2], Elizaveta Romanovna Korchagina[1], Olga Nikolaevna Maltseva[3], Vsevolod Vyacheslavovich Pavshintsev[4] and Alexander N. Orekhov[1]

[1]*Institute for Atherosclerosis Research, Osennyaya 4-1-207, 121609 Moscow, Russia*

[2]*Department of Problems of Atherosclerosis, E.I. Chazov National Medical Research Center of the Ministry of Health of the Russian Federation*

[3]*Institute of Experimental Medicine, 12, Academician Pavlov Street, 197022, Saint Petersburg, Russia*

[4]*Institute of Ecology, Peoples' Friendship University of Russia (RUDN University), 6, Miklukho-Maklaya Street, 117198 Moscow, Russia*

**Address Correspondence to: Anastasia V. Poznyak, Email: tehhy_85@mail.ru*

Received: 27 August 2025; Manuscript No: JDAR-25-170472; Editor assigned: 29 August 2025; PreQC No: JDAR-25-170472 (PQ); Reviewed: 12 September 2025; QC No: JDAR-25-170472; Revised: 19 September 2025; Manuscript No: JDAR-25-170472 (R); Published: 26 September 2025; DOI: 10.4303/JDAR/236452

Abstract

As the global elderly population expands, world faces a rapid demographic transformation characterized by a significant increase in life expectancy and a rising prevalence of chronic conditions, notably Type 2 Diabetes Mellitus (T2DM). This review explores the multifaceted challenges associated with diabetes management in older adults, focusing on the urgent need for personalized intervention strategies. This demographic shift creates complex health needs, necessitating comprehensive management approaches tailored to the unique physiological and psychosocial factors affecting older patients.

We discuss the epidemiology of T2DM in the elderly and its underlying mechanisms, including insulin resistance and the role of lifestyle factors. The review also highlights the critical importance of early detection and prevention strategies, particularly for prediabetes, and emphasizes the necessity of individualized treatment plans that address varied health statuses and functional capacity among older patients. We address the limitations of current therapeutic approaches, which often derive from studies with younger cohorts, underscoring the need for more age-specific research.

Additionally, challenges such as polypharmacy, increased risk of comorbidities, and the potential for adverse treatment outcomes further complicate diabetes care in this age group. We advocate for holistic, integrated care strategies that encompass lifestyle modifications, health education, and appropriate pharmacological interventions, emphasizing patient-centered approaches that factor in the preferences and circumstances of older adults. By addressing these issues, we aim to improve the overall health outcomes, functional capacity, and quality of life for elderly individuals living with T2DM.

Keywords: Type 2 Diabetes Mellitus; Chronic disease; Insulin resistance; Polypharmacy

Introduction

The global elderly population is expanding quickly. This demographic shift, while indicative of societal advancements such as medical breakthroughs and higher living standards, also highlights pressing public health challenges. Among these, the growing prevalence of chronic conditions like Type 2 Diabetes Mellitus (T2DM) stands out as a critical global health issue. Diabetes was responsible for approximately 11.3% of global deaths in 2019. With obesity rates on the rise among the elderly, the risk of diabetes is expected to continue growing. The increase in diabetes prevalence among the elderly differs across regions and ethnicities, being relatively low in European countries but significantly higher in affluent East Asian nations like Korea [1,2].

The combination of T2DM and age-related syndromes in older adults results in complex health needs that require a holistic approach for effective management. Currently, treatment strategies predominantly draw on research conducted with younger cohorts, leaving a significant gap in personalized care for the older T2DM population. This gap underscores the urgent need for more age-specific management plans [3,4]. However, crafting an ideal management plan for older adults with diabetes presents numerous challenges. The manifestation of the disease in this age group can be vague, making it difficult to diagnose and treat. Older adults with T2DM often display a wide range of variability in their condition due to age-associated physiological changes, the presence of other chronic illnesses, and differences in functional, cognitive, and mobility levels [5,6].

Moreover, older individuals are at a higher risk of developing cardiovascular diseases and cancer, which notably increases mortality risk. Critical diabetes-related complications that pose significant dangers in the elderly include the Hyperglycemic Hyperosmolar State (HHS), Diabetic Ketoacidosis (DKA), severe hypoglycemia, and serious acute infections, all of which also heighten the risk of death [7,8]. Even complications of diabetes that are not immediately life-threatening can cause a decline in functional ability and quality of life, potentially leading to a loss of independence. Additionally, neurocognitive disorders are more common among diabetic patients, affecting their capacity to manage blood sugar levels and to react appropriately to hyperglycemia and hypoglycemia [9,10].

Recent societal shifts have also seen an increase in obesity rates, which now extend to the older T2DM population in the form of sarcopenic obesity. Furthermore, the prevalence of polypharmacy in the elderly raises the likelihood of drug interactions and adverse effects. Considering these multifarious challenges, there is a critical need to devise an integrated care strategy for older adults with diabetes. This strategy should be tailored to the unique and diverse characteristics of this demographic, taking into consideration their specific lifestyle preferences, socioeconomic status, and available support networks [11-14].

In this analysis, we delve into the complex nature of T2DM in older adults and the various strategies for managing it. Our goal is to underscore the significance of personalized care and the necessity for treatment plans that cater to the unique requirements of elderly individuals with T2DM by detailing these aspects.

Epidemiology of diabetes mellitus in elderly

The global population is aging, and individuals over 60 years old make up 15% of the total population, which is approximately 7.5 billion people. Among the elderly, about 20% have Diabetes Mellitus (DM), with a similar percentage remaining undiagnosed [15,16]. The prevalence of DM among this age group varies between 18% and 33%, a discrepancy that could be attributed to differences in age, lifestyle, and genetic factors across populations. Additionally, 30% of older adults experience impaired glucose regulation, putting them at a higher risk for developing DM [17-19] (Table 1).

Table 1: Epidemiology and challenges of T2DM in the elderly.

Aspect	Details	Statistics	Implication
Prevalence of T2DM	Approximately 20% of elderly (age 60+) have diabetes; 30% with prediabetes symptoms.	30.1% prevalence in South Koreans aged 65+ (2020)	Significant health burden requiring targeted interventions.
Common complications	Increased risk of cardiovascular diseases, hypoglycemia, and falls.	Children of elderly with T2DM face higher mortality rates.	Need for close monitoring and tailored treatment plans.
Management challenges	Variability in health status and polypharmacy risks complicate care.	5.27 million South Korean adults diagnosed with diabetes.	Highlights the necessity for comprehensive management strategies.
Healthcare needs	Comprehensive, individualized management considering physiological and psychosocial factors.	Varying health statuses hinder standard treatment protocols.	Raises questions on the adequacy of current medical guidelines.

Diabetes in the elderly can be categorized into two main groups: Those who have had diabetes since their youth or middle age, and those who develop type 2 diabetes later in life. Type 1 diabetes is rare among the elderly, as autoimmune diseases typically affect younger individuals. Therefore, older adults with type 1 diabetes are often in the advanced stages of the disease and face multiple complications [20].

The majority of people over 60 years old are affected by type 2 diabetes, which is primarily due to insulin resistance. In the later stages of type 2 diabetes, insulin production may be significantly diminished [21,22].

The complications and management of diabetes in the elderly are influenced by the duration of hyperglycemia, the individual's health background, and the presence of other diseases. Some elderly individuals may not experience any complications and can be easily managed, while others may have multiple complex conditions that are challenging to treat, even in specialized facilities [23-25]. This latter group often includes those who developed diabetes at a younger age. The most common serious health issues in the elderly with diabetes are heart and kidney problems, which can restrict the types of medications that can be safely prescribed [26-28].

T2DM mechanism in elderly

Type 2 DM in the elderly is attributed to multiple factors, including genetic predispositions, a decline in insulin production due to aging, and changes in environmental factors that contribute to central obesity. Central obesity is a key driver of insulin resistance, which underlies metabolic syndrome and type 2 DM in adults and the elderly. The sedentary lifestyle and dietary habits prevalent in modern society are significant contributors to this condition [29-32]. Additionally, recent research has highlighted the potential role of Arginine Vasopressin (AVP) or its C-terminal fragment, Copeptin, in reducing insulin sensitivity in older individuals, impacting liver glycogenolysis and glucagon secretion [33-35].

