

A REVIEW ON ARTIFICIAL INTELLIGENCE IMPACT IN PREVENTION AND PHARMACOTHERAPEUTIC MANAGEMENT OF DIABETES MELLITUS IN COMMUNITY PRACTICE

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Abstract:

Diabetes mellitus is a chronic metabolic disorder which is characterized by prolong hyperglycemia and causes microvascular and macrovascular complications. It is classified into Type I, Type II diabetes mellitus and Gestational diabetes mellitus. The drastic increasing in prevalence of diabetic cases due to lack of control of glycemic levels and substantial health care expenditure causes diabetes mellitus treatment challenge worldwide. The beta-cell dysfunction is accelerated by chronic hyperglycemia which is responsible for progression of diabetic complications. Globally, 382 million people are living with diabetes, and this count is expected to elevate 592 million by 2035. Artificial intelligence (AI) offers a new gateway of opportunity to get better health care treatment for diabetic patients. The new emergence of advance health care technologies (AI) helps to resolve the obstacles of diabetes treatment and alleviate the disease burden of diabetes mellitus complications in future. The AI role in diabetes management relies on disease control, risk factors screening, diagnosis, and treatment. Integrating AI technology into diabetic care plan would shift diabetes care towards positive outcome. The lack of available treatment plan strategies causes diabetes mellitus more challenging and prevention and management requires necessary steps to lower the diabetic problems. Diabetes mellitus care delivery and therapeutic plan strategies should focus on primary care settings with the collaboration of multidisciplinary teams and that emphasis on prevention of diabetes mellitus. Diabetes mellitus is a well notable risk factor for developing cardiovascular diseases and diabetic people has two to four times more likely to develop diabetic risk as compared to non-diabetic people. The major risk factors for diabetes mellitus such as physical inactivity, alcohol, smoking, blood pressure obesity etc. The disease people must bound to lifestyle modifications and treatment plan strategies would effectively delays the onset of diabetic symptoms among the patients.

Keywords: Diabetes mellitus, Hyperglycemia, Artificial intelligence, Diabetic complications, Lifestyle modification, Treatment plan.

INTRODUCTION

In the era of 1920s there is no cure for diabetes mellitus and those who diagnosed with diabetes mellitus have death within a few months to years. The increased prevalence of diabetic cases and proper therapeutic options are needed. Diabetes mellitus is a major metabolic disease in worldwide and its unexpected count may cause serious life threat to human population. At present 387 million people worldwide are affected from the disease. Many research studies determined that asian population may prone to develop diabetes cases due to insulin resistance and greater obesity associated problems. Type 1, Type 2 diabetes mellitus both are defined with abnormal elevation of glucose levels in bloodstream. Type II diabetes mellitus is a mutli systematic disorder which is associated with elevated blood glucose levels that causes defects in insulin secretion and resistance to insulin. The strong association was noted between obesity and diabetes mellitus and controlled by the central nervous system. The diabetes mellitus levels should be monitored in uncontrolled glycemic levels that can alleviate the risk incidence of Type II diabetes mellitus. The International Diabetes Federation estimated that diabetic affecting cases expected to increase by 46% to 783.2 million by the year 2045. The majority of prediabetes cases occurs in low- and middle-income countries¹⁻³. The raising of diabetic cases prevalence is due to sedentary lifestyle, urbanization, and changes in diet and physical activity.

Classification of Diabetes:

Insulin Dependent Diabetes Mellitus

The autoimmune destruction of the pancreatic cells and affect people of all ages usually in children. The regular insulin therapy is essential for the control of elevated glucose levels.

Idiopathic Diabetes

The exact cause of patients having type 1 diabetes there is specific etiologies.

Noninsulin Dependent Diabetes Mellitus

It is known as adult onset diabetes that accounts for 90–95% of all diabetes. The noted metabolic syndromes such as dyslipidaemia can raise the epidemic of type 2 diabetes.

Gestational Diabetes Mellitus

The impaired glucose intolerance occurs in pregnancy condition.

Catamenial Hyperglycaemia

It is a clinical condition that arises due to infection, inadequate insulin can cause diabetic ketoacidosis.

Diabetic complications

It includes microvascular and macrovascular complications. The microvascular complications such as neuropathy, retinopathy, and nephropathy having extreme correlation with glucose levels. The Macrovascular complications of T2DM, such as myocardial infarction and ischemic stroke, inflammation mediated by macrophages responsible for insulin resistance.

