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Anthropometric measures and biomarkers for cardiovascular disease risk factors: evidence from a study of Polish adults participating in the cardiovascular disease prevention program (CHUK)

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ABSTRACT: The Polish national program for the prevention of cardiovascular disease (CHUK) uses the Systematic Coronary Risk Evaluation (SCORE) index which evaluates the upcoming risk of death from cardiovascular causes for a 10 year period, based on information such as age, systolic blood pressure, cholesterol levels, smoking and gender. The aim of this study was to determine health indicators in the population enrolled in the program and identify the relationships between the cardiovascular risk factors. The data was collected from 303 participating individuals; 172 women (aged 35 to 58 years) and 131 men (aged 31 to 60 years). The SCORE index showed a statistically significant positive relationship between CVD and the male gender. The higher frequency of 3–4% and 5–9% for SCORE index in men indicates that they were at a higher risk of cardiovascular incidents. The increased risk of a cardiovascular incidence in men was associated with a higher mean arm circumference, waist circumference, BMI, systolic blood pressure, diastolic blood pressure, total cholesterol, LDL cholesterol, triglyceride and fasting glucose. HDL cholesterol and heart rate were statistically significantly higher in women. Among the study subjects, the most common parameters above the normal range were elevated LDL cholesterol and total cholesterol. The highest correlation with the SCORE index was observed for the age of the subjects, total cholesterol and LDL cholesterol, regardless of gender. The results showed that biochemical parameters and blood pressure were above normal values in almost all subjects. Men had significantly less favorable parameters compared to women of similar age range. According to the SCORE index, total cholesterol and LDL cholesterol significantly increased the risk of cardiovascular incident regardless of gender. Women were characterized by a lower risk of cardiovascular incident according to the SCORE index.

KEY WORDS: Anthropometric measures, arterial blood pressure, biochemical markers, SCORE cut-off points

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Abbreviations: BMI – body mass index, CHUK – Polish national Programme of Cardiovascular Disease Prevention, CVD – cardiovascular disease, ESC – European Society of Cardiology, HALE – healthy life expectancy, HDL cholesterol – high-density lipoprotein cholesterol, LDL cholesterol – low-density lipoprotein cholesterol, SCORE – Systematic Coronary Risk Evaluation

Introduction

In the terminology used by the World Health Organization (WHO), cardiovascular disease (CVD) refers to a group of conditions affecting the heart and circulatory system (blood vessels). They include coronary heart disease, stroke, heart attack, peripheral arterial disease, rheumatic heart disease, congenital heart disease and others. CVDs are the leading cause of death globally with an estimated 17.9 million deaths in 2019, which represents 32% of all global deaths (WHO2021). In Europe, these diseases account for approximately 45% of deaths, (4 million deaths) annually.There is growing evidence that most risk factors for CVDs can be prevented by addressing particular habits, such as tobacco use, unhealthy diet and obesity, lack of physical activity and harmful use of alcohol. Early and on-time detection of risk factors and diagnosis are important components of CVD-health promotion.

Cardiovascular risk is evaluated from known risk factors pertaining to an individual. However,, in reality it is not possible to quantify the numerous risk factors that have been documented to date along with the new ones that research has identified. Evaluating the influence of risk factors is complicated, costly and time-consuming, which is why in practice researchers usually refer to the general estimated risk, based on the most important and well-researched risk factors. According to the (Central Statistical Office put in year), 175,000 people in Poland die annually from cardiac causes, accounting for 46% of all deaths (Gujski et al. 2013). Therefore, this section of the population requires reliable diagnostic tools in order to reduce the death rate. In recent years, attempts have been made to further develop cardiovascular risk assessment systems. The European Society of Cardiology (ESC) recommends the Systematic Coronary Risk Evaluation (SCORE) which assesses upcoming death risk from cardiovascular causes for a 10 year period, using information on age, sex, systolic blood pressure, cholesterol and smoking (Conroy et al. 2003). The two systems have been developed and tailored to low-risk and high-risk countries. The low-risk criterion is a population mortality rate from cardiovascular disease and diabetes of less than 220/100,000 among men and less than 160/100,000 among women. Low-risk European countries include Austria, Belgium, Cyprus, Finland, France, Sweden, Portugal, Norway, Andorra, Denmark, Ireland, Israel, Luxembourg, United Kingdom, Italy, Greece, Spain, the Netherlands, Iceland, Malta, Monaco, Germany, San Marino, Slovenia and Switzerland. The remaining countries, including Poland, have been classified as high risk. In Poland cardiovascular risk factors are evaluated using the CVD questionnaire (Polish term: CHUK) and the SCORE scale. These useful tools enable the assessment of the health status and determine the occurrence of risk

factors for cardiovascular disease. The questionnaire includes the family history of cardiovascular disease, unhealthy behaviors such as smoking, anthropometric indicators of health such as waist circumference, body mass index (BMI), and biomarkers including arterial blood pressure, serum glucose and lipid levels. Consequently,, the aim of this study was to determine the values of anthropometric measurements in a population enrolled in a CVD prevention program (CHUK) and to identify relationships between the biomarkers of cardiovascular risk factors.