Vitamin D deficiency is another factor considered by some researchers to connect osteoporosis, insulin resistance, obesity, DM, and cognitive impairments, including Alzheimer's disease. While some argue that Vitamin D deficiency might result from obesity and chronic conditions like metabolic diseases, experimental evidence suggests that Vitamin D

could counteract fat accumulation, support pancreatic islet cell health, enhance insulin production, lower insulin resistance, and suppress appetite [36-39]. These effects imply that Vitamin D supplementation could potentially prevent and manage metabolic diseases, although current scientific evidence does not fully endorse Vitamin D for the prevention or treatment of DM, obesity, and Alzheimer's disease [40-42].

Deficiencies in other micronutrients, such as magnesium and potassium, have also been implicated in the onset of type 2 DM and the ineffective management of metabolic diseases. Magnesium, in particular, plays a crucial role in carbohydrate metabolism, glucose transport, and the regulation of insulin secretion and function. Its deficiency, which can arise from inadequate intake, gastrointestinal issues, or renal loss, is often linked to poor glycemic control and an increased risk of complications like retinopathy, nephropathy, and foot ulcers in the elderly. However, there is still no conclusive evidence to suggest that the systematic supplementation of these micronutrients can prevent type 2 DM or its complications [43-45].

Prevention and management of diabetes

Management strategies for T2DM (Table 2).

Table 2: Key management strategies for T2DM in the elderly.

Strategy type	Recommended approaches	Target population	Expected outcomes
Prevention	Lifestyle modifications, early detection screenings.	Older adults at risk of T2DM.	Slower progression from prediabetes to T2DM.
Therapeutic goals	Personalized treatment plans with adjusted HbA1c targets.	Frail elderly and those with multiple comorbidities.	Improved management of diabetes and reduced complications.
Medication considerations	Emphasis on safety and low hypoglycemia risk with tailored regimens.	Older adults with varying health conditions.	Better adherence to treatment and fewer adverse effects.
Lifestyle modifications	Balanced diet, tailored physical activity, regular education.	Elderly individuals and their caregivers.	Enhanced quality of life and functional capacity.

Prevention: Numerous large-scale prospective studies have demonstrated that identifying prediabetes, which is characterized by impaired glucose tolerance and/or impaired fasting glucose, offers a chance to slow down or prevent the development of T2DM. Screening high-risk individuals for T2DM, either through specific questionnaires or by examining those who visit outpatient clinics for cardiometabolic issues (like metabolic syndrome, hypertension, or cardiovascular disease), identifies many people with HbA1c levels near 6.5% (48 mmol/mol). It's important to note that prediabetes is defined in different ways, either as HbA1c levels of 5.7%-6.4% or 6.0%-6.4% (39-47 mmol/mol or 42-47 mmol/mol, respectively). Screening is also crucial for detecting previously unrecognized diabetes mellitus, especially for those in or moving to institutional care [46-49].

Both lifestyle changes and medication have proven effective in delaying the transition from prediabetes to T2DM. Specifically, intensive lifestyle modifications have been shown to significantly reduce the rate of progression to T2DM across various age groups. Although most studies on the subject included a smaller number of older adults (defined here as those aged over 60), analyses based on age suggest that lifestyle interventions are particularly beneficial in older populations compared to younger ones [50-52]. The application of these interventions on a wider scale has shown promising results. For instance, preliminary outcomes from the UK's National Health Service Diabetes Prevention Programme indicate a higher engagement rate among older adults, including those over 75, in lifestyle interventions, achieving better outcomes in weight loss and HbA1c reduction than their younger counterparts [53-55]. Among drug treatments, metformin has been effective in delaying prediabetes progression in younger and obese individuals, but its effectiveness is less pronounced in older adults with prediabetes. While thiazolidinediones and acarbose have also been effective in slowing the progression from prediabetes to T2DM, including in older adults, they have not been officially approved for this use [56,57].

Guidelines and treatment goals

Treatment guidelines for managing high blood sugar in older adults with T2DM consider the common heart and kidney issues in this population. They emphasize reducing the risk of low blood sugar and allowing adjustments in treatment goals for frail patients with other health conditions. Due to the varied health statuses of older adults with T2DM, a personalized treatment plan that balances managing risk factors with achieving functional goals is recommended [58-60].

Proper control of blood sugar levels can delay or lessen the impact of complications affecting small blood vessels at any age. However, aggressive treatment approaches may not be as beneficial or feasible for older, frail individuals with T2DM, particularly if these approaches increase the risk of low blood sugar, a significant risk for this age group [61,62]. The advantages of strict blood sugar control are generally seen over many years and may not be as pertinent for those with a shorter expected lifespan. Implementing intensive treatment can also be challenging when patients have other health conditions that limit treatment options [63,64].

Current guidelines for treating T2DM suggest less strict blood sugar targets for older patients, especially those who have had diabetes for a long time, due to their increased risk of low blood sugar and other complications as they age. While patient motivation and the ability to manage their diabetes may not necessarily decline with age, factors like resource availability and delays in advancing treatment can

have an age-related impact [65,66]. For younger, healthier individuals newly diagnosed with T2DM, blood sugar targets below 6.5% or 7% (48 mmol/mol or 53 mmol/mol) are typically recommended and may also be suitable for older, healthy patients. However, guidelines are increasingly recommending less strict targets (e.g., below 8%; 64 mmol/mol) for older, less healthy individuals with a long history of diabetes. For older patients with complex health needs and frailty, HbA1c levels up to 8.5% (69 mmol/mol) may be acceptable, as long as symptoms are managed and risks for vascular complications are appropriately addressed. Older patients can still expect their blood sugar management to be as thorough as is safely and feasibly possible, in line with their preferences and quality of life [67,68].

For older adults with significant disabilities or those in care facilities, aiming for less strict blood sugar levels to control symptoms and minimize low blood sugar risks is advisable. In such cases, involving family, caregivers, and diabetes educators is crucial to ensure treatment plans are effectively communicated and executed [69,70].

Managing non-blood sugar-related risk factors for heart disease, like blood pressure and LDL-cholesterol, is essential for T2DM patients of all ages. While there's debate over whether older adults should have less strict targets than younger individuals, most guidelines recommend blood pressure goals of ≤ 140/85 mmHg for older adults, with lower targets (<130/80 mmHg) for those with heart or blood vessel disease. LDL-cholesterol targets are generally<2.6 mmol/l (100 mg/dl) for all adults, with even lower targets (<1.8 mmol/l; 70 mg/dl) for those at very high risk of heart disease at any age [71,72].

Health education

Education on health for both patients and caregivers continues to be a critical element in managing diabetes, particularly with an emphasis on tailoring this education to suit the specific requirements of the elderly. Highlighting essential topics such as a balanced diet, regular exercise, proper medication use, and the significance of monitoring blood sugar levels can yield significant benefits and should be regularly reinforced [73,74].

Lifestyle: Guidelines for a balanced and healthy diet are crucial for individuals of all ages with T2DM, emphasizing the importance of reducing saturated fats, simple sugars, and salt intake. It's also vital to adjust portion sizes and overall daily calorie consumption to manage weight effectively. However, it's important for older adults to avoid excessive dieting, as it can lead to a rapid loss of muscle mass. Additionally, quick weight loss, whether intentional or not, may mask the failure of β-cells and the progression of T2DM. Older adults should therefore approach dieting with caution to ensure they receive adequate nutrition. If malnutrition is a concern, vitamin supplements may be beneficial for overall health, although amino acid supplements have shown limited effectiveness in combating sarcopenia [75-78].

