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Multifactorial influence of type 2 diabetes on cardiovascular risk assessed by PolSCORE, SCORE2 in the age group 40–69 years

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Abstract

Introduction and Objective. Cardiovascular risk (CV risk) is the probability of developing cardiovascular disease or dying from it within a specified period of time. One of the main factors increasing this risk is diabetes (DM). The aim of the study was to assess the effect of type 2 diabetes (T2DM) on CV risk based on the SCORE and SCORE2 scales, taking other factors into account.

Materials and Method. The study was conducted in a group of 1,540 people aged 40–89 years (226 people with diabetes –T2DM(+)). The following scales were used to assess CV risk: Pol-SCORE and SCORE2. Inclusion criterion was the absence of cardiovascular complications such as: myocardial infarction, overt coronary artery disease, previous stroke, renal failure or complications of T2DM.

Results. In the T2DM(+) group, high and very high CV risk was more frequently noted (Pol-SCORE: 26.1% and 34.5%; SCORE2: 24.3% and 42.5%) compared to T2DM(-). The regression model included an analysis of 10 factors determining CV risk. In estimating CV risk using the Pol-SCORE scale, 8 factors were most important (P=0.86), in the SCORE2 scale a total of 3 factors (TC – total cholesterol; LDL; TGs – triglyceride). In the T2DM(+) group, age(r=0.53) and TC(r=0.43) showed the strongest positive correlation with SCORE2, while for Pol-SCORE – age(r=0.05).

Conclusions. In the CV risk assessment using the Pol-SCORE scale, the following were of significant importance: TC, HDL, LDL, TGs, non-HDL, systolic pressure, diastolic pressure, heart rate. In the risk assessment using the SCORE2 scale, the following were significant: total cholesterol and triglyceride. Diagnosed T2DM significantly increases CV risk.

Key words

cardiovascular risk, diabetes, Pol-SCORE, SCORE2, risk factor

INTRODUCTION

From an etiological, epidemiological, and practical perspective, type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) are distinguished. The latter form accounts for approximately 90% of diabetes cases (DM). Additionally, other forms of DM are identified based on etiology and clinical situation. It is estimated that 537 million people worldwide suffer from DM, which constitutes about 10.5% of the global population. Simulations indicate an increase in the prevalence of DM to 783 million people (12.2%) by the year 2045. Type 1 diabetes occurs in youth and is caused by the autoimmune destruction of beta cells in the pancreas, resulting in an absolute insulin deficiency. Type 2 diabetes occurs in older individuals and is caused by the progressive loss of the ability of beta cells to secrete insulin properly and tissue resistance to the action of insulin, which may be accompanied by an increase in insulin levels [1].

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The primary metabolic disorder in diabetes mellitus (DM) is hyperglycaemia caused by insufficient insulin secretion or impaired insulin action. Chronic hyperglycaemia results in the binding of glucose to proteins, known as glycation. Glycation affects fibrinogen, albumin, immunoglobulin G, collagen, and many others, leading to dysfunction of these proteins. Glycation and oxidative stress stimulate the formation of advanced glycation end products (AGEs), resulting in disturbances in fibrinolysis, endothelial dysfunction, auto-immune diseases, inflammation, immunosuppression, platelet activation and aggregation, among others. [2]. AGEs form compounds not only with proteins but also with lipids and nucleic acids. Both glycation and AGEs play a significant role in the pathogenesis of diabetic complications, such as retinopathy, nephropathy, neuropathy, cardiomyopathy, as well as rheumatoid arthritis, osteoporosis, and aging processes [2].

Chronic complications of DM may result from direct adverse effects on organs and systems or indirect effects resulting from damage to atherosclerotic blood vessels (macroangiopathy) or vessels less than 100 nm in diameter (microangiopathy). With regard to the cardiovascular system, the adverse, CV risk, increasing effects of T2DM are direct and indirect. The aforementioned consequences

of protein glycation often cause multi-organ disease (e.g. kidney disease), which indirectly contribute to increased CV risk. The increased CV risk in the course of DM is influenced by direct and indirect factors. In the course of DM, direct damage to the cells of the myocardium and/or lining of the heart can occur, giving rise to diabetic cardiomyopathy. This is underpinned by electrolyte disturbances and free fatty acid metabolism, which may be influenced by AGEs [2]. The CV risk in patients with DM is most influenced by atherosclerotic coronary artery damage. The development of atherosclerosis in the coronary arteries in the course of DM is influenced not only by their damage by hyperglycaemia and its consequences, but also by a much higher prevalence of major risk factors, such as hypertension, dyslipidaemia, obesity or smoking habits. Consequently, DM increases the CV risk by even 4 times. Therefore, the risk of cardiovascular disease should be assessed [3–6].

The life-threatening and health-threatening consequences of T2DM highlight the need to identify populations at risk for its occurrence. The main risk factors for T2DM include overweight and obesity, family history, low physical activity, having a baby with a birth weight of more than 4,000g, hypertension, and dyslipidaemia [1, 7]. The most common clinical complications of T2DM include acute and chronic coronary syndrome, heart failure, stroke, diabetic kidney and eye disease, diabetic neuropathy, and diabetic foot syndrome. The data presented demonstrate the high CV risk posed by the presence of DM. Treatment goals for T2DM were described as follows: glycated haemoglobin below 7%, hypertension below 130/80 mmHg, normal body weight, LDL-cholesterol fraction below 40 – 100 mg/dL, nonHDL cholesterol below 70 – 150 mg/dL, depending on the magnitude of the CV risk [1], which is described as high or very high in the course of other diseases. These include kidney failure, diabetes mellitus (DM), manifest atherosclerosis, or a history of acute coronary syndrome. In other individuals, risk is calculated using scales based on the presence and strength of major risk factors.

