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REVIEW

Diabetes and work: The need of a close collaboration between diabetologist and occupational physician☆

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Abstract *Aim:* The Italian Society of Occupational Medicine (SIML), the Italian Diabetes Society (SID) and the Association of Diabetologists (AMD) joined a working group that produced a consensus paper aimed to assess the available evidence regarding the interplay between specific working conditions, including shift- and night-time work, working activities at high risk of accidents and work at heights, working tasks requiring high-energy expenditure, working activities at extreme temperatures and diabetes.
Data synthesis: Diabetes is a group of metabolic disorders caused by defects in insulin secretion and/or action affecting millions of people worldwide, many of whom are or wish to be active members of the workforce. Although diabetes, generally, does not prevent a person from properly performing his/her working tasks, disease complications can significantly compromise a person's ability to work. Therefore, it appears evident the need to understand the relationship between occupational risk factors and diabetes. The working group included in the document some practical recommendations useful to ensure diabetic workers the possibility to safely and effectively undertake their jobs and to adequately manage and treat their disease, also in the workplace. In this perspective concerted action of all the workplace preventive figures, occupational physicians and diabetologists should be strongly encouraged.
Conclusions: Further studies are necessary to define workplace-based interventions, which should be minimally invasive towards the work organization, allowing diabetic workers to fully realize their work skills while improving their wellbeing at work.

☆ Consensus paper on diabetes and work from the working group of the Italian Society of Occupational Medicine (SIML), the Italian Diabetes Society (SID) and the Association of Diabetologists (AMD)

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Introduction

Diabetes is a group of metabolic disorders characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1]. The consequent chronic hyperglycemia causes dysfunction, and failure of various organs, including nephropathy, retinopathy, peripheral and/or autonomic neuropathy as well as sexual dysfunction [1–3]. The American Diabetes Association (ADA) classifies diabetes in type 1 caused by a cellular-mediated autoimmune destruction of the pancreatic β-cells and consequent absolute insulin deficiency [1] and type 2 diabetes, characterized by an insulin resistance, commonly associated with a relative insulin deficiency [1].

Recently, the World Health Organization estimated that 422 million adults aged over 18 years were living with diabetes [3,4]. Although diabetes prevalence is highest in the age group 65–79 years, International Diabetes Federation (IDF) estimates that there are 326.5 million people of working age (20–64 years) with diabetes, and 122.8 million people 65–99 years with diabetes with a number of people of working age with diabetes expecting to increase to 438.2 million by 2040 [5,6]. Similar figures are reported in Italy, where it is estimated that 3.2 million people had diabetes in 2016 and those below 65 of age were above 1 million (32% of the diabetic population) [7].

These prevalence estimates make evident the huge economic impact of this pathological condition and its dramatic psychophysical, financial and social burden for patients, care-giving families and communities. Therefore, a careful assessment of the relation between working conditions and diabetes is urgently required. In this regard, the occupational physician (OP), through the health surveillance medical examinations, and the evaluation of the fitness of workers for specific tasks, may play a key role in ensuring a satisfactory fit between person and job [8–10].

In this context, the aim of this consensus paper from a working group of the Italian Society of Occupational Medicine (SIML), Italian Diabetes Society (SID) and Association of Diabetologists (AMD) is to review the available evidence regarding the interrelations between some working conditions that may raise health and safety concerns for diabetic workers and diabetes. The information presented, recommending possible strategies to adequately manage and treat this disease in workplaces and, at the same time, providing practical guidance and suggestions to address adequately the issue of fitness for work, could be very helpful for both diabetic workers, OPs and diabetologists. Indeed, these indications should be able to significantly improve the well-being of diabetic workers and their ability to work, thus realizing in practice the position of the ADA on this topic, that is "*Any person with diabetes, whether insulin (treated) or non–insulin (treated), should be eligible for any employment for which he/she is otherwise qualified.*" [11].