Risk Factors of Diabetes

The risk factors can cause the progression of diabetes mellitus risk. It includes age, weight, family history of diabetes, smoking. T1DM is found in the young people, T2DM is observed in adults. The risk of T2DM increases with age due to the deficiency of insulin secretion that occurs with age, and insulin resistance caused by a change in body composition.

Pathophysiology of T2DM

Type II diabetes mellitus caused by multifactorial etiological factors. The main mechanism in development of Type II diabetes mellitus is defects in insulin production and insulin resistance in peripheral tissues. The dysfunction of pancreatic β -cells lowers insulin secretion that results in the inability to maintain normal glucose levels. Insulin resistance promotes the production of glucose in the liver and decreases glucose uptake in muscle, liver, and adipose tissue, thus creates a flawed loop interaction between insulin action and secretion enhances the hyperglycemic condition. The loss of β -cell-defining transcription factors causes glucotoxicity⁴⁻⁹.

The trans differentiation of β -cells converts differentiated cell type into another. β -cells' function impairing induces the genes. The disallowed genes are genes upregulated in the state of metabolic stress, such as T2DM. The disallowed genes, including a gene encoding repressor element 1 silencing transcription factor whose repression is required for stimulation of insulin. The overexpression of repressor element 1 silencing transcription factor associated with impaired function of β -cells. The over expression of repressor element 1 silencing transcription factor leads to the activation of expression of dual-specificity tyrosine-regulated kinase 1A. Kinase involved in the repression of β -cell proliferation and results in impaired β -cell induces the state of Type II diabetes mellitus. The mitochondria are a source of reactive oxygen species which causes β -cells dysfunction. Mitochondria is very sensitive to due to their low levels of antioxidant enzymes and

high oxygen consumption. The reactive oxygen species in small amounts exert a beneficial effect of stimulating insulin expression and is required for insulin secretion. The larger amounts of reactive oxygen species lead to β -cell dysfunction and leads to cell death.

Insulin Resistance

The excessive production of glucagon, glucocorticoids promotes the occurrence of insulin resistance. The insulin is regulated by different hormones, including growth factors and insulin-like growth factor 1 in the fed state and glucagon, glucocorticoids in fasting condition. Insulin Resistance causes decline in metabolic response to insulin, at a systemic level and lowers blood glucose levels. Insulin Resistance results in low secretion of insulin secretion, insulin antagonists in the plasma, and diminished insulin response in target tissues¹⁰⁻¹⁴.

Common symptoms of Diabetes mellitus

- Increased thirst (Polydipsia)
- Frequent urination (Polyuria)
- Increased hunger
- Weight loss
- Fatigue
- Weakness
- Blurred vision
- Slow healing sores
- Frequent infections
- Numbness
- Skin infection
- Ketones in urine

Novel trends in Diabetes mellitus

Nanotechnology and Diabetes

The nanotechnology involves the use of nanoparticles (<100 nm) for the treatment of diabetes mellitus. These nanoparticles are developed through the manipulation of molecules in a substance. The application of nanotechnology based methods in medicine is known as nanomedicine. The nanomedicine involves applying the knowledge of nanotechnology in the application of drugs that can enhance the ability to target specific cells.

The Nanotechnology having key role in improving the outcomes of diabetic management with the help of nanotechnology-based glucose measurement and insulin drug delivery systems. The nanomedicine can overcome the obstacles in glucose monitoring. The glucose-sensing device contains detector, transducer, and reporter. The detector checks glucose level and transducer converts the measurement into signal. The coupling of these nanoparticles as transducers that enables the proper detection of glucose rapid manner.

Medical Nutrition Therapy in Diabetes

The nutrition therapeutic services aid in the management of diabetes mellitus. The Institute of medicine stated that pregnant women must consume minimum of 175 g carbohydrates daily, and low carbohydrate diet must followed traditionally for the treatment of gestational diabetes mellitus.

Gene therapy

It involves remedying the defective gene via the incorporation of the exogenous gene. At present, the gene manipulation is not limited to the addition of a gene but also gene modulation and editing techniques are possible.

Stem cell therapy in Diabetes

The cellular-based therapeutic techniques currently used in diabetic therapy that involves pancreas transplantation to revive the beta cells for insulin secretion.