In Europe, the SCORE (Systematic Coronary Risk Evaluation) and its Polish version – Pol-SCORE, are the scales most commonly used [8]. This scale is based on the presence of 5 major risk factors, i.e. age (40 – 69 years), gender, smoking habit, total cholesterol and systolic blood pressure, and describes the 10-year risk of death from cardiovascular causes as a percentage. Limitations of this scale include age up to 69 years, total cholesterol concentration only, systolic blood pressure value, and a risk restriction to death. The SCORE2 scale, published in 2021, is more precise. The scale takes into account non-HDL cholesterol concentrations and its version for people aged 70 – 89 years – SCORE2 – OP [6, 9], and also determines the 10-year risk of death or cardiovascular disease. In 2023, a version of the SCORE2 for people with diabetes was developed, dedicated to people with diabetes without overt signs of atherosclerosis. It takes into account the effectiveness of diabetes treatment by determining glycated haemoglobin concentration and renal function by determining glomerular filtration rate [8, 10]. SCORE2 was developed for countries with 4 different levels of risk.

OBJECTIVE

The aim of CVD prevention and treatment is to abolish risk factors. However, even with guideline-compliant reduction in their effect, there is still a risk of an event occurring, which is referred to as residual risk. The presence of residual risk is due to the incomplete elimination of major risk factors, as well as the action of other factors. Knowledge of secondary risk factors may enable more precise CV risk reduction. The aim of the study is to search for and evaluate the effect of additional risk factors. CV risk assessment was performed using the Pol-SCORE and SCORE2 algorithms.

Organization of the study. Research was conducted in primary care outpatient clinics and specialist outpatient clinics in the south-eastern provinces of Poland, after obtaining permission from the Heads of the Outpatient Clinics to conduct an anonymous survey and access medical records. The study was based on a proprietary questionnaire survey including socio-demographic data, CV risk factors, and current measurements of blood pressure, heart rate, body mass index (BMI) and waist circumference. Laboratory tests were considered up-to-date if they had been performed within the last 6 months. Blood pressure measurements were performed according to the Guidelines of the European Society of Cardiology and the European Society of Hypertension [8–10]. Data were obtained from medical records, from a personal interview with participants and from the measurements taken. Based on the data obtained, the 10-year risk of death from causes of CV risk on the basis of the Pol-SCORE scale and the 10-year risk of morbidity or death from causes of CV risk on the basis of the SCORE2 scale were calculated.

Inclusion criteria for the study were the absence of a history of cardiovascular disease, such as myocardial infarction, overt coronary heart disease, previous stroke, severe renal failure, and diabetes with complications.

The study was voluntary and anonymous and participant provided informed consent before commencement of the study. Prior to participating in the study, the participants were informed about the purpose of the research, anonymity, and the possibility of withdrawing from the study at any stage of its duration.

The study was carried out in accordance with the Helsinki Declaration (WMA Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects) [11]. The study did not pose any risk to the study participant and had no impact on treatment. Positive consent was obtained from the Bioethics Committee of the Academy of Zamość in Lublin Province, eastern Poland (No. KBAZ/2U/2025).

Study group. The study was conducted in a group of 1,540 subjects (F -58.1%; M -41.9%); mean age of all subjects – 53.8±8.3 years (T2DM(-): 53.2±8.2; T2DM(+): 57.1±8,3). An almost equal proportion of respondents declared living in urban (49.2%) and rural (50.8%) areas. The vast majority of respondents declared that they were married (81.4%). The most frequently declared level of education in the surveyed group was secondary level (47.3%), followed by tertiary education (38.9%), and the least numerous group declared primary education (13.8%). The most frequently indicated type of work was white-collar worker (40.3%) and manual worker (41.4%). A smaller percentage indicated farmer (14.3%) and without a profession (4.0%). Of the total number of respondents, 71.4% were employed, 14.5% declared a pension, 8.4% a disability pension, and the smallest group declared unemployment (5.6%). Detailed data describing the

study group, divided into T2DM(-) and T2DM(+) groups, are provided in Table 1.

Table 1. General characteristics of the study group of respondents. Categorical and continuous variables