Methods

We searched the PubMed database for studies addressing the relationship between diabetes and work limiting to studies published in English language from January 2000 to December 2017. The literature search strategy has foreseen the use of different key terms such as "diabetes mellitus", "workplaces", "shiftwork", "work at heights", "high-energy expenditure" and "extreme temperatures" in order to define the context and the outcome of the research. These were put together with the operator "AND". The authors independently examined all titles and abstracts retrieved and selected articles of interest. All studies that focused on individuals with diabetes in the workforce aged 18 years or over were included. Of the 369 manuscripts retrieved, after the removal of duplicates, 35 were considered relevant with the aim of this manuscript.

Shiftwork and night-time work

Shiftwork involves working outside the normal daylight hours (7/8 am–5/6 pm) [12–15]. In this regard, the International Labour Office (ILO) defined the shiftwork as "*a method of organization of working time in which workers succeed one another at the workplace so that the establishment can operate longer than the hours of work of individual workers.*" [13].

Current literature offers few studies regarding Type 1 and Type 2 diabetic shift workers [16–19]. Difficulty in reaching an optimal glucose control have been reported in Type 1 diabetics who work nights and shifts because of the irregularities in mealtimes and insulin therapy [16–18]. Some studies have also found a worsening in glucose tolerance, because of an increased insulin resistance during the night, with a prevalence of Type 2 diabetes twice as high in those with rotating night shifts [18,19]. At present, there are no clear guidelines regarding the employment of diabetic patients in shift-works. The ADA [11] takes a non-discriminatory approach if the diabetic worker is highly motivated to perform his job to the best of his ability and if the working environment can provide personnel trained to recognize the hypoglycemic condition (Fig. 1) [20]. Therefore, there are no absolute restrictions for Type 1 and Type 2 diabetics in doing shift and night work.

However, special attention must be paid to evaluate subject's motivation, his ability to manage hypoglycemic episodes, other co-existing risk factors and opportunities to have regularly scheduled meals and therapy. A society that works 24 h a day demands that modern medicine finds solutions so that diabetic workers can maintain healthy/normal glucose levels despite shift work. OPs provide valid support to worker in managing his disease and/or organizing the work itself around the characteristics of his pathology. The exclusion of the diabetic insulin-treated worker from both the daily and night shift as an absolute criterion should not be considered if the subject is highly motivated and presents a high degree of adherence to pharmacological and dietary therapy (Fig. 1). Indeed, it was observed that Type 2 insulin-treated diabetic subjects often did not achieve an optimal glycemic control during night-time shifts due to irregularities in taking insulin therapy and meals [16].