The advantages of even minimal physical activity are widely acknowledged. For older adults facing challenges such as reduced mobility and other health conditions, tailored exercises, including chair-based activities that incorporate resistance and/or aerobic elements, can enhance muscle mass and strength, improve blood sugar control, and boost mental health. A meta-analysis of eight studies focusing on older adults revealed that engaging in resistance exercises for three months or more can reduce HbA1c levels by an average of 0.5%, although no clear link was found with the intensity, frequency, or duration of the exercises [79-82]. While moderate-intensity aerobic exercises also offer functional benefits and can improve HbA1c levels in older individuals, the impact is generally less significant compared to resistance training. The positive effects of resistance training, particularly in pre-frail and frail older patients with T2DM, have been supported by studies that combined exercise with dietary changes [83-85].

The importance of exercise in slowing metabolic decline, aiding weight management, combating sarcopenia, and delaying frailty is undisputed. Yet, for older adults with T2DM, debates continue regarding the best type of exercise, how often and how intensely it should be performed, the length of each session, and whether supervision is necessary. The potential long-term benefits for vascular health also remain uncertain [86-88]. Given the diversity of T2DM and its associated health issues in this age group, exercise plans must be tailored to each individual, guided by clinical judgment. The general recommendation is to start slowly, gradually increasing the intensity to achieve benefits while ensuring the activity is sustainable and does not lead to overexertion [89,90].

The high occurrence of prediabetes among older adults, with some areas seeing up to a 10% yearly progression to T2DM, has highlighted the importance of screening and early intervention for this demographic. Dietary and exercise changes have shown to slow the progression to T2DM and reduce the onset of related health issues into the seventh decade of life, though the effectiveness of these interventions into the eighth decade remains uncertain [91-93]. There is ongoing debate about the cost-effectiveness of refining screening based on risk factors such as age, family and personal medical history, BMI, and ethnicity. It's noteworthy that with increasing age, the overall risk of mortality may lower the population-wide progression rates from prediabetes to T2DM. Additionally, older individuals may experience slower disease progression and have a shorter timeframe for the development of complications compared to younger people [94,95].

Therapeutic choices

While personalized non-drug treatments continue to be a cornerstone in managing T2DM in the elderly, most of these individuals will also need drug therapies. Choosing the right glucose-lowering medications for older adults with T2DM is challenging due to numerous factors. The

ideal treatments should effectively and consistently lower blood sugar levels, minimize risks of hypoglycemia and unwanted weight gain, and be easy to use, well-tolerated, and safe [96,97]. Given the high occurrence of heart and kidney issues in the elderly, medications that either offer protection or are safe for these conditions are preferred. Additional health issues prevalent in this age group, such as depression, cognitive decline, muscle loss, liver problems, osteoporosis, increased fall and fracture risk, frailty, and polypharmacy, also influence the selection of glucose-lowering medications. However, there is a notable lack of strong evidence supporting the use of many glucose-lowering drugs in the elderly, with individuals over 75 years old being underrepresented in clinical trials for new medications [98-100]. While many treatments may still be suitable for healthy older adults, options for those who are frail are more restricted. Special care is also needed when combining medications to reach blood sugar targets, prioritizing options that have the lowest risk of causing hypoglycemia [101-103].

Metformin

Metformin works by enhancing insulin sensitivity, decreasing the release of glucose from the liver, and boosting its uptake by muscles, effectively lowering blood sugar levels. Its minimal risk of causing low blood sugar makes it a preferred choice for treating older adults. However, it is not recommended for individuals at risk of developing lactic acidosis, such as those with a history of stroke, pneumonia, heart attack, heart failure, or kidney problems [104-106]. The medication is considered safe for patients with kidney issues if their Glomerular Filtration Rate (GFR) is 30 ml/min or higher. Weight loss and gastrointestinal issues are other concerns that may limit its use. Elderly individuals are encouraged to drink plenty of water to prevent dehydration and kidney damage, especially during hot weather or periods of prolonged fasting [107,108].

Metformin should be discontinued prior to any surgical procedures or when an elderly patient needs to undergo diagnostic tests involving iodinated contrast materials due to the increased risk of kidney problems in the elderly. Additionally, between 18.7% to 30% of diabetic patients on metformin may experience Vitamin B12 deficiency, which seems to be linked to the age of the patient, the dosage of metformin, and the length of treatment. It is important to regularly monitor Vitamin B12 levels in patients who meet these criteria. A deficiency in Vitamin B12 can lead to peripheral neuropathy, with or without anemia, and can initiate or exacerbate cognitive issues in the elderly [109,110].

Insulin secretagogues: Sulfonylureas and meglitinides

Sulfonylureas are highly favored for their effectiveness, extensive history of use, and affordability, making them a common choice across the general population. They are typically well-received, even among older adults. Nevertheless, the most significant and hazardous side effect associated with these drugs is hypoglycemia [111-113].

Long-acting sulfonylureas, including chlorpropamide, glyburide, and glimepiride, are particularly prone to causing hypoglycemia. It is advisable to avoid these medications in older individuals, especially those who experience frequent diarrhea, have a history of alcohol addiction, or suffer from memory issues, as these conditions can heighten the risk of hypoglycemia and lead to weight gain [114,115].

For older adults, short-acting sulfonylureas, like meglitinides, are often recommended due to their lower incidence of hypoglycemia. However, it's important to note that they still carry a similar risk for weight gain [116,117].

Thiazolidinediones

Thiazolidinediones, including rosiglitazone and particularly pioglitazone, are known to enhance insulin sensitivity and may also boost insulin production in response to glucose in individuals with impaired glucose tolerance. Pioglitazone stands out as the sole thiazolidinedione currently available on the market that serves as an effective option for elderly patients, primarily due to its minimal risk of causing hypoglycemia. It can be administered either as a standalone treatment or in combination with metformin. The primary adverse effect associated with pioglitazone is fluid retention, making it unsuitable for patients suffering from congestive heart failure [118,119].

The full anti-hyperglycemic impact of glitazones may take between 2 to 4 weeks to manifest. As such, they are suitable for patients with a lower initial HbA1c level, those allergic to sulfonylureas, or individuals who prefer not to use insulin. Despite their general tolerability in older adults and the possibility of their use in cases of renal insufficiency, the widespread adoption of thiazolidinediones is hindered by their high cost and certain adverse effects. These include fluid retention, an increased risk of fractures due to bone loss, and a heightened risk of bladder cancer [120-122].

Alpha-glucosidase inhibitors

Alpha-Glucosidase Inhibitors (AGI), including acarbose and miglitol, function by blocking the activity of gastrointestinal alpha-glucosidases. These enzymes are responsible for breaking down carbohydrates into monosaccharides. As a result, AGIs help to minimize the increase in blood sugar levels following meals [123,124].

AGIs can be administered on their own or alongside other diabetes medications such as metformin, sulfonylureas, or insulin. Despite their potential for safety and efficacy, there hasn't been extensive testing of these inhibitors in elderly diabetic patients. The primary adverse effects associated with AGIs are gastrointestinal issues, including bloating and diarrhea, which restrict their usage [125].

Incretin-based therapies

Dipeptidylpeptidase-4 (DPP-4) inhibitors and Glucagon-Like Peptide-1 (GLP-1) receptor agonists are emerging as promising treatments for the elderly due to their low

risk of causing hypoglycemia, either as standalone medications or when combined with metformin [126-128].

DPP-4 inhibitors, while considered to be modest in their ability to reduce blood sugar through various mechanisms, whether used alone or in combination with metformin, sulfonylureas, and thiazolidinediones, do not pose a risk of hypoglycemia and do not affect body weight. This makes them potentially appealing options for older patients, although their long-term safety remains to be confirmed, and they are relatively expensive. Additionally, their dosage needs to be adjusted in cases of renal insufficiency. Recent studies have shown that, in the elderly. Sitagliptin is as effective as sulfonylureas but with a lower hypoglycemia risk and also promotes weight loss [129-132].

GLP-1 agonists, including exenatide, liraglutide, and the more recent lixisenatide, are also beneficial as they do not raise the risk of hypoglycemia unless combined with sulfonylureas. They promote weight loss, making them particularly useful for overweight or obese elderly patients. A combined analysis of six randomized trials indicated that liraglutide is effective and well-tolerated in older individuals. However, like DPP-4 inhibitors, the dosage of liraglutide must be adjusted based on renal function. These medications require a 2-4 weeks dose titration period to achieve their full effect. Additionally, GLP-1 agonists may offer neuroprotective benefits, potentially aiding elderly patients with neurodegenerative conditions [133-136].