Management of Diabetes

The early diagnosis of diabetes is a central part of achieving diabetic management. The lifestyle modification is an integral part of diabetes mellitus management and it is recommended for both pre-diabetic and diabetic patients. The regular physical exercise helps to bring down the plasma glucose levels.

Pharmacological approaches in Treatment of Diabetes mellitus

Diabetes mellitus treatment

Metformin is the first line of medicine prescribed for type 2 diabetes. It helps the body use insulin and minimize the hypoglycemic events.

Side effects: Nausea, Bloating, Diarrhea.

Sulfonylureas

The drugs binds to the sulfonylurea receptor (SUR1) on pancreatic beta cells that closes ATP-sensitive potassium channels which causes depolarization. This process leads to opening of

calcium channels, stimulates the release of insulin from the beta cells, It includes glipizide, glimepiride.

Side effects: Low blood sugar, Weight gain.

Glinides

The drugs causes closing ATP-dependent potassium channels in pancreatic beta cells that causes depolarization and increases calcium influx and it stimulates the pancreatic beta cells to release insulin and lowers the blood glucose levels. The drugs includes repaglinide and nateglinide.

Side effects: Low blood sugar, Weight gain.

Thiazolidinediones

It enhances the insulin sensitivity by activating the PPAR-gamma nuclear receptor and binds to specific DNA sequences and alters the transcription of genes. It helps body tissues to utilize the insulin. It include pioglitazone and rosiglitazone.

Side effects: Weight gain, Broken bones, Fluid retention, Heart failure.

DPP-4 inhibitors

It works by blocking the DPP-4 enzyme that normally breaks down incretin hormones and lowers the blood glucose levels. The drugs include alogliptin, sitagliptin, saxagliptin, linagliptin¹⁵.

Side effects: Pancreatitis, Joint pain.

GLP-1 receptor agonist

The drug can slows the process of gastric empty and help lower blood sugar levels. The drugs include dulaglutide, exenatide, liraglutide, semaglutide.

Side effects: Nausea, Vomiting, Diarrhea.

SGLT2 inhibitors

It blocks the sodium-glucose cotransporter 2 in the kidneys' proximal tubules and reduces glucose reabsorption leads to more glucose and sodium excreted in urine. These medicines include canagliflozin, dapagliflozin, empagliflozin.

Side effects: Vaginal infections, low blood pressure, obesity, urinary tract infections and weakness of bones.

Insulin therapy

The Insulin types vary by the action and duration of the drug. Long-acting insulin, for instance, works throughout the day to maintain the controlled blood sugar levels even. The people with short-acting insulin prescribed at mealtimes¹⁶.

Tirzepatide

It is a novel drug that controls glucose-dependent insulinotropic polypeptide and GLP-1 receptors and improves blood glucose control and significant weight reduction.

Non-Pharmacological Methods of Treatment

The non-pharmacological interventions are essential for controlling type II diabetes mellitus. The Pharmacological approaches should be followed when lifestyle modification alone is not sufficient to achieve positive results.

Regular Physical exercise

The Physical activity is important for treatment of T2DM. The regular exercise improves glycemic control, insulin sensitivity, and muscle function in diabetic people. The aerobic exercises identified to be more effective than single-mode training in managing blood glucose levels and enhancing the metabolic health.

Dietary Interventions

The intake of low-calorie high protein diet can improve glucose metabolism and cardiometabolic outcomes. The Mediterranean diet is an effective form of diet for diabetic patients to control their glycemic levels¹⁷.

Bariatric Surgery

Bariatric surgery is effective in treating both T2DM and obesity. The sleeve gastrectomy, one-anastomosis gastric bypass, and Roux-en-Y gastric bypass have the potential to lower the diabetic complications. The age, baseline BMI, HbA1c, the use of antidiabetic medication, and the duration of diabetes play a major role in T2DM remission must be noted while referring the patients to bariatric surgery.

Hyperbaric Oxygen Therapy

It has shown decrease in blood glucose levels after hyperbaric oxygen therapy in patients with T2DM. The mechanism underlying the decrease in blood glucose levels from hyperbaric oxygen therapy improves the insulin sensitivity.

