

An overview of diabetes mellitus and work life

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ABSTRACT

Diabetes mellitus is one of the chronic diseases, diagnosed at younger ages. That period of life generally means active work life. The patients with DM can serve as productive members of the workforce. In some kind of work sectors, employers have to apply precautions specified for diabetic patients at the workplace. Also in Turkey, the results of TURDEP 2 study showed that 45.3% of people diagnosed with DM (3.4 million people) are between 40 and 59 years of age. Herein, effects of work life on diabetes mellitus, effects of diabetes mellitus on work life, precautions for employers, recommendations for workers were mentioned.

Key words: occupational exposures, diabetes mellitus, work life

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Introduction

Clinical diabetes (diabetes mellitus, DM) is a metabolic disorder caused by inappropriate hyperglycemia due to absolute lack of insulin secretion or a reduction in the biological activity of insulin (or both). Depending on the etiology, DM is classified as type 1 DM, type 2 DM, gestational DM and other special types. Destruction of beta cells in type 1 DM is formed by an autoimmune process in 95% of the cases and idiopathic beta cell destruction in less than 5% of cases. Type 1 diabetic patients are prone to ketoacidosis and require insulin replacement therapy. In the vast majority of the cases with type 2 DM, deficiency of compensatory insulin secretion is accompanied by peripheral insulin resistance [1]. Gestational DM is a variation of type 2 DM that is caused by hormonal changes in pregnancy and familial predisposition. Special types are caused by variant genetic factors at the cellular level.

Geographic diversity is clear on the incidence of type 1 and type 2 DM. Type 1 DM is more prevalent in the Nordic countries. The risk of type 2 DM is high in pacific islands and middle east, while moderate in India and the United States [2]. According

to the Turkey Diabetes, Hypertension, Obesity and Endocrine Diseases Prevalence (TURDEP) study, the number of patients with DM has reached to 7 million in 2013 from 2.5 million in 1998. DM is usually seen in active working aged people. Based on the results of TURDEP 2 study, in Turkey 45.3% of people diagnosed with DM (3.4 million people) are between 40 and 59 years of age [3-4].

Risk Factors of Diabetes Mellitus

The risk of insulin resistance and type 2 DM development increase by weight gain (especially central obesity), physical inactivity and high fat diet. If the parents have diabetes, risk of developing type 2 DM in those people rises to 50%, if only one family member (mother or father) has diabetes, the risk of type 2 DM is less than 20%. If one identical twin has type 2 DM, the risk of DM increases more than 90% on the other twin [5].

Diagnosis of Diabetes Mellitus

Blood glucose should be examined from blood serum after 8-hour fasting. At least two measurements

should be higher than 126 mg/dL for the diagnosis of DM. Additionally, oral glucose tolerance test (OGTT) 2nd hour plasma glucose (≥ 200 mg / dL), random plasma glucose (≥ 200 mg / dL + DM symptoms) and HbA1c ($\geq 6.5\%$) are other criteria for the diagnosis of DM [4].

Diabetes Mellitus Symptoms and Complications

Polyuria, polydipsia (glycosuria attached), orthostatic hypotension, dehydration, fatigue, mental status changes, polyphagia, weight loss, nausea, vomiting, decrease in vision and blurred vision are main symptoms of DM.

Diabetic retinopathy is a microvascular complication. Retinal capillary microaneurysms, macular edema and neovascularization can be seen. It is diagnosed with a retinal examination. Early diagnosis is important to prevent vision loss.

Diabetic nephropathy: is a microvascular complication. Glomerular basement membrane thickens and glomerular sclerosis occurs. Rapidly progressive hypertension and kidney failure develops. Microalbuminuria screening should be performed in 24 hour urine.

