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# Can Diabetes be Controlled by Lifestyle Activities?

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**Abstract**

Diabetes is a complex disease that affects millions of people worldwide. Diabetes is a metabolic disease, in which increased blood glucose levels ultimately lead to heart disease, stroke, kidney failure, foot ulcers, and damage to the eyes. Current prevalence rates of diabetes are extremely high in countries throughout the world. Multiple forms of diabetes have been identified, including type 1, type 2, type 3, neonatal and gestational. The purpose of this article is to discuss recent developments in diabetes research, including prevalence, morbidity and mortality rates, and lifestyle factors that are associated with diabetes onset and progression. This article also discusses how lifestyle factors delay and or prevent diabetes.

## Introduction

Diabetes is a chronic disease that affects millions of people worldwide. Diabetes is mostly polygenic condition, accounts for about 95% of total diabetes cases and it is mostly late-onset. Genetic mutations in single gene cause diabetes, referred monogenic. Monogenic forms of diabetes accounts for about 1-5% of all cases diabetes and monogenic diabetes occur in young people [1]. Genetic mutations in monogenic form of diabetes reduce the production of hormone insulin in the beta cells of pancreas, which is responsible for the maintenance of blood glucose level. Diabetes is a collection of multiple metabolic diseases, in which high levels of blood glucose are present over an extended period of time. Most persons with diabetes remain undiagnosed early in the disease process [2]. In most cases, blood glucose levels in persons with diabetes increase with age, leading to heart disease, stroke, chronic kidney failure, foot ulcers, and damage to the eyes. Such high glucose levels are associated with frequent urination and increased thirst and hunger.

The purpose of this mini-review is to explain recent research findings in investigations of diabetes, including:

a. Prevalence,

b. Morbidity and mortality rates,

c. Types of diabetes,

d. Factors that affect diabetes and

e. Current research findings about diabetes therapeutics.

### Prevalence of diabetes

The worldwide prevalence of diabetes was 2.8% in 2000, and it is expected to increase to 4.4% by 2030. The total number of persons with diabetes worldwide is estimated to increase from 171 million in 2000 to 366 million in 2030 [3]. The most important demographic change regulating to diabetes prevalence across the world is that it is increasing in people older than 65 years [3]. According to the Center for Disease Control and Prevention, in the United States the number of persons with diabetes older than 65 years of age rose nearly 300% between 1980 and 2014, from 5.5 million in 1980 to 22 million in 2014. The percentage of Americans age 65years of age or older remains high at 25.9%, with 1.4 million Americans diagnosed with diabetes each year [4].

### Morbidity and mortality rates of persons with diabetes

Acute complications from diabetes include diabetic ketoacidosis, a life-threatening condition that develops especially in persons with type1 diabetes, when cells in the body are unable to get the glucose they need for energy due to insulin insufficiency. When glucose cannot get into the cells, it stays in the blood. The kidneys filter some of the sugar from the blood

and remove it through urine. But when cells cannot receive sugar for energy, the body begins breaking down fat and muscle for energy. When this occurs, fatty acids are produced and enter the bloodstream, causing a life-threatening chemical imbalance called diabetic ketoacidosis.

Another acute complication from diabetes is nonketotic hyperosmolar coma, which is when blood sugar levels rise, and the body tries to get rid of the excess sugar by passing it into the urine, initially resulting in increased urination. However, at later stages, urination decreases and thirst increases. Without sufficient liquids, dehydration can result, leading to seizures, a coma, and eventually death. This process may take days or even weeks to develop. Persons with type 1 and type 2 diabetes may succumb to this complication.

Current morbidity and mortality rates of persons with diabetes are very high in the United States (Statistics about diabetes, American Diabetes Association. According to the American Diabetes Association, from 2009 to 2012, of the adults aged 18 years or older who were with diagnosed diabetes, 71% had increased blood pressure and 65% had LDL cholesterol levels greater than normal (Statistics about diabetes, American Diabetes Association. Based on statistics from 2003 to 2006, cardiovascular disease death rates were about 1.7 times higher among adults with diagnosed diabetes who were aged 18 years or older compared to adults who did not receive a diabetes diagnosis, after adjusting for age differences in these population groups. In 2010, hospitalization rates due to heart attack were 1.8 times higher among adults diagnosed with diabetes who were aged 20 years or older [4,5]. Also in 2010, after adjusting for age differences, hospitalization rates for victims of stroke were 1.5 times higher among adults diagnosed with diabetes [5].