Variable	N (%)		
	T2DM(-) (n-1314)	T2DM(+) (n-226)	Total (n – 1540)
Gender (n – 1540):			
female	764 (58.1)	123 (54.4)	887 (57.6)
male	550 (41.9)	103 (45.6)	653 (42.4)
Place of residence (n – 1540):			
city	646 (49.2)	112 (49.6)	758 (49.2)
village	668 (50.8)	114 (50.4)	782 (50.8)
Marital status (n – 1540):			
married	1082 (82.3)	171 (75.7)	1253 (81.4)
single	232 (17.7)	55 (24.3)	287 (18.6)
Education (n – 1540):			
elementary	170 (12.9)	42 (18.6)	212 (13.8)
secondary	607 (46.2)	122 (54.0)	729 (47.3)
higher	537 (40.9)	62 (27.4)	599 (38.9)
Profession (n – 1540):			
white collar worker	554 (42.2)	67 (29.6)	621 (40.3)
worker	531 (40.4)	106 (46.9)	637 (41.4)
farmer	181 (13.8)	39 (17.3)	220 (14.3)
without a profession	48 (3.6)	14 (6.2)	62 (4.0)
Employment status (n – 1540):			
working	973 (74.0)	126 (55.8)	1099 (71.4)
disability person	98 (7.5)	32 (14.2)	130 (8.4)
retirement	171 (13.0)	53 (23.5)	224 (14.5)
does not work	72 (5.5)	15 (6.6)	87 (5.6)
Smoking (n – 1540):			
yes	580 (44.1)	130 (57.5)	710(46.1)
no	734 (55.9)	96 (42.5)	830(53.9)
Alcohol consumption (n – 1540):			
yes	942 (71.7)	169 (74.8)	1111 (72.1)
no	372 (28.3)	57 (25.2)	429 (27.9)
Activity – intensivity (n – 997):			
high	175 (13.3)	6 (2.7)	181 (11.8)
middle	444 (33.8)	52 (23.0)	496 (32.2)
low	264 (20.1)	56 (24.8)	320 (20.8)

Variable	M	SD	Me	Q1	Q3	Min	Max
Age (n – 1540)	53.8	8.3	53.0	47.0	60.0	40.0	69.0
Age T2DM(–) (n – 1314)	53.2	8.2	52.0	47.0	59.0	40.0	69.0
Age T2DM(+) (n – 226)	57.1	8.3	58.0	50.0	64.0	40.0	69.0

N – number of observations; % – percent; M – mean; SD – standard deviation; Me – median; Q1 – lower quartile; Q3 – upper quartile; Min – minimum; Max – maximum; T2DM – type 2 diabetes mellitus; T2DM(-) – patient without DM; T2DM(+) – patient with DM.

Questionaire. The study used and analysed the SCORE algorithm to assess 10-year cardiovascular risk.

POL-SCORE Scale. The SCORE (Systematic Coronary Risk Evaluation) system has been used for many years in cardiovascular risk assessment. Experts from the European Society of Cardiology (ESC, European Society of Cardiology) recommend that systems adapted to the characteristics of the local population should be used [12]. Since 2007, Pol-SCORE tables calibrated for the Polish population have been used in Poland. Currently, an updated version of Pol-SCORE 2015 has been developed by the Polish Society of Cardiology which allows estimation of the 10-year risk of cardiovascular death, and reduce the risk of error by up to 20%, compared to the SCORE tables. The scale is applicable to patients aged 40 – 69 years who have no history of cardiovascular disease. The SCORE algorithm is intended for use in primary prevention, i.e. in people without clinical signs of diabetes or chronic kidney disease. When correctly assessing CV risk, several factors must be taken into account. These are: gender, age, smoking, total cholesterol and systolic blood pressure. Based on the given values, the SCORE scale provides an estimate of the individual's percentage risk of death from cardiovascular causes over the next 10 years. The data are presented as a percentage risk of death over 10 years due to CVD: small < 1%, moderate ≥1–5%, large ≥5% to < 10%, very large ≥ 10% [8].

SCORE2 Scale. The SCORE 2 system, introduced by the European Society of Cardiology, estimates the risk of fatal and/or non-fatal cardiovascular events over a 10-year period, including risk in apparently healthy individuals aged <70 years. The SCORE 2 tables do not apply to people with documented cardiovascular disease. The SCORE 2 scale identifies individuals who may benefit from preventive action; immediate preventive action allows for rapid lifestyle changes and modification of risk factors and therapeutic management. The SCORE 2 scale was calibrated in terms of the presence of risk in 4 categories: low risk, moderate risk, high risk, and very high cardiovascular risk. Risk is determined on the basis of national cardiovascular mortality rates in a group of 10,000 people published by the WHO (World Health Organization). The Polish population was included in the group of countries with high cardiovascular risk, together with the Czech Republic [13].

The resulting CV risk scores were calculated and recorded using percentages. Qualitative data were presented by number and percentage, measurable data by mean, standard deviation, median, upper quartile, lower quartile, minimum and maximum value.

Risk factors were analysed, one of which is current cigarette smoking. A study participant was considered a smoker if he or she had smoked at least one cigarette daily in the past 12 months. Parameter values were analysed and presented in the corresponding units of measurement.

Linear correlation analysis for qualitative data was performed using Perason's Chi2 test. The concordance of the distribution of measurable variables with the normal distribution was verified using Shapiro Wilk's W test. The relationship between the 2 groups was performed using Student's t test for independent variables. For non-parametric analysis, the Mann Whitney U test was used for 2 compared groups, and the Kruskalla – Wallis test for more than 2 groups. The correlation of measurable variables was assessed by determining Pearson's r-coefficient. The coefficient allows assessment of the linear correlation between measurable variables, taking values in the range [1;1]. Negative correlations mean that an increase in one variable determines a decrease in the other. Positive correlations indicate an increase in the values of both analysed variables. In medical science, values of r<0.3 indicate a weak correlation, 0.3 – 0.5 a sufficient correlation, 0.6 – 0.7 a moderate correlation, 0.8 – 0.9 a very strong correlation and r=1 an excellent correlation.

To assess the impact of risk factors on cardiovascular risk assessed by the Pol-SCORE and SCORE-2 algorithms, separate models were created using logistic regression. The models allowed the impact of single risk factors and groups of risk factors significantly affecting CV risk to be assessed.