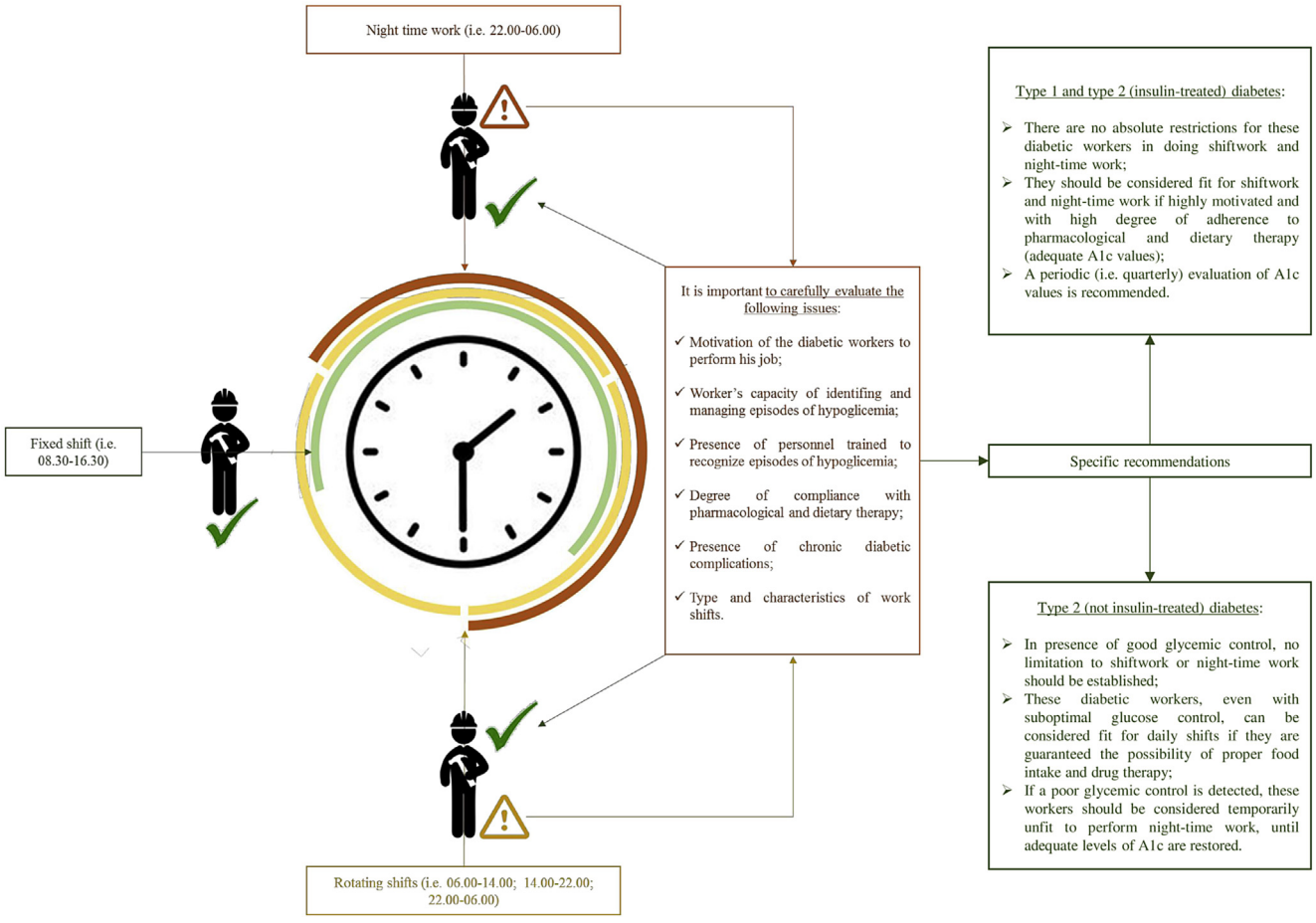

Figure 1 Relationship between diabetic worker and work shifts: key elements for a correct evaluation and specific recommendations.

For Type 2 diabetic subjects not insulin-treated, with good glycemic control, no limitation to shift or night-time work can be posed, if the work activities are carried out allowing a regular therapy and nutrition intake. However, a Type 2 diabetic not insulin-treated worker with a poor glycemic control should be advised not to do night shifts until adequate levels of Glycated Hemoglobin A1c are achieved. In this scenario, a prompt communication on patient's glucose control improvement from the diabetologist to the OP is crucial. Type 2 diabetic subjects, even with suboptimal glucose control, can perform daily shifts if the possibility of a proper therapy and feeding intake is guaranteed (Fig. 1). In this regard, some studies have recently reported abnormal metabolic function or obesity, hypertriglyceridemia and hypercholesterolemia (with low HDL cholesterol) and metabolic syndrome in subjects performing night-time work [11,21–25]. This highlights the relevance to assess work environment and occupational related risks as possible pathogenetic factors in the development of metabolic syndromes related abnormalities and cardiovascular complications.