Sodium-glucose co-transporter type 2 inhibitors

Sodium-Glucose Co-Transporter Type 2 (SGLT2) inhibitors, such as canagliflozin and dapagliflozin, are a new type of medication that lowers blood sugar levels by blocking the reabsorption of glucose in the kidneys. These medications can reduce HbA1c levels by 0.5-0.8% when taken alone or in combination with other treatments. However, their use is restricted due to common side effects like urinary and genital infections, as well as other potential risks including low blood pressure, dizziness, and a decline in kidney function [137-139]. Serious side effects have also been observed, including extreme low blood sugar due to reduced liver glycogen stores, an increase in muscle wasting associated with diabetes, and ketoacidosis, though these are less common. Consequently, SGLT2 inhibitors should be prescribed with caution to elderly patients and avoided entirely in individuals with chronic kidney disease, muscle wasting, or a high risk of dehydration [140-142].

Pramlintide

Pramlintide is a synthetic analogue of human amylin, utilized in the management of both type 1 and type 2 DM. It is administered *via* subcutaneous injection at meal times alongside insulin. The mechanism by which Pramlintide aids in glucose management includes enhancing the uptake of glucose by peripheral tissues and decelerating the emptying of the stomach. Additionally, it induces a feeling of fullness through its action on hypothalamic receptors and suppresses the unnecessary release of glucagon. Pramlintide is also believed to activate the initial rapid phase of insulin release after eating [143,144].

The use of Pramlintide in therapy has been shown to improve A1c levels, reduce body weight, and is linked to a low incidence of severe hypoglycemia in patients with T2DM, irrespective of their prior insulin usage. Nonetheless, the requirement for multiple injections can be a barrier to its adoption in the treatment regimen for DM, particularly among older adults [145-147].

Insulin

Globally, the use of insulin in older adults is often avoided due to concerns about hypoglycemia from both the patients and their families, as well as healthcare providers. There is a common belief that administering multiple insulin injections is too complex and risky for elderly individuals. However, the introduction of long-acting insulin varieties, along with new pen devices and glucose meters, has simplified the administration of insulin analogs for older patients [148,149]. Advances in insulin formulations and other technologies are expected to enhance acceptance and improve the quality of life for those with diabetes. The development of non-invasive insulin delivery methods is anticipated to address the significant issue of treatment adherence. Proposals for non-invasive delivery include oral, buccal, pulmonary, nasal, and transdermal insulin applications [150-152].

The quality of life for patients who take one or two daily doses of intermediate insulin has already seen significant improvements. Nonetheless, before initiating insulin therapy, it's crucial to evaluate whether a patient is both physically and cognitively capable of managing their insulin treatment. This includes being able to prepare insulin doses, operate an insulin pen, determine the correct dose, monitor blood glucose levels accurately, and recognize and address hypoglycemia. For those who are able, insulin represents a viable treatment option [153,154]. For older patients who can administer but not prepare their insulin due to visual impairments or other issues, having a family member or pharmacist prepare a week's worth of insulin doses for storage in the refrigerator can enable them to continue living independently, particularly in developed countries where independent living is common. This is less of an issue in developing countries, where older individuals often live with family members. For instance, a survey in North Africa found that only 2.6% of elderly individuals live alone [155,156].

In patients with chronic renal failure, insulin metabolism is affected, necessitating lower doses of insulin when the GFR falls below 50 ml/min. For older patients needing multiple medications, electronic programmable pill dispensers can aid in improving adherence, though support from family members may still be necessary [157,158].

Additional treatments specific to diabetes management

may include systematic supplementation with Vitamin D, magnesium, and Vitamins E and B, which can enhance both physical and mental activity in the elderly, with or without diabetes [159].

However, there are barriers to effective treatment in the elderly, including missed medication doses due to memory issues or depression-related disinterest in life. Limited dexterity and poor eyesight can also hinder their ability to manage blood glucose monitoring and insulin dosing effectively. Optimal care for elderly individuals with diabetes involves family support and a multidisciplinary approach aimed at reducing cardiovascular risk factors and enhancing life expectancy and quality of life [160,161].

Conclusion

This review underscores the complex interplay of physiological, psychosocial, and lifestyle factors that contribute to the management challenges faced by older adults with T2DM. The findings highlight the urgent need for personalized intervention strategies that cater to the diverse health needs of this demographic, emphasizing the necessity of individualized treatment plans that account for comorbidities, functional capacity, and personal preferences.

Current therapeutic approaches often fall short due to their reliance on research conducted primarily with younger populations, which may not effectively address the unique manifestations of diabetes in older adults. As the elderly population continues to grow, the healthcare system must prioritize age-specific research and develop comprehensive management strategies that encompass lifestyle modifications, pharmacological interventions, and holistic care. The importance of patient-centered care is paramount, as it not only enhances compliance but also improves overall health outcomes and quality of life.

Furthermore, ongoing education for both patients and caregivers are essential in promoting effective self-management practices. By holistically addressing the multifaceted nature of T2DM in older adults and integrating their input into care plans, we can ensure better management of the disease, ultimately leading to enhanced functional capacity and a higher quality of life for elderly individuals living with diabetes. The need for innovative, evidence-based solutions remains critical as we navigate the complexities of aging populations and chronic disease management in the years to come.

Funding

This research was funded by Russian Science Foundation, grant number 22-15-00134-П.

References

1. Z. Ismail, W.I.W. Ahmad, S.H. Hamjah, I.K. Astina. The impact of population ageing: A review, Iran J Public Health, 50(2021):2451-2460.
2. X. Sun, X. Li, Editorial: Aging and chronic disease: Public health challenge and education reform, Front Public Health, 11(2023):1175898.
3. J. Doucet, P. Gourdy, L. Meyer, N. Benabdelmoumene, I. Bourdel-Marchasson, et al. Management of glucose-lowering therapy in older adults with type 2 diabetes: Challenges and opportunities, Clin Interv Aging, 18(2023):1687-1703.
4. J.S. Yun, K. Kim, Y.B. Ahn, K. Han, S.H. Ko, et al. Holistic and personalized strategies for managing in elderly type 2 diabetes patients, Diabetes Metab J, 48(2024):531-545.
5. N. Pandya, E. Hames, S. Sandhu. Challenges and strategies for managing diabetes in the elderly in long-term care settings, Diabetes Spectr, 33(2020):236-245.
6. A.J. Sinclair, A.H. Abdelhafiz. Challenges and strategies for diabetes management in community-living older adults, Diabetes Spectr, 33(2020):217-227.
7. A.R. Gosmanov, E.O. Gosmanova, A.E. Kitabchi. Hyperglycemic crises: Diabetic ketoacidosis and hyperglycemic hyperosmolar state, Endotext, (2021).
8. E.M. Hassan, H. Mushtaq, E.E. Mahmoud, S. Chhibber, S. Saleem, et al. Overlap of diabetic ketoacidosis and hyperosmolar hyperglycemic state, World J Clin Cases, 10(2022):11702-11711.
9. M.J. Sebastian, S.K. Khan, J.M. Pappachan, M.S. Jeeyavudeen, Diabetes and cognitive function: An evidence-based current perspective, World J Diabetes, 14(2023):92-109.
10. N. Aderinto, G. Olatunji, M. Abdulbasit, P. Ashinze, O. Faturoti, et al. The impact of diabetes in cognitive impairment: A review of current evidence and prospects for future investigations, Medicine, 102(2023):e35557.
11. Y. M., M.G. Patel, H.H. Makwana, H. Kalariya. Unraveling the enigma of sarcopenia and sarcopenic obesity in Indian adults with type 2 diabetes - a comparative cross-sectional study, Clin Diabetes Endocrinol, 10(2024):22.
12. J.A. Batsis, D.T. Villareal. Sarcopenic obesity in older adults: Aetiology, epidemiology and treatment strategies, Nat Rev Endocrinol, 14(2018):513-537.
13. S. Wei, T.T. Nguyen, Y. Zhang, D. Ryu, K. Gariani, et al. Sarcopenic obesity: Epidemiology, pathophysiology, cardiovascular disease, mortality, and management, Front Endocrinol, 14(2023):1185221.
14. F. Baygi, S.F. Buhl, T. Thilsing, et al. Sarcopenia and sarcopenic obesity among older adults in the Nordic countries: A scoping review, BMC Geriatr, 24(2024):421.