Statistical analysis was performed using Statistica 13.0PL. A 5 per cent inference error was assumed in the analyses.

RESULTS

Analysis of the results of the Pol-SCORE and SCORE2 scales was conducted, taking diabetes into account. Significant differences were found in each of the compared scales ($p<0.05$). The average CV risk was significantly higher in individuals with diagnosed diabetes. The difference for the Pol-SCORE scale was +2.8 ($p<0.001$) and for SCORE2: +3.8 ($p<0.001$) (Tab. 2).

Table 2. Influence of DM t.2 on 10-years risk of fatal or non-fatal cardiovascular events

SCORE	T2DM(-)		T2DM(+)		Risk difference	p
	M	SD	M	SD	[%]	
Pol – SCORE, % of 10-year risk of death (n – 1,540)	5.4	7.4	8.2	9.2	+ 2.8	<0.001
SCORE2, % of 10- year risk of CV event (fatal or non-fatal), (n – 1540)	6.7	5.8	10.1	7.3	+ 3.4	< 0.001

T2DM – type 2 diabetes mellitus; T2DM(-) – patient without DM; T2DM(+) – patient with DM; CV – cardiovascular diseases; M – mean; SD – standard deviation; p – p value, test t Student.

Diabetes significantly influenced CV risk. The analysis revealed a significant impact of gender, place of residence, smoking, alcohol consumption, and physical activity in combination with the presence of diabetes on the CV risk. The intergroup differences between women with T2DM(-) and T2DM(+) indicated a significantly higher CV risk among women with diabetes in both Pol-SCORE and SCORE2 ($p<0.001$). Similar relationships were observed among men (Pol-SCORE: $p=0.023$; SCORE2: $p=0.002$). Male gender was associated with a significantly higher CV risk compared to female (Pol-SCORE) in both the T2DM(-) and T2DM(+) groups. Among the subjects in the T2DM(+) group assessed by the SCORE2 algorithm, no significant differences in CV risk were found between the 2 analyzed groups ($p=0.055$), with both women and men showing the highest risk of death from CVD. A significant impact of place of residence on CV risk was noted only in the group without diabetes (Pol-SCORE: city – 4.5±6.6; village – 5.3±6.9; SCORE-2 – city: 6.3±5.8; village – 7.1±5.9). However, in both compared groups, the CV risk was higher among individuals living in rural areas. In both the urban and rural resident groups, a significantly

Table 3. Influence of socio-demographic and risk factors on CV risk among patients aged 40 – 69-years-old

Variable	Pol – SCORE (%)		Risk diffrences T2DM(-) vs. T2DM(+)	p	SCORE2 (%)		Risk diffrences T2DM(-) vs. T2DM(+)	p
	T2DM(-) (n-1314)	T2DM(+) (n-226)			T2DM(-) (n-1314)	T2DM(+) (n-226)		
	M (SD)	M (SD)			M (SD)	M (SD)		
Gender:	***	***			***	*(0.055)		
female	2.8 (4.0)	5.8 (6.0)	+3.0	<0.001	5.1 (4.7)	9.2 (6.9)	+4.1	0.001
male	7.8 (8.6)	10.0 (9.8)	+2.2	0.023	8.9 (6.5)	11.1 (7.6)	+2.2	0.002
Place of residence:	**	*(0.07)			**	*(0.39)		
city	4.5 (6.6)	6.9 (7.2)	+2.4	<0.001	6.3 (5.8)	9.8 (7.6)	+3.5	<0.001
village	5.3 (6.9)	8.5 (9.0)	+3.2	<0.001	7.1 (5.9)	10.4 (7.0)	+3.3	<0.001
Marital status:	*(0.40)	*(0.42)			**	*(0.72)		
married	5.0 (6.8)	7.3 (7.7)	+2.3	<0.001	6.8 (5.8)	10.0 (6.7)	+3.2	<0.001
single	4.6 (6.7)	8.8 (9.5)	+4.2	<0.001	6.2 (5.9)	10.4 (8.9)	+4.2	<0.001
Education:	***	*(0.38)			***	*(0.16)		
elementary	7.5 (8.6)	8.4 (8.9)	+0.9	0.170	8.2 (7.4)	9.4 (8.5)	+1.2	0.377
secondary	5.7 (7.3)	7.9 (8.4)	+2.2	<0.001	7.6 (5.9)	10.7 (7.2)	+3.1	<0.001
higher	3.1 (4.8)	6.8 (7.2)	+3.7	<0.001	5.2 (4.8)	9.3 (6.6)	+4.1	<0.001
Profession:	***	*(0.90)			***	*(0.17)		
white collar worker	4.4 (6.9)	7.8 (8.0)	+3.4	<0.001	6.2 (5.7)	10.5 (7.1)	+4.3	<0.001
worker	5.1 (6.6)	7.4 (7.4)	+2.3	<0.001	7.0 (5.6)	10.2 (7.1)	+3.2	<0.001
farmer	6.4 (7.2)	7.4 (8.9)	+1.0	0.181	8.0 (6.6)	8.0 (6.7)	-	0.803
without a profession	3.3 (4.4)	10.3(12.2)	+7.0	0.004	4.5 (5.7)	12.9 (10.1)	+8.4	0.001
Employment status:	***	***			***	***		
working	3.4 (4.5)	6.2 (7.0)	+2.8	<0.001	5.3 (4.6)	8.8 (7.0)	+3.5	<0.001
disability person	7.8 (9.8)	7.6 (7.0)	-0.2	0.225	8.4 (7.2)	9.9 (8.2)	+1.5	0.408
retirement	12.0 (9.7)	11.5 (9.2)	-0.5	0.775	13.6 (5.7)	13.8 (5.9)	+0.2	0.972
does not work	4.4 (7.1)	6.9 (11.9)	+2.5	0.766	5.9 (6.6)	8.0 (8.5)	+2.1	0.243
Smoking:	***	***			***	***		
yes	7.0 (8.7)	9.6 (9.5)	+2.6	<0.001	8.8 (7.0)	12.1 (8.2)	+3.3	<0.001
no	3.2 (4.0)	5.1 (4.6)	+1.9	0.002	5.0 (4.0)	7.3 (4.6)	+2.3	<0.001
Alcohol consumption:	***	* (0.26)			**	*(0.24)		
yes	5.2 (7.0)	7.9 (8.3)	+2.7	<0.001	6.6 (5.9)	9.9 (7.6)	+3.3	<0.001
no	4.3 (6.1)	7.2 (7.8)	+2.9	0.002	6.9 (5.6)	10.7 (6.5)	+3.8	<0.001
Activity:	**	**				*(0.11)		
yes	4.1 (5.9)	6.7 (7.7)	+2.6	<0.001	6.0 (5.5)	9.3 (7.2)	+3.3	<0.001
no	6.6 (8.1)	8.8 (8.7)	+2.2	<0.001	8.0 (6.4)	10.9 (7.4)	+2.9	<0.001
Activity – intensivity:	**	*(0.10)			*(0.06)	*(0.70)		
high	3.9 (4.8)	4.2 (4.3)	+0.3	0.612	6.0 (5.7)	7.7 (5.8)	+1.7	0.419
middle	3.8 (6.0)	5.6 (6.4)	+1.8	0.006	5.6 (5.1)	8.6 (6.5)	+3.0	<0.001
low	4.8 (6.4)	8.0 (8.9)	+3.2	<0.001	6.7 (5.9)	10.1 (8.0)	+3.4	0.002