Work at heights

These activities concern workers mainly involved in house building and constructing activities, which contemplate working at heights. There is no universally recognized definition of work at height. The European commission defined "work at height" as "*all works where there is a risk that a fall could cause personal injury*" [26]. The risk of a fall depends on several factors as inclination of the work level, characteristics of the border between the higher and the lower level [27]. These working activities should be contraindicated for subjects with poorly controlled diabetes or with frequent episodes of hypoglycemia (Fig. 2). This last condition is common in insulin-treated subjects or with drug-inducing hypoglycemia (such as metiglinides or sulfonylureas). The mean to define such situations is the health surveillance. Indeed, working at heights requires the capacity of moving in safety in difficult situations, the cognitive abilities of judgment and behavior useful to cope with the different situations, the absence of equilibrium problems, a good functionality of the sensitive apparatus, no contraindications regarding the use of individual appliances to protect the worker from fall [28].

Work with high-energy expenditure

The energy expenditure of physical activity is expressed in metabolic equivalent of task (1 MET = oxygen requirements at rest: 3.5 ml/kg/min.). Tasks with energy cost superior to 6 MET are at high-energy expenditure.

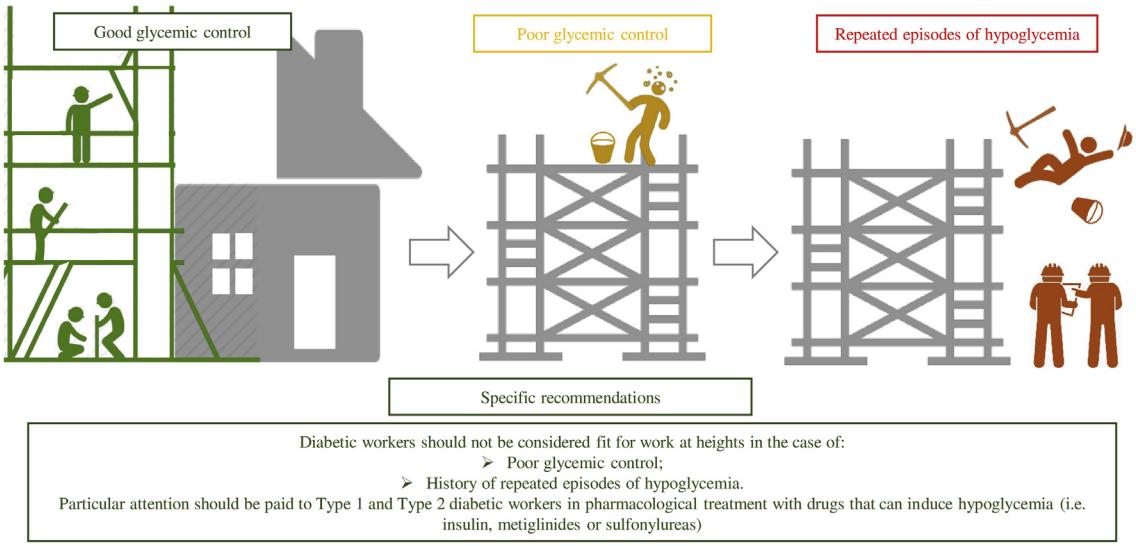

Figure 2 Relationship between diabetic worker and work at heights: specific recommendations.

Agricultural work, heavy weight transporting, skin-divers, firemen, deforestation activities are among this type of work [29,30] (Fig. 3). For insulin treated diabetics these activities can lead to a serious risk because of profound changes in glucose homeostasis. Indeed, glucose availability for energy requirements, necessary for working is connected to timing and to insulin doses. A demanding physical activity carried out shortly after insulin injection can determine a serious risk of hypoglycemia consequently to hyperinsulinemia that stimulates absorption and consumption of glucose by the peripheral tissues [31]. On the contrary, hypoinsulinemia, because of non-inhibition of the hepatic neo-gluconeogenesis and the poor consumption of glucose by the tissues during physical exercise, causes marked hyperglycemia. In these workers therapeutic education plays a key role. Indeed, coupling a structured therapeutic education to pharmacological treatment ensures a better management of the disease thus allowing the diabetic worker to achieve a better glycemic control.