Probiotics

Probiotics treatment may reduce glycated hemoglobin A1c (HbA1c), fasting blood glucose (FBG), and insulin resistance level (HOMA-IR) in type II diabetic patients. The regular intake of probiotics enhances cardiometabolic health by lowering the inflammation and oxidative stress in T2DM patients¹⁸.

Prevention of diabetes-related complications

The treatment approach for type 2 diabetes mellitus depends on conventional therapeutics and continuous adhering to lifestyle modifications. There is an urgent need for effective diabetic screening investigations at initial stages of diabetes mellitus could help to identify the risk people. Focus on identification of new drugs from drug discovery studies can solve the issues with diabetic complications and ultimately minimize the future occurrence of diabetic complications.

Artificial Intelligence (AI) in Diabetic research

The complexity nature of diabetes mellitus innovative treatment approaches required for diagnosis and management. Prompt diagnosis is essential for initiating timely treatment and preventing diabetic complications. The measurement of fasting blood glucose, post prandial blood glucose, random blood sugar tests are used to detect the diabetes mellitus. AI has tremendous role in healthcare which provides new possibilities for improving disease diagnostic accuracy, personalizing treatment and enhances the patient care through continuous interventions with disease people¹⁹⁻²². The AI languages includes Machine learning (ML), deep learning (DL) has remarkable capabilities for assessing the vast amounts of healthcare data. The treatment for diabetes mellitus, AI plays a pivotal role in refining the diagnostic procedures, improving early detection could enhances the patient outcomes. The ML algorithms such as artificial neural networks support vector machines and Bayesian networks deployed for developing the new diagnostic models for prevention of diabetes mellitus using a variety of clinical data inputs. The DL techniques, particularly convolutional neural networks and recurrent neural networks enhance the diagnostic capabilities for diabetes mellitus. Long short-term memory networks, particularly bi-directional long short-term memory networks are effective in analyzing the complex clinical data patterns and valuable for the early diagnosis of diabetes mellitus.

AI role in diagnosis of diabetes

Diabetes mellitus remain undiagnosed for several years as the condition is generally asymptomatic in early stages. The diagnosis of diabetes mellitus at a later stage that can results in reduced life

expectancy and increased health issues. AI-based tools have a potential to provide cost effective and accurate diagnosis. AI can accurately predict the risk of diabetes using patients demographic details such as age, gender, BMI, family history of diabetes etc. New sensing technologies, like facial screening, tongue screening, are in the early stages of development to screen diabetes²³⁻²⁹.

AI insulin injections

AI devices can use data from continuous glucose monitoring biosensor devices to provide personalized diabetic care. The AI algorithms are designed to predict glucose levels. The AI systems improve glycemic control by maintaining stable blood sugar levels. The d-Nav[®] insulin device is novel innovative technology that can predict glucose levels and advise diabetic patients on insulin dose intake. Integrating AI in diabetes care not only optimize treatment and also empowers people with diabetes to monitor their diabetic condition effectively³⁰⁻³⁴.

AI in Gestational diabetes mellitus

It impacts the health of the mother and foetus. AI can improves the pregnancy outcomes through personalized health care intervention approach. AI helps in assessing gestational diabetic risk, and maternal health of women. AI reduces the gestational associated risk by tailored health care interventions based on individual lifestyle and family genetic sequence. The newly developed mobile health apps like SineDietool,, MobiGuide, GDm-Health tools can provide instant clinical decision support to the gestational women³⁵⁻³⁸.

AI imaging technology

AI helps to lower the diagnostic errors and enable prompt health care interventions. The machine learning tools used to improve the imaging practices includes MRI, CT, Ultrasound scan considered for efficiency and accuracy for detection of diabetes complications issues.

Artificial Intelligence (AI) in primary health care practice

AI is an effective tool in a primary health care settings and it may help in formulating preventive the disease risk strategies for high-risk diabetic population. AI technology helps to manage the people with diabetes who cannot get daily treatment at hospitals. The AI based solutions provide real-time health information to disease people. AI accurately predict the risk of diabetes using patients demographic factors such as age, gender, BMI, waist circumference, hypertension,

smoking, family history of diabetes, and physical activity. The novel sensing technologies, facial recognition, tongue feature fusion are in the early stages of development which would be helpful for diabetic patients to screen their clinical profile at the initial stages³⁹⁻⁴⁰.