In 2005 to 2008, of the adults with diabetes aged 40 years or older, 4.2 million (28.5%) had diabetic retinopathy, that is, damage to the small blood vessels in the retina, which can ultimately result in loss of vision [4,5]. In 2011, diabetes was listed as the primary cause of kidney failure in 44% of all new cases of kidney failure.

And in this same year, a total of 228,924 people of all ages who were diagnosed with kidney failure were living on chronic dialysis except for those who had a kidney transplant [4,5]. A recent 2017 study reported that health problems associated with diabetes had been significantly underreported in the United States, and that Americans with diabetes have about a 90% higher death rate than those without diabetes [6]. These rates of illnesses, morbidity, and mortality figures underscore diabetes as a major and increasing health concern.

## Cost of diabetes

In 2012, the costs of treating illnesses associated with diabetes, such as blindness, heart attack, and stroke, rose to $245 billion in the United States, with direct medical costs of about $176 billion. After adjusting for age and sex differences in persons diagnosed with diabetes, their average medical expenditures were found to be 2.3 times higher than for persons without diabetes [4,5].

## Types of diabetes

The levels of glucose in the blood determine the severity of diabetes, but the age of diabetes onset usually determines its type. Multiple forms of diabetes have been identified, including type 1, type 2, type 3, neonatal and, gestational [2,7,8].

**Type 1 diabetes:** Type 1 diabetes is early-onset, usually when the patient is 30 years of age or younger. Five percent of the total number of diabetic patients has type 1. Type 1 diabetes occurs after first 6 months of life. Early-onset, type 1is typically associated with inherited gene mutations [2]. Type 1 diabetes is also called an insulin-dependent diabetes because persons with type 1 diabetes need to manage their blood glucose levels through insulin shots.

**Type 2 diabetes:** Type diabetes is a late-onset disease, in that its symptoms first appear in persons older than 30 years of age. Type 2 diabetes covers over 90% of the total diabetic population. Type 2 diabetes encompasses persons with higher-than-normal blood sugar levels, which may lead to increased insulin resistance and insulin deficiency [2,10]. Type 2 diabetes is associated with some non-modifiable and some modifiable risk factors.

**Type 3 diabetes**: Type 3 diabetes has been identified as a possible form of Alzheimer's disease [2,8]. Persons with type 3 diabetes exhibit cognitive impairment and oxidative stress that affect glucose metabolism symptoms that also characterize persons with AD, in terms of insulin resistance, and mitochondrial dysfunction. Several recent studies have also shown underlying, mechanistic links across metabolic changes and carbohydrates, lipids, proteins, and brain dysfunction in persons with AD and in persons with type 3 diabetes [8].

**Neonatal diabetes:** Neonatal diabetes occurs in the first six months of life and it is monogenic. It is a condition occurs one in 100,000 to 500,000 live births. Infants with neonatal diabetes do not produce sufficient insulin and this condition often confused with type 1 diabetes.

**Gestational diabetes:** Gestational diabetes is the onset of diabetes in mothers during pregnancy, typically accompanying carbohydrate intolerance. Gestational diabetes is usually diagnosed at later stages of pregnancy.

The following conditions are associated with gestational diabetes in pregnant mothers:

a. Age 25 or older,

b. Over weight mother, particularly body mass index is 30 or higher,


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c. Mothers have polycystic ovarian syndrome,

d. Have a medical condition that makes diabetes more likely, such as glucose intolerance,

e. Mothers, who take medications like glucocorticoids for asthma or an autoimmune disease,

f. Mothers who take beta-blockers for high blood pressure, or antipsychotic drugs and

g. Mothers who African American, Native American, Asian American, Hispanic, or Pacific Islander [2,10].