15. F. Chentli, S. Azzoug, S. Mahgoun. Diabetes mellitus in elderly, Indian J Endocrinol Metab, 19(2015):744-752.

16. O. Gheith, N. Farouk, N. Nampoory, M.A. Halim, T. Al-Otaibi, et al. Diabetic kidney disease: Worldwide difference of prevalence and risk factors, J Nephropharmacol, 5(2015):49-56.

17. O. Pinhas-Hamiel, P. Zeitler. Type 2 diabetes in children and adolescents - a focus on diagnosis and treatment, Endotext, (2023).

18. C.W. Chia, J.M. Egan, L. Ferrucci. Age-related changes in glucose metabolism hyperglycemia, and cardiovascular risk, Circ Res, 123(2018):886-904.

19. A.A. Choudhury, V. Devi Rajeswari, Gestational diabetes mellitus - a metabolic and reproductive disorder, Biomed Pharmacother, 143(2021):112183.

20. S.A. Antar, N.A. Ashour, M. Sharaky, M. Khattab, N.A. Ashour, et al. Diabetes mellitus: classification, mediators, and complications; a gate to identify potential targets for the development of new effective treatments, Biomed Pharmacother, 168(2023):115734.

21. D. Bradley, W. Hsueh. Type 2 diabetes in the elderly: Challenges in a unique patient population, J Geriatr Med Gerontol, 2(2016):14.

22. M. Zhu, X. Liu, W. Liu, Y. Lu, J. Cheng, et al. β cell aging and age-related diabetes, Aging, 13(2021):7691-7706.

23. M.S. Kirkman, V.J. Briscoe, N. Clark, H. Florez, L.B. Haas, et al. Diabetes in older adults, Diabetes Care, 35(2012):2650-2664.

24. T. Uchida, H. Ueno, A. Sekishima, H. Sekishima, A. Konagata, et al. The relationship between DASC-8 categories and the effectiveness of education on insulin self-injection techniques in elderly patients with diabetes, Diabetol Int, 15(2024):439-446.

25. A.V. Poznyak, V.A. Orekhova, V.N. Sukhorukov, V.A. Khotina, M.A. Popov, et al. Atheroprotective aspects of heat shock proteins, Int J Mol Sci, 24(2023):11750.

26. B.M. Atak Tel, G. Aktas, S. Bilgin, S.B. Baltaci, T. Taslamacioglu Duman, et al. Control level of type 2 diabetes mellitus in the elderly is associated with polypharmacy, accompanied comorbidities, and various increased risks according to the Beers criteria, Diagnostics, 13(2023):3433.

27. K.K. Clemens, N. O'Regan, J.J. Rhee. Diabetes management in older adults with chronic kidney disease, Curr Diab Rep, 19(2019):11.

28. R. Ravender, M.E. Roumelioti, D.W. Schmidt, M.L. Unruh, C. Argyropoulos, et al. Chronic kidney disease in the older adult patient with diabetes, J Clin Med, 13(2024):348.

29. U. Galicia-Garcia, A. Benito-Vicente, S. Jebari, A. Larrea-Sebal, H. Siddiqi, et al., Pathophysiology of type 2 diabetes mellitus, Int J Mol Sci, 21(2020):6275.

30. N.J. Pillon, R.J.F. Loos, S.M. Marshall, J.R. Zierath. Metabolic consequences of obesity and type 2 diabetes: balancing genes and environment for personalized care, Cell, 184(2021):1530-1544.

31. I. Kyrou, C. Tsigos, C. Mavrogianni. Sociodemographic and lifestyle-related risk factors for identifying vulnerable groups for type 2 diabetes: A narrative review with emphasis on data from Europe, BMC Endocr Disord, 20(2020):134.

32. J. Guo, X. Huang, L. Dou. Aging and aging-related diseases: From molecular mechanisms to interventions and treatments, Sig Transduct Target Ther, 7(2022):391.

33. S. Enhörning, B. Hedblad, P.M. Nilsson, G. Engström, O. Melander, et al. Copeptin is an independent predictor of diabetic heart disease and death, Am Heart J, 169(2015):549-556.

34. D.B. Andersen, J.J. Holst. Peptides in the regulation of glucagon secretion, Peptides, 148(2022):170683.

35. H.A. Carroll, L.J. James. Hydration, arginine vasopressin, and glucoregulatory health in humans: A critical perspective, Nutrients, 11(2019):1201.

36. H. Wang, W. Chen, D. Li, X. Yin, X. Zhang, et al. Vitamin D and chronic diseases, Aging Dis, 8(2017):346-353.

37. L. Di Filippo, R. De Lorenzo, A. Giustina, P. Rovere-Querini, C. Conte. Vitamin D in osteosarcopenic obesity, Nutrients, 14(2022):1816.

38. F. Amirkhizi, Z. Khademi, S. H. Shahraki, M. Rahimlou. Vitamin D insufficiency and its association with adipokines and atherogenic indices in patients with metabolic syndrome: a case-control study, Front Endocrinol (Lausanne), 14(2023):1080138.

39. E. Rebelos, N. Tentolouris, E. Jude. The role of vitamin D in health and disease: A narrative review on the mechanisms linking vitamin D with disease and the effects of supplementation, Drugs, 83(2023):665-685.

40. Z.H. Al-Oanzi, F.O. Alenazy, H.H. Alhassan, Y. Alruwaili, A.I. Alessa, et al. The role of vitamin D in reducing the risk of metabolic disturbances that cause cardiovascular diseases, J Cardiovasc Dev Dis,

10(2023):209.

41. K.J. Qi, Z.T. Zhao, W. Zhang, F. Yang. The impacts of vitamin D supplementation in adults with metabolic syndrome: A systematic review and meta-analysis of randomized controlled trials, Front Pharmacol, 13(2022):1033026.

42. C. Argano, L. Mirarchi, S. Amodeo, V. Orlando, A. Torres, et al. The role of vitamin D and its molecular bases in insulin resistance, diabetes, metabolic syndrome, and cardiovascular disease: State of the art, Int J Mol Sci, 24(2023):15485.

43. P. Dubey, V. Thakur, M. Chattopadhyay. Role of minerals and trace elements in diabetes and insulin resistance, Nutrients, 12(2020):1864.

44. G. Piuri, M. Zocchi, M. Della Porta, V. Ficara, M. Manoni, et al. Magnesium in obesity, metabolic syndrome, and type 2 diabetes, Nutrients, 13(2021):320.

45. D. Fiorentini, C. Cappadone, G. Farruggia, C. Prata. Magnesium: Biochemistry, nutrition, detection, and social impact of diseases linked to its deficiency, Nutrients, 13(2021):1136.

46. J.B. Echouffo-Tcheugui, E. Selvin. Prediabetes and what it means: The epidemiological evidence, Annu Rev Public Health, 42(2021):59-77.

47. A.G. Tabák, C. Herder, W. Rathmann, E.J. Brunner, M. Kivimäki, et al. Prediabetes: A high-risk state for diabetes development, Lancet, 379(2012):2279-2290.

48. X. Zhu, Z. Yang, Z. He, J. Hu, T. Yin, et al. Factors correlated with targeted prevention for prediabetes classified by impaired fasting glucose, impaired glucose tolerance, and elevated HbA1c: A population-based longitudinal study, Front Endocrinol (Lausanne), 13(2022):965890.

49. M. Lugner, A. Rawshani, E. Helleryd. Identifying top ten predictors of type 2 diabetes through machine learning analysis of UK Biobank data, Sci Rep, 14(2024):2102.