In not insulin treated diabetics, without vascular complications and with an active life-style, activities that imply a high-energy expenditure are not contraindicated (Fig. 3). However, hypoglycemia risk has to be taken into account if the diabetic subject is treated with sulphonylureas or glinides. Moreover, the condition of an overweight subject who practices very little physical activity, with a reduced cardiovascular performance or other cardiovascular complications or risk factors, must be carefully assessed because of an increased risk of ischemic heart disease and mortality [32].

Working in extreme temperatures

Working in extremely high or low temperatures can be a risk for the worker's health due to the experience of heat or cold stress [33–36]. Regarding low temperatures, insulin treated diabetic subjects are at greater risk to develop hypothermia because of the possible occurrence of hypoglycemia and ketoacidosis. Furthermore, hypothermia reduces the endogenous insulin secretion, causes endogenous insulin resistance and reduces glucose and other energy substrates utilization. Consequently, control of glycaemia values becomes difficult in low temperatures and the risk of worsening metabolic control may increase (Fig. 4). Moreover, another aspect to be considered is the difficulty that insulin-treated diabetic workers may encounter in making the necessary capillary glycemic measurements, which may be less accurate in low temperatures [37]. Unfortunately, few epidemiologic studies addressed the effects of exposure to low temperatures on diabetic workers [38].

High temperatures can be at risk to diabetic workers because of alteration of the endothelial flow. This condition causes alteration of the thermoregulatory mechanisms with consequent reduction of heat wasting and therefore with an elevated risk of developing pathologies related to high temperatures. Such a condition should be avoided in any diabetic subject allowing him to assume adequate quantities of water and electrolytes and to monitor constantly the levels of glycaemia (Fig. 4) [33,35]. More detailed medical evaluation may be deemed appropriate on a case-by-case basis by the responsible healthcare professional and in this context communication between the diabetologist and the OP may be suitable.

Discussion

Usually diabetes does not adversely affect the working ability or capacity, but in some specific and particular cases, the management of diabetic workers is a challenging issue which necessarily requires in-depth individual evaluations and the adoption of special and "reasonable accommodations" [39]. This particular