T2DM – type 2 diabetes mellitus; T2DM(-) – patient without DM; T2DM(+) – patient with DM; M – mean; SD – standard deviation; * (intra-group analysis) – p≥0,05; **(intra-group analysis) – p<0,05; ***(intra-group analysis)-p<0,001; N – number of observations; % – percent; p – analysis between T2DM(-) i T2DM(+)

higher CV risk was noted among individuals with diabetes (p<0.001). The only lack of significant differences was found in the SCORE2 scale among individuals with diabetes living in urban and rural areas (p=0.39).

The analysis indicated that in the group of individuals without diabetes, significantly lower CV risk (Pol-SCORE and SCORE-2) was observed among those with higher education (p<0.001), compared to individuals with other levels of education. On the other hand, the analysis of average CV risk in the group of individuals with higher education, considering diabetes burden and the absence of this disease, indicated that the average increase in CV risk among burdened individuals assessed by the Pol-SCORE algorithm, was significantly higher (+3.7) compared to the other two groups. In the assessment of risk based on the SCORE-2 algorithm, the average increase in CV risk in the burdened group was higher (+4.1). Analyzing occupational status, it was found that in the group of unburdened individuals, the highest average CV risk was recorded among farmers (Pol-SCORE – 6.4±7.2; SCORE-2 – 8.0±6.6). Analyzing each form of occupational status in both groups, the burden of disease caused a significant increase in CV risk, except in the case of farmers, where the increase in CV risk was not statistically significant, although an increase was noted. Smoking significantly increased the CV risk among the analyzed groups, particularly in the T2DM(+) group (Pol-SCORE – p=0.002; SCORE2 – p<0.001). Similarly, engaging in physical activity and the absence of alcohol consumption significantly reduced the risk of death from CVD. Conversely, diabetes burden significantly increased the risk of death from CVD (p<0.05). Intense and moderate levels of physical activity significantly reduced CV risk compared to the group with low levels of physical activity. However, the difference in average CV risk among individuals engaging in high levels of physical activity between the burdened and unburdened groups was small. Marital status did not significantly affect CV risk. Detailed intergroup and intragroup analyses are presented in Table 3.

The study group had an estimated risk of death in the next 10 years from cardiovascular causes calculated according to the Pol-SCORE algorithm and CORE-2, estimated in the 1,540 respondents in the study group aged 40 – 69 years. Diabetes significantly affected CV risk in the study group (p<0.001). High and very high CV risks were recorded more often in the group of people with diagnosed and treated diabetes (26.1% and 34.5%). Low and moderate CV risk was significantly more common in the non-diabetic group, compared to the diabetic group. The same relationships were noted in the SCORE2 scale. In the burdened group, 24.3% had a high risk and 42.5% a very high risk of death from cardiovascular causes. The lower risk was among unburdened subjects. People with diabetes were significantly more likely to have a 2-fold lower incidence of low risk, and a 2-fold higher incidence of very high CV risk compared to those without the disease. Unburdened individuals had a lower risk of developing cardiovascular morbidity or death (Tab. 4).

Correlations between the SCORE2 and Pol-SCORE scales were also assessed in the DM and nDM groups.