50. J. Vajje, S. Khan, A. Kaur, H. Kataria, S. Sarpoolaki, et al. Comparison of the efficacy of metformin and lifestyle modification for the primary prevention of type 2 diabetes: A meta-analysis of randomized controlled trials, Cureus, 15(2023):e47105.

51. R.M.M. Khan, Z.J.Y. Chua, J.C. Tan, Y. Yang, Z. Liao, et al. From pre-diabetes to diabetes: Diagnosis, treatments and translational research, Medicina (Kaunas), 55(2019):546.

52. N.G. Nikiforov, T.V. Kirichenko, M.V. Kubekina, Y.S. Chegodaev, A.D. Zhuravlev, et al. Macrophages derived from LPS-stimulated monocytes from individuals with subclinical atherosclerosis were characterized by increased pro-inflammatory activity, Cytokine, 172(2023):156411.

53. M. Whelan, L. Bell. The English national health service diabetes prevention programme (NHS DPP): A scoping review of existing evidence, Diabet Med, 39(2022):e14855.

54. E. Barry, T. Greenhalgh, S. Shaw, C. Papoutsi. Explaining the UK's 'high-risk' approach to type 2 diabetes prevention: Findings from a qualitative interview study with policy-makers in England, BMJ Open, 13(2023):e066301.

55. B. Parkinson, E. McManus, R. Meacock. Level of attendance at the English National Health Service Diabetes Prevention Programme and risk of progression to type 2 diabetes, Int J Behav Nutr Phys Act, 21(2024):6.

56. R. W. Sibony, O. Segev, S. Dor, I. Raz. Drug therapies for diabetes, Int J Mol Sci, 24(2023):17147.

57. D. Patel, I.E. Ayesha, N.R. Monson, N. Klair, U. Patel, et al. Hamid. The effectiveness of metformin in diabetes prevention: A systematic review and meta-analysis, Cureus, 15(2023):e46108.

58. M.P. Baruah, S. Kalra, A.G. Unnikrishnan, S.A. Raza, N. Somasundaram, et al. Management of hyperglycemia in geriatric patients with diabetes mellitus: South Asian consensus guidelines, Indian J Endocrinol Metab, 15(2011):75-90.

59. M.J. Davies, V.R. Aroda, B.S. Collins, R.A. Gabbay, J. Green, et al. Management of hyperglycemia in type 2 diabetes, 2022. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD), Diabetes Care, 45(2022):2753-2786.

60. A.V. Poznyak, V.N. Sukhorukov, M.A. Popov, Y.S. Chegodaev, A.Y. Postnov, et al. Mechanisms of the Wnt pathways as a potential target pathway in atherosclerosis, J Lipid Atheroscler, 12(2023):223-236.

61. W.D. Strain, S. Down, P. Brown, A. Puttanna, A. Sinclair, et al. Diabetes and frailty: An expert consensus statement on the management of older adults with type 2 diabetes, Diabetes Ther, 12(2021):1227-1247.

62. A.J. Sinclair, D. Pennells, A.H. Abdelhafiz. Hypoglycaemic therapy in frail older people with type 2 diabetes mellitus-a choice determined by metabolic phenotype, Aging Clin Exp Res, 34(2022):1949-1967.

63. S. Vijan, J.B. Sussman, J.S. Yudkin, R.A. Hayward. Effect of patients' risks and preferences on health gains with plasma glucose level lowering in type 2 diabetes mellitus, JAMA Intern Med, 174(2014):1227-1234.

64. C. von Loeffelholz, A.L. Birkenfeld. Tight versus liberal blood-glucose control in the intensive care unit:

special considerations for patients with diabetes, Lancet Diabetes Endocrinol, 12(2024):277-284.

65. E. Leung, S. Wongrakpanich, M.N. Munshi. Diabetes management in the elderly, Diabetes Spectr, 31(2018):245-253.

66. American diabetes association professional practice committee. Older adults: Standards of care in diabetes -2024, Diabetes Care, 47(2024):S244-S257.

67. N.A. ElSayed, G. Aleppo, V.R. Aroda, R.R. Bannuru, F.M. Brown, et al. Children and adolescents: standards of care in diabetes-2023, Diabetes Care, 46(2023):S230-S253.

68. N.A. ElSayed, G. Aleppo, V.R. Aroda, R.R. Bannuru, F.M. Brown, et al. Glycemic targets: Standards of care in diabetes-2023, Diabetes Care, 46(2023):S97-S110.

69. F. Ahmad, S.H. Joshi. Self-care practices and their role in the control of diabetes: A narrative review, Cureus, 15(2023):e41409.

70. A.V. Poznyak, D.A. Kashirskikh, A.Y. Postnov, M.A. Popov, V.N. Sukhorukov, et al. Sialic acid as the potential link between lipid metabolism and inflammation in the pathogenesis of atherosclerosis, Braz J Med Biol Res, 56(2023):e12972.

71. C. Jeong, B. Kim, J. Kim, H. Baek, M.K. Kim, et al. Optimal LDL cholesterol levels in young and old patients with type 2 diabetes for secondary prevention of cardiovascular diseases are different, Endocr Connect, 12(2023):e230142.

72. J.J. Joseph, P. Deedwania, T. Acharya, D. Aguilar, D.L. Bhatt, et al. Comprehensive management of cardiovascular risk factors for adults with type 2 diabetes: A scientific statement from the American Heart Association, Circulation, 145(2022):e722-e759.

73. P. Camargo-Plazas, M. Robertson, B. Alvarado, G.C. Paré, I.G. Costa, et al. Diabetes Self-Management Education (DSME) for older persons in Western countries: A scoping review, PLoS One, 18(2023):e0288797.

74. M.M. Shaban, H.M. Sharaa, F.G.M. Amer, M. Shaban. Effect of digital based nursing intervention on knowledge of self-care behaviors and self-efficacy of adult clients with diabetes, BMC Nurs, 23(2024):130.

75. A. Reynolds, J. Mitri. Dietary advice for individuals with diabetes, Endotext [Internet], MDText.com Inc, South Dartmouth (MA), (2024).

76. M. Asif. The prevention and control of type-2 diabetes by changing lifestyle and dietary pattern, J Educ Health Promot, 3(2014):1.

77. The Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD). Evidence-based European recommendations for the dietary management of diabetes, Diabetologia, 66(2023):965-985.

78. T.P. Minari, L.H.B. Tácito, L.B.T. Yugar, S.E. Ferreira-Melo, C.F. Manzano, et al. Nutritional strategies for the management of type 2 diabetes mellitus: A narrative review, Nutrients, 15(2023):5096.

79. C. Di Lorito, A. Long, A. Byrne, R.H. Harwood, J.R.F. Gladman, et al. Exercise interventions for older adults: A systematic review of meta-analyses, J Sport Health Sci, 10(2021):29-47.

80. S. Fien, C. Linton, J.S. Mitchell, D.P. Wadsworth, H. Szabo, et al. Characteristics of community-based exercise programs for community-dwelling older adults in rural/regional areas: A scoping review, Aging Clin Exp Res, 34(2022):1511-1528.

81. M. Izquierdo, R.A. Merchant, J.E. Morley, S.D. Anker, I. Aprahamian, et al. International exercise recommendations in older adults (ICFSR): expert consensus guidelines, J Nutr Health Aging, 25(2021):824-853.

82. M. Izquierdo, R.A. Merchant, J.E. Morley. International exercise recommendations in older adults (ICFSR): Expert consensus guidelines, J Nutr Health Aging, 25(2021):824-853.

83. J. Lee, D. Kim, C. Kim. Resistance training for glycemic control, muscular strength, and lean body mass in old type 2 diabetic patients: A meta-analysis, Diabetes Ther, 8(2017):459-473.

84. L. Jiahao, L. Jiajin, L. Yifan. Effects of resistance training on insulin sensitivity in the elderly: A meta-analysis of randomized controlled trials, J Exerc Sci Fit, 19(2021):241-251.