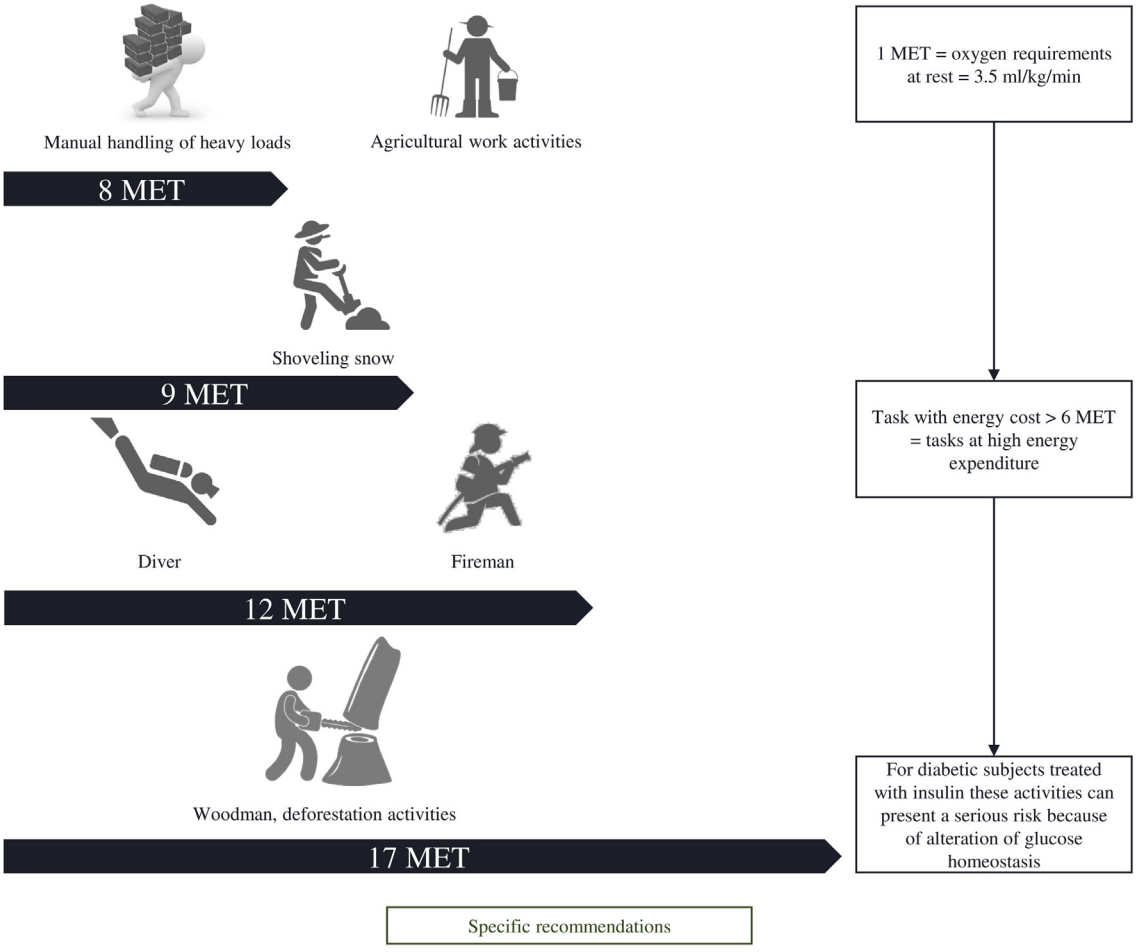

Figure 3 Examples of working activities at high-energy expenditure: specific recommendations.

attention towards the diabetic worker should not be interpreted as a limitation, but rather as an opportunity to guarantee the possibility to undertake safely and effectively the job that he has been selected to perform and, on the other hand, to allow him also a full social and economic realization of his life. To achieve these objectives, it is necessary to carry out an adequate evaluation of the relationship between the characteristics of a specific job and the individual's medical condition. This assessment should take into account any health issues (such as recurrent episodes of hypoglycemia eventually associated with loss of consciousness and seizure) and/or diabetes complications that might be an obstacle to the proper and secure performance of working tasks.

In this context, the greatest challenge for the diabetic worker is to maintain euglycemic blood glucose levels regardless of the working tasks performed. Indeed, obtaining a good glycemic control requires a delicate balancing act that is based on different and concomitant intervention strategies (i.e. diet, therapeutic education, pharmacological treatment). In this regard, it should be noted that, avoiding too high blood glucose levels, especially by administering insulin or oral agents such as sulfonylureas, unavoidably increases risk of hypoglycemia. On the other hand, hypoglycemia is a major limiting factor toward achieving good glycemic control both in Type 1 and Type 2 diabetic subjects [40]. Recurrent hypoglycemia reduces symptomatic and hormone responses to subsequent hypoglycemia, leading to impaired awareness of hypoglycemia (IAH). IAH occurs in up to one-third of adults with type 1 diabetes [41], increasing their risk of severe hypoglycemia sixfold and contributing to substantial morbidity, with clear implications for employment [42].

The occurrence of multiple episodes of hypoglycemia can represent a serious problem for the health and safety

Figure 4 Relationship between diabetic worker and working activities in extreme temperatures: specific recommendations.

of both the diabetic worker and his colleagues. For example, as evaluated above, working at heights could be contraindicated since an episode of hypoglycemia, leading to disorientation or in the worst-case scenario to loss of consciousness, could result in the occurrence of extremely serious accidents [28]. Nevertheless, the OP should not exclude *a priori* a diabetic worker from carrying out these jobs, or at least he should not do so without first having carried out a careful individual and multidisciplinary assessment of the individual's health status by asking the advice of the diabetologists. Indeed, the application of any limitations should be limited to the diabetic workers who fail to achieve a good glycemic control.

