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Diabetes and impaired glucose metabolism is associated with more cold-related cardiorespiratory symptoms

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ABSTRACT

Aims: Diabetes and impaired glucose metabolism cause metabolic, neural and circulatory disturbances that may predispose to adverse cooling and related symptoms during the cold season. This study assessed the prevalence of cold-related cardiorespiratory symptoms in the general population according to glycaemic status.

Methods: The study population consisted of 2436 men and 2708 women aged 45–74 years who participated in the National FINRISK cold sub-studies in 2002 and 2007. A questionnaire assessed cold-related symptoms (respiratory, cardiac, peripheral circulation). Glycaemic status was determined based on fasting blood glucose, oral glucose tolerance tests or reported diagnosis of diabetes and categorized into normal glucose metabolism, impaired fasting blood glucose, impaired glucose tolerance, screening-detected type 2 diabetes and type 2 diabetes.

Results: Type 2 diabetes was associated with increased odds for cold-related dyspnoea [Adjusted OR 1.72 (95% CI, 1.28–2.30)], chest pain [2.10 (1.32–3.34)] and respiratory symptoms [1.85 (1.44–2.38)] compared with normal glucose metabolism. Screened type 2 diabetes showed increased OR for cold-related dyspnoea [1.36 (1.04–1.77)], cough [1.41 (1.06–1.87)] and cardiac symptoms [1.51 (1.04–2.20)]. Worsening of glycaemic status was associated with increased odds for cold-related dyspnoea (from 1.16 in impaired fasting glucose to 1.72 in type 2 diabetes, $P = 0.000$), cough (1.02–1.27, $P = 0.032$), chest pain (1.28–2.10, $P = 0.006$), arrhythmias (0.87–1.74, $P = 0.020$), cardiac (1.11–1.99, $P = 0.000$), respiratory

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(1.14–1.84, $P = 0.000$) and all symptoms (1.05–1.66, $P = 0.003$).
Conclusions: Subjects with diabetes and pre-diabetes experience more cold-related cardiorespiratory symptoms and need instructions for proper protection from cold weather to reduce adverse health effects.

1. Introduction

People who live in the northern hemisphere are recurrently exposed to environmental cold while commuting, at work and during their leisure time [1]. Various cold-related symptoms are common in the general population [2] and are elicited by physiological reactions due to environmental cold exposure [3]. Our previous reports show that cardiovascular and respiratory symptoms are reported manifold during wintertime in persons with a cardiovascular or respiratory disease [4,5]. Cold-related symptoms may predict the worsening of a chronic condition or be an indicator of an undiagnosed disease. At worst, symptoms may explain an increased risk of adverse health events and the globally detected higher wintertime morbidity and mortality [6,7].

In 2014, the global prevalence of diabetes mellitus among adults was estimated at 9% [8]. Furthermore, diabetes alone is estimated to account for 15% of deaths related to cardiovascular diseases [9]. Type 2 diabetes (T2D) accounts for around 90% of all cases of diabetes observed worldwide [10]. It often remains undetected, and screening detected cases may account for 30–60% of all cases of type 2 diabetes [11]. A considerable amount of people have prediabetes with a glycaemic state between normal and diabetic, and it is estimated that up to 70% of these may acquire the disease during their lifetime [12]. In Finland, the prevalence of persons with impaired glucose metabolism, which includes type 2 diabetes and prediabetic metabolic disturbances, such as impaired fasting glucose and impaired glucose tolerance, was as high as 42.0% in men and 33.4% in women in the age group of 45–74 years [11].

One may entertain that cold-related symptoms would be particularly common among people with pre-diabetic metabolic conditions or diabetes because the physiological responses to cold may aggravate the course of the underlying metabolic disturbance. A recent review indicates that diabetes is associated with reduced ability to maintain body temperature during thermal stress (heat, cold) [13]. Impaired functioning of the autonomic nervous system among those with prediabetes and diabetes [14,15] may lead to increased vasoconstriction and elevated blood pressure and mismatch of myocardial oxygen demand and supply, thus eliciting cardiac symptoms. Decreased arterial compliance [16], altered vasomotor control and blood flow to the extremities could result in either enhanced or blunted peripheral circulatory responses [17–19] and associated symptoms in the cold. In addition, peripheral neuropathy [20] can alter both sensory function and the ability to regulate heat loss in the extremities. Decreased insulin sensitivity associated with prediabetes and diabetes may blunt heat production through brown adipose tissue in the cold [21]. Depending on disease progression, the altered neural, metabolic and circulatory disturbances mentioned above may affect thermal, cardiovascular and respiratory responses in a cold environment and lead to various symptoms.

To our knowledge, no population-based information exists on the prevalence of cold-related cardiovascular or respiratory symptoms among persons having diabetes or impaired glucose metabolism. This information may prove useful for predicting and preventing cold-related health outcomes, but may also provide a tool for detecting individuals with impaired glucose metabolism. Our hypotheses were that (1) pre-diabetes and/or diabetes are associated with increased reporting of cold-related symptoms and (2) the prevalence of symptoms increases with worsening of glycaemic status. To test these hypotheses, we compared the prevalence of cold-related symptoms among individuals stratified by glycaemic status in a large population-based representative sample in Finland.

2. Methods

Finland is a subarctic country locating between 60 and 70°N Lat (Fig. S1) in the coastal zone of the Eurasian continent. The climate is partly maritime, partly continental. Winter (daily temperature less than 0 °C) is the longest season in Finland, lasting about approximately 100 days in the southwestern Finland and 200 days in the north (Finnish Meteorological Institute, Climate service).

2.1. *Study population*

The material for the present research is derived from the National FINRISK Study which is a large Finnish population survey on risk factors on chronic, noncommunicable diseases which has been carried out since 1972 every five years using independent, random and representative population samples from different parts of Finland. The data from the present study was collected in 2002 and 2007. The information from the sub-studies related to cold exposure, cold-related symptoms and complaints, health and performance were linked with relevant parameters from the main questionnaire inquiring about the respondent's socioeconomic background factors, health behavior and health, as well as to the clinical measurements and glucose tolerance tests.

Data collection was carried out from January to April in six areas in Finland using random sampling stratified by sex and 10-year age groups. The study areas were (1) the county of North Karelia, (2) the county of North Savo, (3) the cities of Turku and Loimaa and the 11 surrounding municipalities, (4) the cities of Helsinki and Vantaa, (5) the province of Oulu