85. C.L. Hwang, J. Lim, J.K. Yoo, H.K. Kim, M.H. Hwang, et al. Effect of all-extremity high-intensity interval training vs. moderate-intensity continuous training on aerobic fitness in middle-aged and older adults with type 2 diabetes: A randomized controlled trial, Exp Gerontol, 116(2019):46-53.

86. D. Argyropoulou, N.D. Geladas, T. Nomikos, V. Paschalis. Exercise and nutrition strategies for combating sarcopenia and type 2 diabetes mellitus in older adults, J Funct Morphol Kinesiol, 7(2022):48.

87. S.T. Lim, S. Kang. Exercise therapy for sarcopenia and diabetes, World J Diabetes, 14(2023):565-572.

88. S. Kim, S. Kim, K.H. Hong. Association of combining diet and physical activity on sarcopenia and obesity in elderly Koreans with diabetes, Nutrients, 16(2024):964.

89. J.P. Kirwan, J. Sacks, S. Nieuwoudt. The essential role of exercise in the management of type 2 diabetes,

Cleve Clin J Med, 84(2017):S15-S21.

90. American Diabetes Association Professional Practice Committee. Facilitating behavior change and well-being to improve health outcomes: Standards of medical care in diabetes-2022, Diabetes Care, 45(2022):S60-S82.

91. P. Tuso. Prediabetes and lifestyle modification: Time to prevent a preventable disease, Perm J, 18(2014):88-93.

92. A.I. Al Shuwaysh, E.L. Fabella, M. Al Hassan, Y.T. Al Hassan, A. Al Hassan, et al. Association between risk for prediabetes and type 2 diabetes mellitus prevention among faculty members and administrative staff of a Saudi university, Cureus, 15(2023):e41926.

93. M.R. Rooney, A.M. Rawlings, J.S. Pankow, J.B. Echouffo Tcheugui, J. Coresh, et al. Risk of progression to diabetes among older adults with prediabetes, JAMA Intern Med, 181(2021):511-519.

94. H.B. Beyene, C. Giles, K. Huynh, et al. Metabolic phenotyping of BMI to characterize cardiometabolic risk: Evidence from large population-based cohorts, Nat Commun, 14(2023):6280.

95. R. Ruze, T. Liu, X. Zou, J. Song, Y. Chen, et al. Obesity and type 2 diabetes mellitus: Connections in epidemiology, pathogenesis, and treatments, Front Endocrinol, 14(2023):1161521.

96. F. Sugandh, M. Chandio, F. Raveena, L. Kumar, F. Karishma, et al. Advances in the management of diabetes mellitus: A focus on personalized medicine, Cureus, 15(2023):e43697.

97. K. Gadó, G.Á. Tabák, I. Vingender, G. Domján, G. Dörnyei, et al. Treatment of type 2 diabetes mellitus in the elderly-special considerations, Physiol Int, 111(2024):143-164.

98. American diabetes association professional practice committee. Older adults: Standards of medical care in diabetes-2022, Diabetes Care, 45(2022):S195-S207.

99. L. Soraci, A. Cherubini, L. Paoletti, G. Filippelli, F. Luciani, et al. Safety and tolerability of antimicrobial agents in the older patient, Drugs Aging, 40(2023):499-526.

100. R. Vaishya, A. Misra, A. Vaish. Hand grip strength as a proposed new vital sign of health: A narrative review of evidences, J Health Popul Nutr, 43(2024):7.

101. J. Sanz-Cánovas, A. López-Sampalo, L. Cobos-Palacios, M. Ricci, H. Hernández-Negrín, et al. Management of type 2 diabetes mellitus in elderly patients with frailty and/or sarcopenia, Int J Environ Res Public Health, 19(2022):8677.

102. A.V. Blagov, V.N. Sukhorukov, S. Guo, D. Zhang, M.A. Popov, et al. Impaired mitochondrial function in T-lymphocytes as a result of exposure to HIV and ART, Cells, 12(2023):1072.

103. A.J. Sinclair, D. Pennells, A.H. Abdelhafiz. Hypoglycaemic therapy in frail older people with type 2 diabetes mellitus-a choice determined by metabolic phenotype, Aging Clin Exp Res, 34(2022):1949-1967.

104. H. Nasri, M. Rafieian-Kopaei. Metformin: Current knowledge, J Res Med Sci, 19(2014):658-664.

105. L. He. Metformin and systemic metabolism, Trends Pharmacol Sci, 41(2020):868-881.

106. N. Apostolova, F. Iannantuoni, A. Gruevska, J. Muntane, M. Rocha, et al. Mechanisms of action of metformin in type 2 diabetes: Effects on mitochondria and leukocyte-endothelium interactions, Redox Biol, 34(2020):101517.

107. I. Ioannidis. Diabetes treatment in patients with renal disease: Is the landscape clear enough? World J Diabetes, 5(2014):651-658.

108. R.Y. Alhassani, R.M. Bagadood, R.N. Balubaid, H.I. Barno, M.O. Alahmadi, et al. Drug therapies affecting renal function: An overview, Cureus, 13(2021):e19924.

109. K.Y. Hur, M.K. Kim, S.H. Ko, M. Han, D.W. Lee, et al, Metformin treatment for patients with diabetes and chronic kidney disease: A Korean Diabetes Association and Korean Society of Nephrology consensus statement, Diabetes Metab J, 44(2020):3-10.

110. M.O. Baerlocher, M. Asch, A. Myers. Five things to know about metformin and intravenous contrast, CMAJ, 185(2013):E78.

111. D. Sola, L. Rossi, G.P.C. Schianca, P. Maffioli. Sulfonylureas and their use in clinical practice, Arch Med Sci, 11(2015):840-848.

112. R.A. Costello, S. Nicolas, A. Shivkumar. Sulfonylureas. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, (2024).

113. M. Longo, G. Bellastella, M.I. Maiorino, J.J. Meier, K. Esposito, D. Giugliano, et al. Diabetes and aging: From treatment goals to pharmacologic therapy, Front Endocrinol, 10(2019):45.

114. T. Yanase, I. Yanagita, K. Muta, H. Nawata. Frailty in elderly diabetes patients, Endocr J, 65(2018):1-11.

115. S.A. Antar, N.A. Ashour, M. Sharaky, M. Khattab, N.A. Ashour, et al. Diabetes mellitus: Classification, mediators, and complications; A gate to identify potential targets for the development of new effective treatments, Biomed Pharmacother, 168(2023):115734.

116. Glycemic goals and hypoglycemia: Standards of care

in diabetes-2024, Diabetes Care, 47(2024):S111-S125.

117. T. Kelly, D. Unwin, F. Finucane. Low-carbohydrate diets in the management of obesity and type 2 diabetes: A review from clinicians using the approach in practice, Int J Environ Res Public Health, 17(2020):2557.

118. R.V. Giglio, N. Papanas, A.A. Rizvi, M. Ciaccio, A.M. Patti, et al. An update on the current and emerging use of thiazolidinediones for type 2 diabetes, Medicina (Kaunas), 58(2022):1475.

119. J.S. Eggleton, I. Jialal. Thiazolidinediones, StatPearls [Internet], Treasure Island (FL): StatPearls Publishing

120. K. Makrilakis. The role of DPP-4 inhibitors in the treatment algorithm of type 2 diabetes mellitus: When to select, what to expect, Int J Environ Res Public Health, 16(2019):2720.

121. J. Boursier, R. Anty, C. Carette, B. Cariou, L. Castera, et al. Management of diabetes mellitus in patients with cirrhosis: An overview and joint statement, Diabetes Metab, 47(2021):101272.

122. A.N. Orekhov, V.I. Summerhill, V.A. Khotina, M.A. Popov, J.K. Uzokov, et al. Role of mitochondria in the chronification of inflammation: Focus on dysfunctional mitophagy and mitochondrial DNA mutations, Gene Expr, 22(2023):329-344.

123. M. Akmal, P. Patel, R. Wadhwa. Alpha glucosidase inhibitors, StatPearls [Internet], Treasure Island (FL): StatPearls Publishing; (2024).

124. H. Kashtoh, K.H. Baek. Recent updates on phytoconstituent alpha-glucosidase inhibitors: An approach towards the treatment of type 2 diabetes, Plants, 11(2022):2722.

