Cardiometabolic-Based Chronic Disease in Czechia

Subjects: Health Care Sciences & Services

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Unlike the traditional adiposity and dysglycemia classifiers, which do not capture the complexity of cardiometabolic pathophysiology, the Cardiometabolic-Based Chronic Disease (CMBCD) model was proposed to incorporate the natural history of the cardiometabolic disease in four stages: 1—risk; 2—pre-disease; 3—diseases; and 4—complications. The CMBCD model combines the dysglycemia and abnormal adiposity drivers into the chronic care model as DBCD and ABCD, with the presence of earlier primary drivers (genetics, environment, and behavior) and later metabolic drivers (hypertension and dyslipidemia) impacting the eventual cardiovascular disease phenotype. The CMBCD model triggers proactive detection and stratification of subjects at risk using a culturally adapted approach to improve successful implementation and precision.

adiposity cardiometabolic risk cardiovascular disease chronic disease dysglycemia

insulin resistance nutrition obesity type 2 diabetes

1. Introduction

In contrast to the decreasing burden and mortality related to cardiovascular disease (CVD) and certain related CVD risk factors, such as hypertension, dyslipidemia, and tobacco use, the prevalence of dysglycemia and abnormal adiposity are increasing in Czechia. From 1990 to 2019, the number of disability-adjusted life years (DALYs) increased by 18.6% for dysglycemia and by 10.4% for body mass index (BMI) > 23.0 kg/m [1][2]. In 2020, epidemiological data affirmed that both dysglycemia and abnormal adiposity increased the risk of severe COVID-19 [2], highlighting the need for urgent implementation of cardiometabolic risk mitigation strategies [3]. On a global scale, there is an array of both biological and cultural/social determinants of disease that interact and drive cardiometabolic-based chronic disease (CMBCD).

This review evaluates the key drivers for dysglycemia and abnormal adiposity in Czechia based on the epidemiology of various biological and cultural/social determinants of health. Particular variables of interest include demographic characteristics, modifiable cardiometabolic risk factors (dysglycemia, abnormal adiposity, hypertension, dyslipidemia, healthy eating, physical activity, and tobacco use), and ethnocultural and social-economic risk factors (healthcare infrastructure, health literacy, disparities in access to quality healthcare, housing/income/educational levels, and mental health). By analyzing the results of a formal literature searching protocol on cardiometabolic drivers in Czechia, discrepancies, emergent relationships, and essential elements of an effective preventive care plan can be identified. Furthermore, this methodology can be replicated for other

regions of the world to expose epidemiological differences that warrant refinements and adaptations to current prevention and treatment strategies.

2. Current Analysis on Research Results

A total of 7255 articles were retrieved from the databases, and 1809 duplicates were excluded. Thus, 332 articles were subjected to a full-text review: we excluded 23 studies analyzing the data from the same epidemiological studies, and another 131 studies were not aligned with the purpose of the review. Finally, 38 studies were included in our narrative review (10 on biological risk factors, 11 on cardiometabolic risk factors, 11 on behavioral risk factors, 3 on environmental risk factors, and 3 on mental health). Additionally, a hand search using references in identified articles was performed.

Czechia is a unitary state with representative democracy, a parliamentary republic, and decentralized administration with 14 regions and over 6000 municipalities [4]. The main industries include engineering, food processing, chemical, and metallurgy [4]. The Czechian population is linguistically homogenous; the official language is Czech [4]. About 94% of adults aged 25–64 years have at least upper secondary education [4].

Czechia is denominationally neutral (no official religion) and freedom of religion is granted [4]. In 2019, there were 41 churches and religious societies, the largest being the Roman Catholic Church, Czech Brethren Evangelic Church, and the Czechoslovak Hussite Church [5]. Life expectancy at birth (years) increased from 67.5 in men and 73.3 in women in 1960 to 76.2 in men and 82.1 in women in 2018. These descriptors of the Czechian population provide context for interpretation of the following results.

Biological characteristics (genetic predisposition) are a powerful driver for the presence of dysglycemia and abnormal adiposity across diverse populations. A summary of important biological determinants for dysglycemia and abnormal adiposity in the Czech population is presented in **Table 1**.