Diabetic neuropathy: Nerve damage caused by microvascular complication. Symmetric polyneuropathy and autonomic neuropathy are the most common types. Symmetric polyneuropathy is located in distal extremities which are expressed as "gloves and socks". The sensation of touch, vibration, and heat are decreased; paresthesia and dysesthesia occur in the patients. The risk of developing diabetic foot increases as a result of choosing inappropriate shoes, decreased feeling of pain, touch and warmth sensation. In the autonomic neuropathy, orthostatic hypotension, resting tachycardia, dysphagia, nausea and vomiting, constipation or diarrhea, urinary incontinence and erectile dysfunction may occur. Diabetics are also prone to carpal tunnel syndrome.

Macrovascular Diseases: There is an increased risk of angina pectoris, myocardial infarction, cerebrovascular disease and peripheral artery disease.

Infection: DM increases susceptibility to bacterial and fungal infections. Usually it causes mucocutaneous fungal infections (oral or vaginal candidiasis) and bacterial foot infections that may progress to osteomyelitis.

Other Complications: Apart from the complications mentioned above, cataract, optic neuropathy, adhesive capsulitis, sclerodactyly, nonalcoholic

fatty liver disease, tinea pedis, diabetic dermopathy, diabetic scleroderma, vitiligo, acanthosis nigricans, susceptibility to infections, depression and dementia are often seen in diabetic patients [6].

Prediabetes:

Prediabetes is a description indicating the increased relative risk of diabetes in the future that expressed as impaired fasting glucose and/or impaired OGTT. Prediabetes is defined as a factor that increases the cardiovascular risk. Based on American Diabetes Association (ADA) there are three criteria: fasting blood glucose 100-125 mg / dL, after 75 g OGTT 2nd hour glucose 140-199 mg / dL, and HbA1c is between 5.7-6.4%. Prediabetes is the presence of any of these conditions [7].

Workplace Factors and their effects on Diabetes

Physical Factors

Noise: Noise triggers stress. Presence of acute noise is a factor that affects psychological, metabolic and immunological functions. Noise is associated with the release of stress hormones due to the activation of sympathetic branch of the autonomic nervous system and hypothalamic-pituitary-adrenal axis system. Chronic elevation of stress hormones, especially cortisol, increases hypertonic and diabetogenic effects and leads to deterioration of adipose tissue metabolism. Besides hormonal effects noise leads to sleep disorders. Sleep disorders are also associated with diabetes [8]. In a meta-analysis, the association between DM and long-term noise exposure is reported from nine trials. As a result of this meta-analysis, environmental noise exposure on the development of type 2 DM is a significant risk (19-22%), but occupational noise is not associated with high risk of developing DM [9].

Extreme hot and cold: Body temperature less than 35°C or above 41°C, can be tolerated for a very short time by humans. Uncomplicated, insulin-dependent diabetes makes things difficult for patients who work outside the home at cold weather. Early development of peripheral arteriosclerosis refines these patients against cold and increases the risk of local frostbite. Heat cramps, heat stroke are more common in patients with additional diseases such as DM, obesity, malnutrition and dementia especially in the elderly [10].

Vibration: A study of the prevalence of Dupuytren's contracture and its correlation with factors that included 97537 miners was conducted by Burke

et al. Information about age, hand dominance, Dupuytren's contracture, vibration exposure, history of DM, smoking habits and weekly alcohol use were collected. No correlation was found between the development of Dupuytren's contracture and the duration of vibration exposure, but if the miner had diabetes mellitus, the risk increased significantly [11].

Chemical Factors: Heavy metals are known to affect human health adversely, particularly in less developed countries. The accumulation of heavy metals in the body and its chronic toxicity is induced by uncontrolled industrialization.

Zinc: It is an essential element in cell division and apoptosis. In experimental and clinical studies zinc deficiency has been associated with the development of diabetes [12-14].

Arsenic: Organic and inorganic forms of arsenic exist in environment. Many epidemiological studies prove that arsenic in the drinking water is associated with cancer, nervous system disorders, peripheral vascular disease (black foot disease) and endocrine dysfunction [15-17]. A limited number of studies revealed that arsenic impairs glucose metabolism and insulin secretion from beta cells in mammals [18-19]. Arsenic increases oxidative stress and influences Akt-related signal pathways via oxidative stress [20-21].