Most often, significantly higher values of the correlation coefficient between the value of a parameter and the value of individual algorithms assessing CV risk, were recorded among people with diabetes. When analyzing CV risk with the Pol-SCORE algorithm, the highest positive correlations were recorded for age (0.50), systolic blood pressure (0.41), body weight (0.39), waist circumference (0.39), TC (0.38) and non-HDL fraction (0.34). However, all these correlations were sufficient correlations. Correlations in the analysis of CV risk assessed by the SCORE-2 algorithm indicated in the burden group significant correlations between CV risk and age (0.53), TC (0.43), systolic blood pressure (0.38), waist

Table 4. Effect of diabetes on the 10-year risk of death from cardiovascular causes in the study group aged 40–69 years according to POL-Score and SCORE2

CV risk	Pol – SCORE (%)				CV risk	SCORE2 (%)			
	T2DM(-)		T2DM(+)			T2DM(-)		T2DM(+)	
	n	%	n	%		n	%	n	%
<1%	439	33.4	32	14.2	<2%	378	28.8	36	15.9
1–5%	399	30.4	57	25.2	2 – 5%	323	24.6	39	17.3
6–7%	215	16.4	59	26.1	6 – 10%	337	25.6	55	24.3
>7 %	261	19.9	78	34.5	>10%	276	21.0	96	42.5
Total	1,314	100.0	226	100.0	Total	1,314	100.0	226	100.0
p	<0.001				p	<0.001			

T2DM – type 2 diabetes mellitus; T2DM(-) – patient without DM; T2DM(+) – patient with DM; *p – p-value; Chi2 Pearson test.

Table 5. Correlation coefficient (r) between variable value and CV risk according to the presence of T2DM..

Variable	Pol – SCORE (r; p)		SCORE2 (r; p)	
	T2DM(-) (n-1314)	T2DM(+) (n-226)	T2DM(-) (n-1314)	T2DM(+) (n-226)
Age [years]	0.58 <0.001	0.50 <0.001	0.64 <0.001	0.53 <0.001
alcohol consumption [g/week]	0.15 <0.001	0.27 <0.001	0.19 <0.001	0.20 0.007
average weekly recreational activity [min/week]	-0.01 0.692	-0.07 0.443	0.07 0.025	0.02 0.793
height [m]	0.17 <0.001	0.27 <0.001	0.15 <0.001	0.12 0.076
body weight [kg]	0.21 <0.001	0.39 <0.001	0.27 <0.001	0.35 <0.001
BMI [kg/m2]	0.15 <0.001	0.28 <0.001	0.23 <0.001	0.30 <0.001
waist circumference [cm]	0.21 <0.001	0.39 <0.001	0.24 <0.001	0.37 <0.001
systolic blood pressure [mmHg]	0.43 <0.001	0.41 <0.001	0.49 <0.001	0.38 <0.001
diastolic blood pressure [mmHg]	0.24 <0.001	0.21 0.001	0.22 <0.001	0.07 0.306
heart rate [HR] [beats/min]	0.14 <0.001	0.16 0.014	0.12 <0.001	0.06 0.330
TC – total cholesterol [mg/dL]	0.25 <0.001	0.38 <0.001	0.30 <0.001	0.43 <0.001
HDL – cholesterol fraction [mg/dL]	-0.03 0.258	0.03 0.587	-0.02 0.502	0.03 0.651
LDL – cholesterol fraction [mg/dL]	0.13 <0.001	0.23 <0.001	0.11 <0.001	0.20 0.003
non HDL fraction [mg/dL]	0.25 <0.001	0.34 <0.001	0.26 <0.001	0.34 <0.001
TGs – triglycerides [mg/dL]	0.09 0.001	0.04 0.497	0.08 0.006	0.06 0.346

T2DM – type 2 diabetes mellitus; T2DM(-) – patient without DM; T2DM(+) – patient with DM; r – correlation coefficient; p – p value, correlation rPearson.

circumference (0.37), body weight (0.35), non-HDL fraction (0.34), and BMI value (0.30). However, all these correlations were strong enough. In the non-HDL group, the statistically significant strongest moderate correlation was between risk assessed by the SCORE – 2 algorithm and age; correlation value – r=0.64. Age was significant in estimating the risk of death from CVD causes, and significantly increased this risk (Tab. 5).

When analyzing the influence of factors on CV risk assessed by the Pol-SCORE algorithm, only those multiplications of risk factors (among quantitative variables) that indicated significant correlations were shown. The remaining factors and correlations did not indicate significant relationships. On the other hand, for the analyses of the same factors in the SCORE2 algorithm, no significant results were reported, hence the same correlations and their values were shown as for Pol-SCORE, for comparison of analysis effects.

Another regression analysis was carried out for CV risk assessed by the SCORE-2 algorithm, creating a model that took into account those factors that showed a significant effect on risk scores in this algorithm. For CV risk assessed by the Pol-SCORE algorithm, it was indicated that factors 1 – 8 occurring together strongly affect the values of the Pol-SCORE algorithm (TC, HDL, LDL, TGs, non-HDL, systolic pressure, diastolic pressure, heart rate). The single most strongly correlated factor with the results of the Pol-SCORE algorithm was heart rate. For the SCORE-2 algorithm, TC and TGs correlated most strongly with the SCORE-2 algorithm score (0.96). A slightly lower correlation was indicated for the TC and LDL-fraction factor pair (0.89) (Tab. 6).