**Mechanistic action in diabetes:** Hypoglycemic hormone, insulin is produced by the pancreas. In turn, insulin regulates glucose metabolism which also in turn regulates plasma glucose. Genetic abnormalities of insulin gene lead to insufficient and/or defective production of insulin, typically leading to type 1 diabetes [2]. In type 2 diabetes, the body is unable to regulate sugar levels in the blood. Several factors are involved in sugar level regulation in type 2 diabetes, including genetic and environmental interactions and increased calorie intake (high fat diet) and lack of exercise. All of these factors induce insulin-related abnormalities, ultimately leading to events that cause late-onset type 2 diabetes. Overall, the elevated level of blood glucose is due to the failure of beta cells in the pancreas to produce insulin or to regulate insulin resistance.

**Modifiable and non-modifiable factors associated with diabetes:** There are many factors associated with the onset of diabetes, some of which are modifiable and some not modifiable.

**a. Modifiable factors:** Persons diagnosed with diabetes are behaviors that persons can change in order to manage their diabetes and to lower blood glucose levels, such as altering diet, increasing exercise, and eliminating unhealthy lifestyle activities (e.g., smoking, excessive alcohol, insufficient sleep) [2]. Modifiable factors in persons who are pre-diabetic, regardless of their age, are a diet high in fat and low in fresh fruits, vegetables, and whole grains. Foods containing low levels of sugar may also prevent and/or delays diabetes onset. In addition, the maintenance of normal cholesterol and blood pressure levels may also reduce pre-diabetes symptoms and diabetes onset.

**b. Non-modifiable factors:** Sex, age, ethnicity, and changes in genomes are major non-modifiable factors. People over 65 are likely to develop pre-diabetes, and most with type 1 and type 2 diabetes are unaware of their pre-diabetic conditions. People have increased risk of developing pre-diabetes after age 40 years of age [2]. Individuals with inherited DNA changes in the genome are susceptible to diabetes.

**I. Ethnicity:** Ethnicity plays a key role in development of pre-diabetes. Some ethnic groups carry a higher risk of developing diabetes. These ethnics groups are Africans, Alaskan Natives, American Indians, Asians, Latinos, and individuals of Pacific Islander descent.

**II. Genetics:** Changes in the genome contribute significantly to both early-onset type 1 and late-onset type 2 diabetes. Individuals with polymorphisms in individual genes in the genome are likely to be obese and to develop pre-diabetes and diabetes [7]. Polymorphisms in the genes HLA-DQA1, HLA-DQB1, and HLA-DRB1 in persons with diabetes have been found to correlate with the development of type 1diabetes [7]. Genetic polymorphisms in these genes alter proteins play critical roles in the immune system of type 1 diabetes. It is likely that interactions between genome changes with environmental conditions and/or diet promote obesity, pre-diabetes, and diabetes in human populations. In addition, epigenetic factors, including diet and lifestyle are other major contributors to the development of obesity, pre-diabetes, and diabetes.

**III. Exercise:** Exercise plays an important role in the maintenance of body weight and blood sugar levels and in reducing pre-diabetes symptoms. Health benefits associated with physical activity are rapidly being identified. For example, exercise improves blood circulation, reduces the risk of heart disease, reduces the risk of stroke, improves self-esteem, and improves whole-body blood glucose levels [11]. Some exercises may also improve changes in skeletal muscle since skeletal muscle is responsible for the disposal of glucose from the blood. In addition, white adipose tissue shows beneficial effects with physical activity and exercise [11].

**IV. Diet:** Diet plays a significant role in the maintenance of blood sugar levels in in persons who are obese or who have pre-diabetes and diabetes symptoms. Mounting evidence suggests that nutritional therapy is useful for improving glycemic control and metabolism. Recent research into diabetes also suggests the importance of using evidence-based, rather than anecdotal-based, nutritional therapy that is based on a patient's level of insulin [12-14]. Nutritional education in diabetes self-management programs is a critical component of a therapeutic plan for persons with diabetes.