Cadmium: Long time exposure to cadmium results in kidney accumulation. Proximal tubule damage occurs and calcium reabsorption decreases [22-23]. As a result, long-term cadmium exposure leads to bone loss, causes itai-itai disease that is characterized by the combination of osteomalacia and osteoporosis [24-25].

In the epidemiological studies of refinery workers exposed to cadmium, it has been shown that workers' blood have high levels of blood glucose and low insulin levels [26]. Mechanism of this action of cadmium on insulin secretion process has not been clearly demonstrated [27]. However, cadmium associated cellular toxicity is defined as metalloenzymes interaction, protein thiol differentiation, energy metabolism inhibition, DNA and membrane structure/function decomposition and oxidative stress [28-30]. Furthermore, in many studies cadmium induced hyperglycemia is linked with increased lipid peroxidation, with decreased insulin secretion, the increase of glucogenic enzyme activation and with impaired insulin receptor [31-32]. Cadmium has been shown to induce dose-dependent reduction in GLUT-4 protein in mouse adipocytes and expression of m-RNA.

Additionally, cadmium impairs glucose tolerance in mice [33].

Mercury: Organic and inorganic mercury compounds trigger cellular damage in many cells such as renal cells, astrocytes, lymphocytes, fibroblast cells, human gingiva, alveolar epithelial cells and pancreatic beta cells [33-34]. Mercury affects islet beta cell function and survey by oxidative stress *in vivo* and *in vitro* [35-37].

Nickel: Nickel toxicity depends on the skin or oral exposure. In previous studies oral exposure of nickel was found to be toxic mostly to the kidney, lung, liver and heart [38-41]. Nickel toxicity causes many diseases such as pneumonitis, rhinitis, sinusitis, dermatitis, nasal cavity and lung cancer [42]. Nickel, while increasing hepatic glycosis, gluconeogenesis and pancreatic glucagon secretion, reduces peripheral glucose utilization; as a result it induces hyperglycemia [43].

Psychosocial Factors

Stress: It is known that psychosocial stress and work-related stress increase the risk of diabetes via the hypothalamic-pituitary-adrenal axis activation [44-45]. In a meta-analysis, Cosgrove and colleagues examined the relationship between work-related psychosocial stress and type 2 DM. In this study, no significant relationship was determined [46]. Increased heart rate and blood pressure enhance the risk of cardiovascular disease. Work-related physical inactivity and negative lifestyle conditions such as smoking trigger chronic diseases especially in women [47]. Stress leads to DM through physical inactivity and obesity [48-49]. In a case-control study, conducted by questionnaire method, 201 Type 2 DM and 201 control patients were questioned about their overall situation and occupational stress [50]. Occupational stress scores were higher in type 2 DM patients than the control group ($p < 0.01$). In this study, among the risk factors for type 2 DM are identified as alcohol use, family history of diabetes, waist circumference, high triglycerides level, the total score of occupational stress; on the other hand protective factors are identified as educational status and HDL level.

Other Factors

Shift work: The development of new diabetes has been more associated with shift workers [51-52]. Continuous shift work affects type 2 DM, insulin resistance, weight gain, sleep disorder, eating habits and stress level [53]. In a meta-analysis of 12 studies

Table 1. Adaptation precautions for workers with diabetes mellitus

Sufficient time to measure blood glucose level and eat snacks and also to have a proper room for resting
A safe place to relax during the hypoglycemic period until blood sugar levels recovered.
Food and diabetic supplies should be kept close
Provide adequate break to have diabetes treatment and provide proper training for diabetes management
Arranging regular work schedule instead of shifts
If difficulty in standing due to diabetic neuropathy, sitting on a chair during working should be provided
If there are changes in vision due to diabetes, wide-screen computer monitor should be useful

including 14595 type 2 diabetic patients, shift work and relation to DM ratio were higher in males than that of females. Shift work was determined as a risk for diabetes compared to that of daytime work [54].