Table 6. Levels of risk factors affecting CV risk (PolSCORE, SCORE2)

Risk factors	SS	MSefekt	F	p	P	R
relative to PolSCORE						
8	254.37	254.373	7.880	0.005	0.80	0.66
6*8	167.51	167.512	5.189	0.023	0.62	
1*2*3*5*6*8	169.53	169.529	5.252	0.022	0.63	
1*2*3*4*5*6*7*8	297.37	297.367	9.212	0.002	0.86	
1*10	237.84	237.835	6.868	0.009	0.74	0.65
1*2*10	210.39	210.389	6.075	0.014	0.69	
1*3*10	168.71	168.713	4.872	0.028	0.60	
1*2*3*10	184.27	184.268	5.321	0.021	0.63	
relative to SCORE2						
8	75.14	75.136	3.316	0.069	0.44	0.69
6*8	59.62	59.620	2.631	0.105	0.37	
1*2*3*5*6*8	16.50	16.499	0.728	0.394	0.14	
1*2*3*4*5*6*7*8	61.99	61.989	2.736	0.098	0.38	
1	354.55	354.546	13.842	<0.001	0.96	0.65
3	100.13	100.129	3.909	0.048	0.51	
10	124.62	124.621	4.866	0.028	0.60	
1*3	259.72	259.722	10.140	0.001	0.89	
4*10	120.11	120.109	4.689	0.031	0.58	
1*4	365.23	365.231	14.260	<0.001	0.96	
1*3*4	205.07	205.068	8.007	0.005	0.81	
1*4*5*10	109.97	109.973	4.294	0.039	0.54	

* SS – sum of squares; MS – intergroup variance quotient; F – F-test value; p; P – correlation power; R – regression model; 1 – total cholesterol; 2 – HDL fraction; 3 – LDL fraction; 4 – triglyceride; 5 – non-HDL fraction; 6 – systolic pressure; 7 – diastolic pressure; 8 – heart rate;9 – activity (min/week); 10 – drinking alcohol(g/week).

DISCUSSION

Cardiovascular diseases (CVD) are the most common cause of disability and death worldwide. The World Health Organization (WHO) reports that in 2019, almost 18 million people died from CVD, which constitutes about 30% of all deaths [14]. In Poland in 2021, more than 170,000 people died which constituted 35% of all deaths. Prevention and treatment are an important challenge, especially in view of the forecasts of an increase in the number of deaths. The Central Statistical Office (GUS) assumes an increase in the percentage of deaths due to CVD in Poland to 51.1% in 2050 [15].

Cardiovascular diseases constitute a very large burden for the health care system, especially in groups of the elderly, where multimorbidity and the need for combined treatment of patients occur with high frequency. For many years, CVD has been in first place in the triad of mortality and morbidity analyzed on a global scale [16]. There is also a significant reduction in health-related quality of life in both mental and physical dimensions due to CVD and DM [17,18] in the population, therefore, proper determination of CVD risk is important from both clinical and preventive perspectives.

In the 2019 update of the American Heart Association on Heart Disease and Stroke Statistics, the incidence of CVD among patients, on average, was 35 – 40% in the group of people aged 40 – 60 years, 75 – 78% in patients aged 60 – 80 years, while in patients over 85 years of age, the incidence of CVD exceeded 85% [19] The most common risk factors for CVD include hypertension, diabetes, dyslipidaemia, obesity, smoking, and age [20]. According to studies, there is a higher risk of CVD and death in people with type 2 diabetes, compared to people without diabetes. This result is independent of ethnic group and gender [21].

The results of the current study show that patients with diagnosed diabetes have a high and very high risk of CV risk compared to patients without this disease.

The CV risk in patients with diabetes is significantly influenced by factors, among which the most important in the conducted study were: age, systolic blood pressure, body weight, abdominal circumference, total cholesterol level, and non-HDL fraction level. For comparison, it is worth noting that the risk of CVD among patients with type 2 diabetes is also significant in European countries with low CV risk. This is confirmed by the results of studies obtained on the basis of the analysis of CVD risk in patients with type 2 diabetes treated in primary care in Catalonia, Spain, where the majority of patients diagnosed with type 2 diabetes showed a high or very high risk of fatal cardiovascular events, of which one-third of the examined without diagnosed cardiovascular disease also showed a very high risk of CVD. The risk of cardiovascular disease was significantly associated with other risk factors, among which the most important were arterial hypertension (72%), dyslipidaemia (60%), obesity (45%) and cigarette smoking (14%) [22].

The fact that patients with combined risk factors had significantly increased CV risk is of significant importance in the presented study. This is also confirmed by studies conducted in a group of patients with diagnosed diabetes in Italy, where the majority of people classified as very high risk had 3 or more cardiovascular risk factors [23].

Taking into account the results of numerous studies, it should be clearly emphasized that the risk of death due to

CV increases with age [24, 25]. This relationship was also demonstrated in the current study, and is of great importance from the perspective of the projected increase in the number of elderly people, both in Poland and worldwide, which constitutes a serious challenge for healthcare systems [16].

The research results obtained indicate that CV risk significantly depends on the influence of factors such as: body mass, abdominal circumference, BMI. These results are significant because weight reduction is a fundamental factor in the treatment of obesity and diabetes, which should significantly contribute to reducing the risk of CVD, both among patients with diabetes and in people not burdened with this disease entity [26].