Table 1. Important biological factors for cardiometabolic risk *.

Biological Factors	References
• The FTO rs9939609 variant was associated with obesity	[6] [7] [8] [9] [10][11]
• FTO rs17817449 SNP was related to BMI in males and postmenopausal females	
• *FTO* rs17817449 SNP was associated with the susceptibility to T2D and development of T2D complications	[6] [6] [6] [12]
• The effect of the FTO rs17817449 variant on BMI is mediated through the effect on the basal metabolic rate, and its effect is more pronounced in women	[13] [14] [6][15]

Biological Factors	References
• FTO and MC4R gene variants enhance the impact of an intensive lifestyle intervention on BMI decrease in overweight/obese children; this association was not confirmed in overweight females • The TMEM18 rs7561317 was associated with underweight • BDNF rs925946 and MC4R rs17782313 were associated with metabolic syndrome • PCSK1 rs6235 was negatively related to increased blood glucose • INSIG2 polymorphism has no significant effect on BMI and plasma lipids • PPARα and PPARγ2 polymorphisms have no significant effect on anthropometric, biochemical, hormonal, and psychobehavioral characteristics of the subjects • NYD-SP18 rs6971019 SNP is related to BMI in males; variants within NYD-SP18 and FTO genes revealed a significant additive effect on BMI values in males • Prevalence of MC4R homozygous and heterozygous mutations among Czech obese children is 2.4%, and it is not associated with different responses to diet management	

* This is a partial list of research conducted on Czech populations regarding biological determinants of cardiometabolic risk. Abbreviations: ABCD—adiposity-based chronic disease, BDNF—brain-derived neurotrophic factor, BMI—body mass index, DBCD—dysglycemia-based chronic disease, FTO—fat mass and obesity-associated, INSIG2—insulin-induced gene 2, MC4R—melanocortin 4 receptor, NYD-SP18—testis development protein, PCSK1—proprotein convertase subtilisin/kexin Type 1, PPARs—peroxisome proliferator-activated receptors, SNP—single-nucleotide polymorphisms, TMEM18—transmembrane protein 18, T2D—type 2 diabetes.

Cardiovascular disease mortality decreased in Czechia from 1989 to 2019, and this downward trend can be attributed to a decreasing prevalence of certain CMBCD risk factors [16] Among the major risk factors with a declining rate are the prevalence of tobacco use in men (from 45% in 1989 to 23.9% in 2016), hypertension in women (from 42.5% in 1989 to 33.5% in 2016), and dyslipidemia in both sexes (men: from 87.7% in 1989 to 74.8% in 2016; women: from 87.5% in 1989 to 69.9% in 2016). The use of lipid-lowering medications increased more than two-fold in both sexes and reached 14.6% in men and 10.0% in women in 2016 (with statins comprising 78.8% of all the prescribed lipid-lowering drugs). The number of individuals treated by antihypertensive drugs has increased in both genders, and the rate of hypertension control improved from 3.9% in 1985 to 32.9% in 2017 [16].

The prevalence of obesity in men has shown an increasing trend over the past 30 years (from 19.7% in 1985 to 37.7% in 2016) [16], while in women, there was no change (28.0% in 1985 to 27.6% in 2016) [16] (**Table 2**). The

prevalence of diabetes has shown an increasing trend in both sexes from 6.9% and 5.4% in 1985 [16] to 11.5 % and 8.3 % in 2014 [6] in men and women, respectively.

Table 2. Studies of prevalence of cardiometabolic risk factors in adults of Czechia.