Artificial Intelligence role in Diabetes mellitus

The diabetes mellitus become a global public health concern in the 21st century. The management of patients with diabetes involves regular diabetic screening of blood glucose levels. The diabetes management needs continuous integration with other departments such as endocrinology, podiatry, nutrition, nephrology, and ophthalmology. The diabetes mellitus is perhaps the most prominent example of a high prevalent chronic disease which would focus on patient's active continuous role in its management due to its dependence on strict adherence to diet and exercise and its need for self-monitoring of individuals⁴¹⁻⁴³. The advent of digital health technologies such as artificial intelligence helps to address the obstacles and alleviate the continuous progression of diabetic disease burden in the community.

Machine learning applications in diabetic research:

It includes:

1. The artificial neural networks includes Boltzmann machines, multi-layer perceptron, radial basis function networks, Hopfield networks etc.
2. The bayesian learning includes Naive Bayes, Gaussian naive Bayes, multiple naive Bayes, Bayesian networks etc.
3. The decision trees, such as Iterative Dichotomiser 3, C4.5 algorithm, 0 algorithm, chi-squared automatic interaction detection, decision stump etc.
4. Ensemble methods, such as random forest, AdaBoost, and XGBoost, etc.
5. The linear models, such as linear regression, logistic regression, generalized linear models, quadratic discriminant analysis, least absolute shrinkage, multi-modal logistic regression etc.

Applications of AI in prevention of diabetes

Prediction of diabetes onset

The prediction of diabetes mellitus is an integral part of chronic disease and accurate identification of individuals highly likely to develop diabetes mellitus at the illness stage. The digital health technologies could drastically lower the incidence of diabetes by implementing health care interventions for diabetic people at initial stages.

Management of risk factors of diabetes mellitus using AI

The modifiable risk factors are identified using AI algorithms. It can predict the future risk factors of diabetes mellitus such as hypertension, obesity, smoking, lack of physical activity etc.

Application of AI in screening of diabetes mellitus

Diabetes mellitus screening

The early stages of screening of type II diabetes mellitus is often asymptomatic. The delay in screening and diagnosis of diabetes mellitus lead to severe health complications which eventually lowers the life expectancy of disease patients.

Health education

The regular health education for diabetic people can empowers the diabetic patient's knowledge and awareness of diabetic treatment approaches that can facilitate management of disease condition.

Automatic diet monitoring

The dietary monitoring is critical step in patients with diabetes. The especially as self-reporting of food intake is inaccurate. Therefore, it is a necessary step to develop an solution for dietary monitoring. It is divided into two categories based on degree of automation. The semi-automatic system requires users to select the approximate position of the food in the picture. In automated dietary monitoring systems, users send food pictures to the server, that can assess the selected food images and predict the nutritional composition of the food⁴⁴⁻⁴⁶.

AI-based diet recommendations

A targeted dietary approaches control the blood sugar levels, lipids, proteins, nutrients. The dietary recommendation system for patients with diabetes is based on their knowledge of nutrition, considering intake of eating patterns.

Future recommendations

The Integration of AI-based digital health technologies into diabetes care and closer collaboration between AI specialists and health care team should be encouraged to explore an innovate ideas could be incorporated into regular clinical practice can strengthen the diabetic treatment. The development of an AI-assisted digital health tools for diabetes management enables the new models of diabetes care⁴⁷⁻⁵⁰.

Conclusion

Type II diabetes mellitus is a global health issue. More than 400 million people are affected by diabetes mellitus worldwide, the number of affecting people with diabetes mellitus is continues to raising. The proper diagnosis and treatment of type II diabetes mellitus requires effective treatment method. The defects in insulin production and insulin resistance in body tissues lead to lower the insulin synthesis and β -cells dysfunction which results in occurrence of diabetic symptoms⁵¹. The appropriate physical activity, intake of balanced diet, and psychological interventions could arrest the future complications of diabetes include renal failure, heart attack, stroke, and retinopathy etc. There is a need for diabetic education and health care team support for regular adherence to prescribed medications can improves the quality of life of diabetic people. To effective control of diabetic complications which emphasis on health care policies to reinforce the treatment resources leads to diabetic free society⁵²⁻⁵³. AI technology fosters the diagnostic accuracy and personalizing treatment strategies by integrating advanced health care data sources. AI improve early detection through accurate diagnostic methods and non-invasive screening methods could minimize the further progression of diabetic complications.

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