Often, an improvement in the control of glycemic levels can be simply achieved by providing diabetic workers with particular workplace accommodations thus avoiding, or however significantly reducing, the need to apply limitations or to exclude them from a specific job [11]. These special accommodations should be aimed at guaranteeing to diabetic workers the possibility to manage, even in the workplace, their own disease, while minimizing the impact on the workplace, not affecting the work organization and not involving additional economic costs for the company. Appropriate examples of reasonable accommodations consist in providing all the work breaks that workers need to adequately monitor their blood glucose levels and/or to administer insulin as well as the possibility to eat food or drink beverages at their work station when they experience some episodes of hypoglycemia or hyperglycemia [11].

Hypoglycemia risk has to be taken into account also if diabetic subject is treated with sulphonylureas or glinides. In this regard, in subjects with Type 2 diabetes, the availability of several new class of drugs (DPP4 inhibitors, GLP1 receptor agonists and SGLT2 inhibitors) that may be added to metformin and/or pioglitazone could help to achieve a good glycemic control without risk of hypoglycemia. When insulin treatment is required, the new long acting insulins (Degludec and Glargine U300) could reduce the risk of hypoglycemia [43]. In Type 1 diabetic patients with poor metabolic control and frequent episodes of hypoglycemia, use of technology in diabetes, either better warning systems through Continuous Glucose Monitoring (CGM) or through improved insulin delivery via Continuous Subcutaneous Insulin Infusion (CSII), can substantially reduce hypoglycemia rates without worsening glycemic control [44]. Moreover, since continuous structured diabetes self-management education has a favorable impact on improvement on glycemic control, it is evident that all diabetic workers should be referred to receive or reinforce specific education programs.

Regarding the possible occurrence of chronic diabetes-related complications, their management in terms of negative impact on the work capacity and/or ability must be based on a careful multidisciplinary evaluation. Therefore, in these cases, OP should collaborate with several

specialists, involving in the evaluation from time to time, cardiologists, nephrologists, ophthalmologists, neurologists, depending on the complication occurred in the diabetic worker [11]. Moreover, a close collaboration between OPs and diabetologists should be established regarding the therapeutic diabetic patient education since it is considered a central element of the management of diabetes being able to reduce the risks of complications and death.

Recently, the American College of Occupational and Environmental Medicine has pointed out that among the various expertises possessed by an OP there must be the ability to promote effectively health [8]. In this regard, the core of health promotion actions carried out by OP is the fight against smoking and alcohol consumption, or the promotion of a healthy diet and physical activity [45]. In the case of the diabetic worker, the health promotion conducted by the OP assumes even greater importance not only to improve his health conditions, but also to prevent new diabetes cases. Indeed, it is well acknowledged that being overweight or obese is strongly linked to diabetes [46,47]. Consequently, an adequate health promotion activity aimed at contrasting the obesity, by favoring and supporting a healthy diet and regular physical activity, could be of great help in managing the overall energy balance and counteracting increased blood glucose levels [4]. Healthy-eating messages placed in the company cafeterias or the offer of free or discounted vouchers for physical activity facilities, are excellent examples of practical health promotion interventions [48].

Conclusions

Diabetes usually has no impact on an individual's ability to do a particular job. However, in some cases the diabetic worker deserves special attention and a specific evaluation. This in-depth assessment represents the attempt to ensure that diabetic worker performs in total safety the work for which he is qualified. Characterizing and essential elements of this evaluation rely on individual and multidisciplinary analysis of the relationship between the characteristics of the specific job requirements and the individual's health status. The information collected and analyzed during this assessment should be able to define the best "reasonable accommodations" to make available to diabetic workers, in order to allow them to promote their skills and realize "diabetic-friendly" workplaces. In this consensus paper, we provided a first priority list of occupational risk factors and working activities in which the proposed evaluation should be adopted. Future studies will have to identify practical tools and operational strategies that should be able to improve and fully realize the work skills of the diabetic worker exposed to other occupational risk factors or performing different working activities (i.e. work-related stress or professional drivers).

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