Authors	Year of Publication (Data Collection Years)	Location	Participants (N)	Current Smoking (%)	Obesity (%)	Overweight (%)	Diabetes (%)	Prediabetes (%)	Hypertension (%)	Dyslipidemia (%)	Physical Inactivity (%)
Cifkova R et al. [17]	2020 (2016/2017)	Post-Monica National	1684 (25–64 y.o.)	M: 23.9 F: 20.9	M: 37.7 F: 27.6				M: 50.6 F: 33.5	M: 74.8 * F: 69.9 *	
Brož J. et al. [18]	2020 (2014)	EHES National	1189 (25–64 y.o.)	T: 29.5	T: 27.5	T: 36.4	T: 9.6 M: 11.5 F: 8.3	T: 27.8 M: 26.4 F: 28.7	T: 38.0	T: 62.0 ** T: 11.1 ***	
Movsisyan N et al. [19]	2017 (2013–2016)	Kardiovize population-based sample from Brno	2160 (25–64 y.o.)	T: 23.5 M: 25.3 F: 21.9	T: 19.0 M: 20.0 F: 18.1	T: 34.0 M: 43.0 F: 26.6	T: 5.1 M: 7.1 F: 3.5		T: 40.0 M: 46.0 F: 35.0	T: 68.8 ‖ M: 70.7 ‖ F: 67.1 ‖	T: 14.4 ¶ M: 16.8 ¶ F: 12.3 ¶
Čapková N et al. [20]	2017 (2014)	EHES National	1220 (25–64 y.o.)		M: 29.0 F: 25.0	M: 44.0 F: 30.0	M: 8.6 F: 5.7		M: 47.0 F: 26.0	M: 77.0 † F: 66.0 †	
Ministry of health report [21]	2014	National	-	T: 30.0	T: 17.0	T: 40.0	T: 7.0		M: 36 F: 31	M: 81.0 * F: 71.0 * Post Monica	T: 32.0 •
Cifkova R et al. [22]	2011 (2006–2009)	Post-Monica National	3612 (25–64 y.o.)	M: 31.9 F: 23.3	M: 32.4 F: 28.3	M: 44.4 F: 27.3	M: 9.4 F: 4.7		M: 47.8 F: 36.6	M: 81.0 ‡ F: 70.6 ‡	
Lustigova M et al. [23]	2018 (2002–2005)	HAPPIEE Havirov/Karvina, Hradec, Jihlava, Kromeriz, Liberec and Usti nad Labem	8499 (45–69 y.o.)	T: 26.0	T: 25.9		T: 11.8		T: 45.9		T: 55.5 ○
Zejglicová K et al. [24]	2006 (1998–2002)	HELENA random 400 men and 400 women in	14190 (quest) 3669	T: 38.8	T: 22.5 M: 24.1	T: 42.3			T: 41.4 M: 52.5 F: 32.9		T: 53.5 ○ M: 52.2 ○

Authors	Year of Publication (Data Collection Years)	Location	Participants (N)	Current Smoking (%)	Obesity (%)	Overweight (%)	Diabetes (%)	Prediabetes (%)	Hypertension (%)	Dyslipidemia (%)	Physical Inactivity (%)
		27 towns across Czechia	(exam) 45–64 y.o.		F: 21.2	M: 50.4 F: 36.1					F: 54.6 °
Cifkova R et al. [17]	2020 (1985)	Monica National	2570 (25–64 y.o.)	M: 45.0 F: 23.9	M: 19.7 F: 28.0		T: 6.1 M: 6.9 F: 5.4 [7]		M: 51.9 F: 42.5	M: 87.5 * F: 87.7 *	

* Dyslipidemia—total cholesterol ≥5.0 mmol/L; OR/AND (HDL-c < 1.0 mmol/L (men); HDL-c < 1.2 mmol/L (women)); OR/AND usage of lipid-lowering drugs. ** Dyslipidemia—total cholesterol ≥5 mmol/L OR/AND usage of lipid-lowering drugs. *** Dyslipidemia—HDL-c ≥ 1,2 mmol/L in men and ≥1mmol/L in women OR/AND usage of lipid-lowering drugs‖ Dyslipidemia—total cholesterol ≥ 5.0 mmol/L; OR/AND LDL-c ≥ 3 mmol/L; OR/AND triglycerides ≥1.7 mmol/L; OR/AND taking lipid-lowering drugs. † Dyslipidemia—total cholesterol >5.0 mmol/L; AND/OR HDL-c ≤ 1.2 mmol/L; AND/OR usage of lipid-lowering drugs. ‡ Dyslipidemia—total cholesterol ≥5.0 mmol/L; OR/AND (HDL-c < 1.0 mmol/L (men); HDL-c < 1.2 mmol/L (women)); OR/AND LDL-c ≥ 3.0 mmol/L; OR triglycerides ≥ 1.7 mmol/L; OR/AND usage of lipid-lowering drugs. ¶ Physical inactivity—achieved less than 600 MET-min/week. • Physical inactivity—achieved less than 150 min/week of moderate-intensity PA or/and 75 min/week vigorous-intensity PA. ∘ Physical inactivity—physical activity less than 3 h/week. Abbreviations: T—total; M—male; F—female.