**V. Education and awareness:** An awareness of and education about obesity, pre-diabetes conditions, and diabetes are important for persons with diabetes to consider changing their lifestyle. Educational material is available from clinics and local hospitals, and even from online sources. But currently, it is the responsibility of persons with diabetes to seek out these educational materials. Self-management classes about diabetes and lifestyle choices may be useful in providing persons with information to help them maintain the best quality of life possible, given their diabetes and in providing pre-diabetic persons information to help them avoid becoming diabetic [12,15]. The main objective of these self-management classes is teaching persons, self-sufficiency in using problem-solving skills to lead a healthier life. Overall, such self-management education has been an effective tool in reducing diabetes in persons currently at risk or in persons already diagnosed with the disease.


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## Research into the Molecular Mechanisms Underlying Diabetes

Research is being actively pursued to better understand molecular mechanisms underlying both type 1 and type 2 diabetes, using cell, rodent, nonhuman primate and human models [16,17]. Increasing evidence suggests that diabetes is a polygenic condition, in which DNA changes in multiple genes are involved in the development of diabetes. The regulation of genes has been found to change in persons with diabetes, and this dysregulation in turn affects the synthesis of proteins, a problem known to occur in persons with type 1 and type 2 diabetes.

In addition, elevated inflammatory responses, oxidative stress, and mitochondrial dysfunction are cellular events that have been extensively reported in obese persons and persons with type 1 and type 2 diabetes [18]. In these populations, defective regulation of insulin has been found to induce inflammation, oxidative stress, and mitochondrial dysfunction in tissues typically affected by diabetes, including tissues of the pancreas, liver, and brain, and skeletal muscles.

A naturally occurring mouse model for diabetes, the TallyHo mouse model, shows diabetic characteristics similar to those of humans with diabetes [19]. Genetic studies of TallyHo mice revealed that multiple DNA changes in multiple genes result in diabetic features found in humans with diabetes [19-21], including increased body weight, increased blood sugar levels, abnormal insulin regulation, and increased inflammation in the pancreas, liver, brain, and skeletal muscles. These features were found to increase with age in the TallyHo mice, just as they were found to increase with age in humans with diabetes [21]. It is possible that the types of polygenic changes found in the TallyHo mice also exist in humans with diabetes. Research is needed to better understand the molecular relationships between genome changes and diabetic characteristics in humans who have been so diagnosed.

Most recently, several researchers have newly proposed that AD is a type 3 diabetes, based on molecular similarities in obese persons with diabetes who exhibit insulin resistance and who also have AD [8]. These studies revealed that insulin is involved in the activation of the glycogen synthase kinase 3β, an enzyme that, in excess, results in the phosphorylation of tau. Phosphorylated tau is involved in the formation of neurofibrillary tangles, a hallmark of AD. Interestingly, insulin also plays a crucial role in the formation and increase of amyloid beta (A□), also a hallmark of brains from persons with AD.

## Current Status of Therapeutics

Researchers in basic science, pharmaceutical companies, and clinicians worldwide are intensely working on identifying therapeutic targets that are capable of reducing abnormalities associated with diabetes, including the reduction of insulin resistance and insulin deficiency. However, no therapeutic targets have been identified. However, recent research into treatments for diabetes has resulted in several FDA-approved molecules that target diabetes. These FDA-approved products include Metformin, Januvia, and drugs with alpha-glucosidase inhibitors, such as Orlistat [2]. Since diabetes is a polygenic condition, researchers are attempting to develop genome-based treatments, based on the particular genetic composition of individual with diabetes rather than treatments designed for most persons with diabetes, regardless of their genetic make-up. Clinicians are also researching changes in lifestyle activities that could help maintain blood pressure and healthy blood sugar levels in persons with diabetes, with such lifestyle changes including increased daily exercise and a well-balanced diet that has no sugars, reduced fats, and fresh fruits and vegetables.

Since most people are undiagnosed early on in the diabetes disease process, increased education about symptoms of diabetes may lead persons to seek out health care providers early, rather than late, in the diabetes disease process and to learn how changes in their lifestyle activities can be reduce their symptoms of diabetes.