Long-time work: In Japanese employees there was no significant association between diabetes and long-time work [55].

Diabetic Patients at Work Life

Precautions: The employer is required to provide the worker with DM in terms of adaptation precautions [56] as summarized in Table 1.

Health Surveillance

Pre-employment Medical Examination

Anamnesis: Patient's symptoms related to DM diagnosis are questioned. If there are previous laboratory findings, those should be examined by workplace physician. Eating habits and nutritional status, details of previous treatment program, current medications, exercise details, acute complication frequency, previous and current infections (diabetic foot, etc.), chronic complications, atherosclerosis risk factors (smoking, hypertension, obesity, dyslipidemia, family history), other endocrine diseases, smoking and alcohol use, drug addiction, reproductive life and family history should be questioned in detail.

Physical Examination: Height and weight measurements, waist circumference measurement, blood pressure, fundus examination, oral examination, thyroid palpation, cardiac examination, abdominal examination, pulse examination (palpation and auscultation), hand/finger examination (sclerodactyly and dupuytren's contracture), foot examination (in terms of diabetic foot), skin examination, neurological examination should be completed carefully.

Laboratory data: HbA1c, fasting lipid profile, microalbuminuria, serum creatinine, TSH, ECG monitoring should be conducted.

Periodic Medical Examinations

HbA1c, fasting lipid profile, microalbuminuria, serum creatinine, TSH, annual ECG monitoring, blood sugar level monitoring should be performed periodically [3]. Medical examination frequency should be based on patient's clinical status. Patients without complication should be checked annually. In medical examination foot examination is important for the development of diabetic foot. Dietary recommendations should be given.

Works not Recommended to Operate by Diabetic Patients

There are some limitations on selection of business area for insulin using diabetic patients. Frequent and severe hypoglycemia, especially in high-risk jobs put individuals and society at risk [56]. Works that should not be attempted include: military, air pilot, use of a vehicle carrying loads in excess of 7.5 tones, driving a bus carrying over 16 people, work on a ship, driving a train or working on the edge of a railway.

General Recommendations

Diabetes control can be achieved by making lifestyle and dietary modification. Incidence of developing type 2 diabetes is less in individuals with body mass index lower than 25 kg/m², consuming a diet with high fiber, unsaturated fatty and low glycemic index, in people who exercise regularly, avoiding smoking and alcohol drinking [57].

Long-term mortality has been shown to be 50-60% lower in those who do heavy aerobic exercise

compared to the patients that do less exercise [58]. Glycemic index should be considered in the food consumption. This definition is based on the rate of carbohydrate digestion and absorption. Type 2 diabetics should eat low glycemic index foods. Sweeteners such as saccharin, aspartame, cyclamate may be suitable for diabetic patients. High protein diet is not suitable; in some cases it may trigger early diabetic nephropathy [59]. In particular, heavy labor workers' calorie requirement for a half day period should be planned as main and snack menu. If possible this menu should be planned as four cups [60].

Sites for injecting insulin should be taught to patients by nurses. Patients should regularly monitor their blood sugar and use their drugs properly. Side effects of drugs and disease complications should be explained. Hepatitis B vaccine should be applied. Influenza vaccine should be recommended annually. Pneumococcal vaccine should be given above 65 years. In nephrotic syndrome or chronic renal failure, patient could need repetitive vaccination [61-63].

Conclusion

DM is a widespread disease in our century and the age of diabetic patients covers work life's period. DM can cause complication, disability itself but on the other hand individual with DM can be more susceptible to temperature alterations, toxic exposure, stress at workplace. The patients with DM can serve as productive members of the workforce. In some kind of work sectors, employers have to apply precautions specified for diabetic patients at the workplace. The therapies for, and effects of, diabetes differ notably from person to person, so employers must regard each person's capacities and needs on an individual basis. People with diabetes should always be examined with the assistance of experienced diabetes health care professionals. The requirements of the specific job and the individual's ability to perform that job, with or without reasonable accommodations, always need to be considered.

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