Using a new chronic care model, the prevalence of ABCD [7] in the Czech population was 62.8% [8]. Only 2.3% of those were metabolically healthy (Stage 0 ABCD), 31.47% with mild adiposity-related complications (stage 1 ABCD) and 29.1% with moderate and severe adiposity-related complications (stage 2 ABCD). Total ABCD as well as all of the ABCD stages, except for stage 1, were more prevalent in men. Using another new chronic care model, type 2 diabetes (T2D) was interpreted as a dysglycemia-based chronic disease (DBCD) based on a spectrum ranging from insulin resistance (present in 54.2 % of the population) to prediabetes (in 10.3 % of the population), to T2D (in 3.7% of the population), and vascular disease (in 1.2% of the population)

The Eastern European and Czech eating patterns are characterized by high consumption of saturated fats, salt, and alcohol, with insufficient intake of fresh fruit, vegetables, whole grains, and fish [9]. Consumption of processed meat is a traditional part of the Eastern European diet [9]. Despite the relatively small population, in 2018, Czechia placed 14th place regarding the production of processed meat globally, with 14,000 tons produced annually [10]. Being male, having a low income, being physically inactive, and smoking tobacco was associated with a lower intake of fresh produce, legumes, whole grains, nuts, seeds, and milk [11].

Since 1989, there has been an increase in the consumption of healthy foods: pulses (from 1.3 to 2.8 kg/person/year), nuts (from 2.6 to 3.6 kg/person/year), vegetable oils (from 12.5 to 17.2 kg/person/year), vegetables (from 68.7 to 87.3 kg/person/year), and fruits (from 70.5 to 80.4 kg/person/year). On the other hand,

there was a reported decrease in the consumption of milk and dairy products (from 259.6 to 247.5 kg/person/year), meat (from 97.4 to 80.3 kg/person/year), lard (from 6.8 to 4.5 kg/person/year), butter (from 9.4 to 5.4 kg/person/year), refined sugar (from 39.8 to 34.1 kg/person/year), and salt (from 6.3 to 5.7 kg/person/year) [12].

Traditional Czech dishes are rich in red meat, potatoes, gravies, and root vegetables. (Czech version of meatloaf, made of minced pork and beef meat, bacon, onions, and garlic), and guláš (meat stew, usually served with bread dumplings or slices of dark bread). (lentils, served with boiled eggs and pickled cucumbers), and "ovocné knedlíky" (yeast/curd cheese/potato dough dumplings filled with seasonal fruits, sprinkled with sugar, grated curd cheese, and melted butter). Soups, including vegetable soups, broth, and legume soups, are also an important part of Czech cuisine.

According to the World Health Organization (WHO), consumption of pure alcohol in Czechia was 14.4 L per person per year, in 2016. This is 47% higher than the average amount in the WHO European region, and one of the highest globally [13]. On average, one Czechian inhabitant consumes 144 L of beer, 19 L of wine, and 7 L of distillates per year, with 6.1–9.5% consuming alcohol daily [14]. In a population-based, cross-sectional survey in Czechia [15] on alcohol consumption in the past 12 months, 28.2% of men and women did not drink alcohol; 45.6% consumed less than 7 or 14 standard drinks per week for women and men, respectively; and 26.2% had at least 7 or 14 standard drinks per week for women and men, respectively.

The prevalence of physically inactive adults (performing less than 150 min of moderate-intensity and less than 75 min of vigorous-intensity physical activity per week) in Czechia has increased from 31.4% in 2013 to 42.7% in 2017 [17]. The time spent sitting per day had also increased from 58% in 2005 to 62% in 2017 [18]. Age and sex inequalities are present in the physical activity patterns of the Czech population. Subjects older than 65 years and middle-age adults (40–64 years old) have a 4 and 1.7 times higher chance, respectively, to be physically inactive in comparison with young adults (18–39 years old) [19].