However, as research results indicate, regular moderate or intensive physical activity has a beneficial effect on reducing CV risk. This relationship is confirmed by numerous studies showing the impact of activity on metabolic control and CVD risk factors in T2DM [27]. Analysis of available longitudinal studies published since 2012 updates and extends the growing body of research on the links between physical activity and obesity, coronary heart disease and diabetes. According to the authors, regional and global plans of action should emphasize the beneficial effects of regular physical activity, and implement specific actions to achieve greater commitment to one's health among people of all ages [28].

The authors' studies showed a negative correlation between the average level of physical activity (min/week) and CV risk, which meant that a decrease in average physical activity caused an increase in CV risk. However, this relationship did not show statistical significance.

Another factor that plays a significant role and can have serious health consequences and thus threaten the patient's life, is cigarette smoking. Studies have shown that CV risk increases due to addiction, especially in patients with diagnosed diabetes [27, 29].

Given the above recommendations presented in numerous scientific publications regarding smoking cessation, it is a key lifestyle intervention in patients with T2DM with or without CVD, with evidence showing a 36% reduction in mortality in patients with CVD [30, 31]. The authors' studies confirmed an increase in CV risk in people who smoked cigarettes. The average risk analyzed between the group of smokers without and with diabetes was +2.6, and in non-smokers +1.9 (Pol-SCORE); in the case of SCORE-2, the following CV risk values were noted: +3.3 and +2.3. Therefore, the risk in the case of smoking increases, on average, by +0.7 (Pol-SCORE) and +1.0 (SCORE2).

A significant increase in the risk of CVD in patients with diagnosed diabetes is presented in studies conducted among patients hospitalized due to metabolic disorders in the Diabetes Clinic at the Emergency Hospital 'Pius Brinzeu' in Timisoara, Romania – a country with a high risk of CVD. The obtained results confirmed a very high CV risk, which threatened the group of 87.2% of the examined patients, high risk in 11.4% of patients and moderate risk in the group of 1.4% of patients [32]. For comparison, the presented authors' research results indicate a very high risk of death from cardiovascular causes in 42.5% of the examined persons, while the risk was high in 24.3% (SCORE2). On the Pol-SCORE scale, these values were 34.5% (very high risk) and 26.1% (high risk), respectively.

Additionally, the authors' studies emphasize the significant influence of correlated risk factors on CV risk. The presence of a total of 8 factors (total cholesterol, HDL, LDL, triglyceride, Non-HDL, systolic pressure, diastolic pressure, heart rate) increased CV risk on the Pol-SCORE scale (p=0.86). In the case of SCORE2 scale, total cholesterol and triglyceride (0.96) were of the greatest importance in assessing CVD risk.

Thus, the results of studies available in the literature confirm the results of the authors' studies. It has been proven that the high prevalence of diabetes in emerging economies and the relative lack of treatment technologies, make patients with diabetes more susceptible to vascular complications. In addition, the relatively low awareness and adherence to recommendations among patients may make it even more difficult to prevent vascular complications. A representative survey showed that there exists a large number of undiagnosed diabetics in the population. At the same time, the aging of the world's population makes it difficult to reduce the prevalence of diabetes, and many studies indicate an increasing impact of gestational diabetes [33].

It should be noted that hospitalized patients may have an increased CV risk compared to outpatients due to the presence of other comorbidities. Therefore, it is also worthwhile to expand future studies to determine how other diseases may affect CV risk.

Awareness of typical risk factors may result in faster preventive action and lead to elimination or delay of the occurrence of CV risk factors in both diabetic and non-diabetic patients. This requires clinicians to carefully evaluate patients and select those at high risk of sudden cardiac death. In order to obtain the expected results, the assessment of risk factors based on the Pol – SCORE scale and the SCORE2 scale plays an important role.

Limitations of the study. A limitation of the study is that it did not verify data on the use of lipid-lowering drugs, e.g. statins, by the respondents, which are often used by patients with diabetes to help lower cholesterol levels and reduce the risk of CVD. In the absence of such information, it is not known whether the values of individual lipid fractions are the result of taking the drugs or not. Omitting these drugs in the analyses may significantly prevent the assessment of the final lipid profile values, and thus significantly affect the result of a comprehensive assessment of the impact of diabetes on cardiovascular risk, similarly to the lack of detailed data on the effectiveness of hypertension treatment, on the prophylactic use of aspirin, on the presence of smoking in the past, the duration of diabetes, and the method or the place of treatment.

CONCLUSIONS

- Individuals without T2DM, men, smokers, residents of rural areas, with low levels of education, farmers, pensioners, who consume alcohol, and do not engage in sports, have a higher cardiovascular risk assessed using the Pol-SCORE scale. Additionally, age, higher systolic blood pressure, body weight, waist circumference, and total cholesterol, increase CV risk.
- Individuals with T2DM, men, pensioners, smokers, and those who do not engage in sports, have a higher cardiovascular risk assessed using the Pol-SCORE scale. Furthermore, age and higher systolic blood pressure significantly increase CV risk.

- Individuals without T2DM, men, residents of rural areas, married individuals, with low levels of education, farmers, pensioners, smokers, and non-drinkers, have a higher cardiovascular risk assessed using the SCORE2 scale. Additionally, age and higher systolic blood pressure significantly increase CV risk.
- Individuals with T2DM, pensioners, and smokers, have a higher cardiovascular risk assessed using the SCORE2 scale. Furthermore, age and higher total cholesterol levels significantly increase CV risk.

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