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## References

1. National Statistics Report (2014) Center Disease Control. USA.
2. Boles A, Kandimalla R, Reddy PH (2017) Dynamics of Diabetes and Obesity: Epidemiological Perspective. Biochim Biophys Acta 17: S0925-S4439.
3. Wild S, Roglic G, Green A, Sicree R, King H (2004) Diabetes Care 27(5): 1047-1053.
4. American Diabetic Association.
5. Statistics about Diabetes.
6. Stokes A, Preston SH (2017) Deaths Attributable to Diabetes in the United States: Comparison of Data Sources and Estimation Approaches. PLoS One 12(1): e0170219.
7. Karvonen M, Tuomilehto J, Libman I, LaPorte R (1993) A review of the recent epidemiological data on the worldwide incidence of type 1 (insulin-dependent) diabetes mellitus. World Health Organization DIAMOND Project Group. Diabetologia 36(10): 883-892.
8. Kandimalla R, Thirumala V, Reddy PH (2017) Is alzheimer's disease a type 3 diabetes? A critical appraisal. Biochim Biophys Acta 16: 30215-30250.
9. Pugazhenthi S, Qin L, Reddy PH (2016) Common Neurodegenerative Pathways in Obesity, Diabetes and Alzheimer's Disease. Biochim Biophys Acta 16: S0925-4439.
10. US Preventive Services Task Force (2008) Screening for gestational diabetes mellitus: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 148(10): 759-765.
11. Stanford KI, Middelbeek RJ, Goodyear LJ (2015) Exercise effects on white adipose tissue: beiging and metabolic adaptations. Diabetes 64(7): 2361-2368.


How to cite this article: Hemachandra R P. Can Diabetes be Controlled by Lifestyle Activities?. 2017; 1(4): 555568. DOI: 10.19080/CRDOJ.2017.1.555568.

12. Franz MJ, Boucher JL, Evert AB (2014) Evidence-based diabetes nutrition therapy recommendations are effective: the key is individualization. Diabetes Metab Syndr Obes 7: 65-72

13. Evert AB, Boucher JL, Cypress M, Dunbar SA, Franz MJ, et al. (2013) Nutrition therapy recommendations for the management of adults with diabetes. Diabetes Care 36(11): 3821-3842.

14. Sonestedt E, Lyssenko V, Ericson U, Gullberg B, Wirfalt E, et al. (2012) Genetic variation in the glucose-dependent insulinotropic polypeptide receptor modifies the association between carbohydrate and fat intake and risk of type 2 diabetes in the Malmo Diet and Cancer cohort. J Clin Endocrinol Metab 97(5): E810-E818.

15. Boles AN, Khan H, Lenzmeier TA, Molinar-Lopez VA, Ament JC, et al. (2016) Impact of Exercise and Education in Adults of Lubbock, Texas: Implications for Better Lifestyle. Front Aging Neurosci 8: 85.

16. King AJ (2012) The use of animal models in diabetes research. Br J Pharmacol 166(3): 877-894.

17. Laber S, Cox RD (2017) Mouse Models of Human GWAS Hits for Obesity and Diabetes in the Post Genomic Era: Time for Reevaluation. Front Endocrinol (Lausanne) 8: 11.

18. Bhatti JS, Bhatti GK, Reddy PH (2016) Mitochondrial Dysfunction and Oxidative Stress in Metabolic Disorders- A Step towards Mitochondria Based Therapeutic Strategies. Biochim Biophys Acta 16: 30292-30297.

19. Kim JH, Sen S, Avery CS, Simpson E, Chandler P, et al. (2001) Genetic analysis of a new mouse model for non-insulin-dependent diabetes. Genomics 74(3): 273-286.

20. Kim JH, Stewart TP, Soltani-Bejnood M, Wang L, Fortuna JM, et al. (2006) Phenotypic characterization of polygenic type 2 diabetes in TALLYHO/JngJ mice. J Endocrinol 191(2): 437-446.

21. Parkman JK, Mao X, Dillon K, Gudivada A, Moustaid-Moussa N, et al. (2016) Genotype-dependent Metabolic Responses to Semi-Purified High-Sucrose High-Fat Diets in the TALLYHO/Jng vs. C57BL/6 Mouse during the Development of Obesity and Type 2 Diabetes. Exp Clin Endocrinol Diabetes 124(10): 622-629.


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