The most popular team sports in Czechia are football, floorball, ice hockey, volleyball, basketball, and kickball (an original Czech sport in which the players kick the ball over a low net). The most popular individual activity is walking, followed by jogging, running, cycling, hiking, inline and ice skating, and skiing [20]. Dog walking is also a frequent activity, as Czechia has the second-highest rate of dog ownership in Europe (38%) [21]. Local evidence suggests that dog owners display a better cardiovascular health profile than non-owners [22].

Health literacy reflects one's knowledge, motivation, and competency to access, understand, appraise, and apply health information to make judgments and decisions in everyday life [23][24]. Self-efficacy is the confidence in individuals' ability to perform certain tasks and attain determined goals; it is closely linked with health literacy and is associated with better cardiometabolic outcomes [25]. In 2014, in Czechia, the prevalence of low level of health literacy was 59% (below the European average 47.6%) [26], higher in subjects with older age (≥40) and with the level of education lower than university degree [26]. In diverse populations, a low level of health literacy is associated with increased risk of T2D [27], less knowledge about T2D [28], lower adherence to diabetes medications [29], and higher risk for T2D related-complications [30].

Compared with those with higher education, less-educated men and women showed 11 and 3 years of lower life expectancy, respectively [31]. Additionally, lower education levels have been associated with a higher presence of prediabetes and diabetes [6], as well as the presence of adiposity and dysglycemia-related complications, compared with those with higher educational levels [8][32].Income. There was a low level of disparity in access to quality healthcare and specialized health services among different income and education groups [31]. Nevertheless, in certain rural regions, especially Liberecký, Ustecký, Zlinský, and Středočěský, there was a lack of primary care clinicians [31][33].

A few studies, including small samples in Czechia, found that individuals with dysglycemia or abnormal adiposity experience more stress and depressive symptoms [34][35][36], anxiety [35], and lower quality of life [35]. Nevertheless, population-based studies evaluating these associations are lacking in Czechia.

The healthcare system in Czechia is based on obligatory participation of insured persons, with free-for-service healthcare funded by mandatory employment-related insurance plans since 1992 [37]. Health insurance fully covers preventive, diagnostic, ambulant and hospital care (excluding cosmetic surgeries without underlying health reasons), spa care, and patient transport. Insurance also fully or partially covers dental care, medicines, and medicinal aids [38]. If that total amount of supplementary payments paid for partially covered medicines exceeds CZK 5000 (EUR 197) per year, the health insurance is obliged to pay the exceeding amount back to the person [39].

In Czechia, general practitioners provide primary diabetes care for approximately 27.4% of patients with diabetes [40] and are the healthcare professionals who diagnose the disease most frequently [40][41]. A series of regular preventive healthcare checks is established and is covered by insurance [42]. Patients with poor metabolic control, presence of complications, or in need of multi-drug treatment, including insulin, are usually referred to a diabetologist, but overall care is still shared between a general practitioner and diabetologist [43]. Lifestyle and rehabilitation programs are provided by physicians, as well as physiotherapists and dietitians, with close collaboration.

For patients with diabetes, 25 centers of specialized care ("Centers of Diabetology") are available, offering initial consultations and ongoing care for patients with insulin pumps, severe diabetes complications, or organ failure caused by diabetes. The diabetes transplant program is provided by one of these centers [44]. The diabetes care system in Czechia also offers specialized centers of foot care (33 centers), education (41 centers), and psychological care (42 centers) for patients with diabetes [44]. In short, comprehensive diabetes care is generally covered by health insurance in Czechia [41][45][46].

According to a Czech cross-sectional study focusing on patients with T2D, results showed that 34.2% of patients achieved an HbA1c <7% (53 mmol/mol), regardless of treatment modality [47]. The diabetes control in subjects using insulin for the treatment study (DIAINFORM) showed that the frequency of acceptable metabolic control (HbA1c <7% (53 mmol/mol)) in patients with T2D treated with insulin was 37.1% [48].