125. A.D. Dahlén, G. Dashi, I. Maslov. Trends in antidiabetic drug discovery: FDA approved drugs, new drugs in clinical trials and global sales, Front Pharmacol, 12(2022):807548.

126. T. Kanie, A. Mizuno, Y. Takaoka. Dipeptidyl peptidase-4 inhibitors, glucagon-like peptide 1 receptor agonists and sodium-glucose co-transporter-2 inhibitors for people with cardiovascular disease: A network meta-analysis, Cochrane Database Syst Rev, 10(2021):CD013650.

127. A.R. Aroor, C. Manrique-Acevedo, V.G. DeMarco. The role of dipeptidyl peptidase-4 inhibitors in management of cardiovascular disease in diabetes; focus on linagliptin, Cardiovasc Diabetol, 17(2018):59.

128. K. Saini, S. Sharma, Y. Khan. DPP-4 inhibitors for treating T2DM-hype or hope? An analysis based on the current literature, Front Mol Biosci, 10(2023):1130625.

129. K. Makrilakis. The role of DPP-4 inhibitors in the treatment algorithm of type 2 diabetes mellitus: When to select, what to expect, Int J Environ Res Public Health, 16(2019):2720.

130. K. Saini, S. Sharma, Y. Khan. DPP-4 inhibitors for treating T2DM-hype or hope? An analysis based on the current literature, Front Mol Biosci, 10(2023):1130625.

131. W. Ghusn, M.D. Hurtado, A. Acosta. Weight-centric treatment of type 2 diabetes mellitus, Obes Pillars, 4(2022):100045.

132. M.P. Gilbert, R.E. Pratley. GLP-1 analogs and DPP-4 inhibitors in type 2 diabetes therapy: Review of head-to-head clinical trials, Front Endocrinol (Lausanne), 11(2020):178.

133. L. Collins, R.A. Costello. Glucagon-like peptide-1 receptor agonists, StatPearls [Internet], Treasure Island (FL): StatPearls Publishing, (2024).

134. M.S. Popoviciu, L. Păduraru, G. Yahya, K. Metwally, S. Cavalu, et al. Emerging role of GLP-1 agonists in obesity: A comprehensive review of randomised controlled trials, Int J Mol Sci, 24(2023):10449.

135. N. Alfaris, S. Waldrop, V. Johnson, B. Boaventura, K. Kendrick, et al. GLP-1 single, dual, and triple receptor agonists for treating type 2 diabetes and obesity: A narrative review, EClinicalMedicine, 75(2024):102782.

136. R. Le, M.T. Nguyen, M.A. Allahwala, J.P. Psaltis, C.S. Marathe, et al. Cardiovascular protective properties of GLP-1 receptor agonists: More than just diabetic and weight loss drugs, J Clin Med, 13(2024):4674.

137. H. Bays. Sodium glucose co-transporter type 2 (SGLT2) inhibitors: Targeting the kidney to improve glycemic control in diabetes mellitus, Diabetes Ther, 4(2013):195-220.

138. P. Dandona, A. Chaudhuri. Sodium-glucose co-transporter 2 inhibitors for type 2 diabetes mellitus: An overview for the primary care physician, Int J Clin Pract, 71(2017):e12937.

139. R.J. Perry, G.I. Shulman. Sodium-glucose cotransporter-2 inhibitors: Understanding the mechanisms for therapeutic promise and persisting risks, J Biol Chem, 295(2020):14379-14390.

140. C. Morace, G. Lorello, F. Bellone, C. Quartarone, D. Ruggeri, et al. Ketoacidosis and SGLT2 inhibitors: A narrative review, Metabolites, 14(2024):264.

141. P. Ghimire, A.S. Dhamoon. Ketoacidosis, StatPearls [Internet], Treasure Island (FL): StatPearls Publishing; (2024).

142. P.R.E. Jarvis. Euglycemic diabetic ketoacidosis: A potential pitfall for the emergency physician, Clin Exp Emerg Med, 10(2023):110-113.

143. C.N. Boyle, Y. Zheng, T.A. Lutz. Mediators of amylin action in metabolic control, J Clin Med, 11(2022):2207.

144. A. Güemes, P. Georgiou. Review of the role of the nervous system in glucose homoeostasis and future perspectives towards the management of diabetes, Bioelectron Med, 4(2018):9.

145. E. Toschi, M.N. Munshi. Benefits and challenges of diabetes technology use in older adults, Endocr Metab Clin North Am, 49(2020):57-67.

146. S.L. Samson, P. Vellanki, L. Blonde, E.A. Christofides, R.J. Galindo, et al. American association of clinical endocrinology consensus statement: Comprehensive type 2 diabetes management algorithm-2023 update, Endocr Pract, 29(2023):305-340.

147. C. Langerman, A. Forbes, G. Robert. The experiences of insulin use among older people with type 2 diabetes mellitus: A thematic synthesis, Prim Care Diabetes, 16(2022):614-626.

148. I. Blumer, M. Clement. Type 2 diabetes, hypoglycemia, and basal insulins: Ongoing challenges, Clin Ther, 39(2017):S1-S11.

149. J. Freeman. Management of hypoglycemia in older adults with type 2 diabetes, Postgrad Med, 131(2019):241-250.

150. S. Cernea, I. Raz. Insulin therapy: Future perspectives, Am J Ther, 27(2020):e121-e132.

151. G.B. Bolli, A.Y.Y. Cheng, D.R. Owens. Insulin: Evolution of insulin formulations and their application in clinical practice over 100 years. Acta Diabetol, 59(2022):1129-1144.

152. A. Caturano, R. Nilo, D. Nilo, V. Russo, E. Santonastaso, et al. Advances in nanomedicine for precision insulin delivery. Pharmaceuticals, 17(2024):945.

153. P. Zhang, Y. Bao, M. Chen, H. Zhang, D. Zhu, et al. Changes of health-related quality of life after initiating basal insulin treatment among people with type 2 diabetes. Medicine, 102(2023):e34718.

154. A.N. Lau, T. Tang, H. Halapy, K. Thorpe, C.H. Yu, et al. Initiating insulin in patients with type 2 diabetes. CMAJ, 184(2012):767-776.

155. A.S. Forough, P.R. Esfahani. Impact of pharmacist intervention on appropriate insulin pen use in older patients with type 2 diabetes mellitus in a rural area in Iran, J Res Pharm Pract, 6(2017):114-119.

156. R.O. Akinyemi, J. Yaria, A. Ojagbemi, M. Guerchet, N. Okubadejo, et al. Dementia in Africa: Current evidence, knowledge gaps, and future directions, Alzheimers Dement, 18(2022):790-809.

157. T.M. Maddox, J.L. Januzzi Jr, L.A. Allen, K. Breathett, S. Brouse, et al. 2024 ACC Expert consensus decision pathway for treatment of heart failure with reduced ejection fraction: A report of the American College of Cardiology Solution Set Oversight Committee, J Am Coll Cardiol, 83(2024):1444-1488.

158. L. Lohan, F. Galtier, T. Manson, T. Mura, A. Castet-Nicolas, et al. Compliance with prescription guidelines for glucose-lowering therapies according to renal function: Real-life study in inpatients of internal medicine, endocrinology and cardiology units, Medicina, 57(2021):1376.

159. R. Basiri, B. Seidu, L.J. Cheskin. Key nutrients for optimal blood glucose control and mental health in individuals with diabetes: A review of the evidence, Nutrients, 15(2023):3929.

160. L.M. Fonseca, J.J. Schmidt, F.J. Snoek, R.S. Weinstock, N. Chaytor, et al. Barriers and facilitators of self-management in older people with type 1 diabetes: A narrative review focusing on cognitive impairment, Diabetes Metab Syndr Obes, 17(2024):2403-2417.

161. M.D. Adu, U.H. Malabu, A.E.O. Malau-Aduli, B.S. Malau-Aduli. Enablers and barriers to effective diabetes self-management: A multi-national investigation, PLoS One, 14(2019):e0217771.