In Czechia, obesity care is multidisciplinary, provided by general practitioners, physicians specializing in diabetology/endocrinology, dietitians, physiotherapists, and psychologists [49]. The level of care depends on the stages of adiposity-related complications. For patients with obesity, there are 19 specialized obesity clinics and 5 centers offering an individualized approach to prevent and treat obesity, and 8 centers are providing metabolic and bariatric surgery [50].

A summary of the most successful health-promoting projects implemented in Czechia is presented in **Table 3**. The large scale of those initiatives and the positive impact of the dysglycemia and abnormal adiposity drivers face many challenges, including lack of a scientific understanding of these drivers among diverse population groups, such as implementation, application of project management, use of organizational and procedural tools, and improving cooperation among stakeholders [51].

Table 3. Health promotion in Czechia *.

Project Title	Main Themes	Setting
Healthy aging project [52]	• Support of lifelong employment, learning, and social security of senior citizens • Improvement in health and social services for seniors • Awareness raising, anti-stigmatization, and anti-discrimination • Housing and residential social services	• Interdisciplinary cooperation, especially between health and social areas, including local governments, educational institutions, non-governmental organizations, and business. Cooperation with the National Network of Healthy Cities and reginal hygienic stations
Health Promoting School [53][54]	• Improving the assortment of food in vending machines, school canteens, and buffets according to dietary recommendations • Regular physical activity in school (providing place and time for physical activity every day)	• Kindergartens and primary schools

Project Title	Main Themes	Setting
	• Educating teachers about healthy nutrition and sport and incorporating this knowledge into the whole educational process • Full-time access to drinking water	
Healthy City [55]	• Increasing the number of parks and recreation zones in the city • Improving public transport • Improving the level of safety in the city • Improving the cleanliness of public spaces • Raising awareness about importance of sport and nutrition • Raising awareness about non-communicable diseases (diabetes, CVD, oncological diseases) • Tackling the obesogenic environment	• Over 2152 cities and towns with 5423 million inhabitants (52% of Czech citizens)
Healthy Workplace [56]	• Healthy and safe workplace conditions • Coping with stress	• Office and workspaces around the country

Project Title	Main Themes	Setting
	• Decreasing the amount of work-related injuries • Prevention of chronic musculoskeletal disorders and back pain • Decreasing the level of noise pollution	
Delicious life [57]	• Improving the knowledge of senior citizens about nutrition and motivation to achieve positive changes and be physical activity • Improvement in social participation	• Social care institutions
Educational program physical activity and nutrition [58]	• Improving the quality of physical education classes in schools • Adding physical activity breaks before and in between classes • Creating afterschool clubs of various physical activities • Providing all-day access to sugar-free drinks • Increasing the amount of information about healthy nutrition in the curriculum • Improving the quality and increasing the variety of food in school canteens	• Primary Schools

Project Title	Main Themes	Setting
	• Changing the assortment of the snacks in school vending machines in the direction of a healthier one	
The National Cycling Development Strategy of the Czech Republic for 2013–2020 [59]	• Ensuring the financing of a cycling infrastructure • Increasing the safety of bicycle traffic • Methodological support for the development of bicycle transport in cities and the "Cycling Academy" project	• Whole country

* This is a list of selected examples.

3. Conclusions

According to the findings of this literature search, an effective cardiometabolic preventive care program for Czechia needs to focus on shifting the traditional understanding and management of cardiometabolic factors towards a CMBCD complication-based model with particular attention given to the implementation of targeted interventions to avoid the progression of the cardiometabolic disease. In CMBCD stage 1, more attention should be given to primordial prevention with educational campaigns targeting unhealthy behaviors, incorporating community engagement, and reinforcing healthy eating habits; in stage 2, the implementation of primary prevention programs, e.g., the diabetes prevention program, promoting healthy dietary patterns, regular physical activity, and other lifestyle interventions should be transculturally adapted and scaled up; in stage 3, the emphasis remains on the secondary prevention as a necessary intervention to mitigate disease progression and development of complications; in stage 4, tertiary prevention strategies to prevent the advance of complications and mortality are implemented with the highest healthcare cost compared to lifestyle preventive strategies.

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