Material and Methods

The study used data from a cardiovascular disease prevention program (CHUK) implemented in one of the primary health care clinics in Szczecin, Poland. Based on the program recommendations provided by the National Health Fund, patients whose ages were >35 years up to 50 years were invited for a medical appointment in a given month and calendar year. Individuals who presented for the study on the dates agreed with their family physician, underwent an assessment of the presence of possible cardiovascular risk factors using the CHUK tool. The collected research data was distinctive , not only because of the statistical data on the health status of the Polish population from the West Pomeranian region, but also since this information identified relationships between specific cardiovascular risk factors in individuals participating in the program.

Data was collected from 303 participating individuals; 172 women (aged 35 to 58 years, mean age 42.8 years ± 7.2SD) and 131 men (aged 31 to 60 years, mean age 42.5 years ±7.4SD). The factors analyzed included waist and arm circumference, BMI, blood pressure, heart rate, fasting glucose, and serum triglyceride and lipid levels. Normality of distributions was checked using a Shapiro-Wilk test. For intergroup comparisons, Mann-Whitney U tests along with Kruskal-Wallis ANOVA and post-hoc tests were used. Comparisons of qualitative characteristics were made using a Chi^2 test. Correlation analysis was performed using a Spearman rank-order correlation. Differences were considered statistically significant at $p<0.05$.

The study was approved by the Bioethics Committee of the Karol Marcinkowski Medical University in Poznań, Poland (Resolution No. 679/18).

Results

Anthropometric parameters, biochemical parameters and SCORE index were compared between male and female participants, with all variables statistically significantly different between the genders. Males showed higher mean values of arm circumference, waist circumference, BMI, systolic blood pressure, diastolic blood pressure, total cholesterol, LDL cholesterol, triglycerides, fasting glucose and SCORE index than in females. In contrast, females showed a higher mean heart rate and HDL cholesterol values (Table 1).

A summary of the numerical parameter results which were within or outside the normal range is presented in Table 2. Subjects with abnormal values were observed for all but HDL parameters.

A summary of the numerical parameter results which were within or outside the normal range is presented in Table 2. Individuals with abnormal values were observed for nearly every parameter

(i.e. except HDL). The most common out-of-normal parameter was elevated LDL cholesterol (74.3%) and elevated total cholesterol (55.1%). Alternatively,, no below-normal values were observed for HDL cholesterol. Triglycerides were

Table 1. Descriptive statistics of anthropometric and biochemical-physiological characteristics in the male and female study participants

Characteristic	Mean±SD		Median (IQR)		*p*
	Males	Females	Males	Females	
Age, years	42.5±7.4	42.8±7.2			0.601
Arm circumference [cm]	31.1±3.33	28.1±3.08			<0.001
Waist circumference [cm]	94.2±11.12	81.0±10.39			<0.001
BMI [kg/m^2]			26.2 (86.0;100.0)	23.8 (74.0;87.0)	<0.001
Systolic blood pressure [mmHg]			125.0 (120.0;130.0)	115.0 (110.0;125.0)	<0.001
Diastolic blood pressure [mmHg]			80.0 (75.0;81.0)	70.0 (65.0;76.5)	<0.001
Heart rate [bpm]			66.0 (63.0;70.0)	76.0 (68.9;80.0)	<0.001
Total cholesterol [mg/dl]			210.0 (185.0;241.0)	201.5 (180.0;227.5)	0.045
HDL cholesterol [mg/dl]			52.0 (44.0;65.0)	64.0 (54.0;76.0)	<0.001
LDL cholesterol [mg/dl]			127.0 (110.0;156.0)	117.0 (94.5;143.5)	0.003
Triglycerides [mg/dl]			107.0 (75.0;165.0)	83.0 (61.5;125.5)	<0.001
Fasting glucose [mg/dl]			93.0 (89.0;100.0)	90.0 (85.0;95.0)	<0.001
SCORE	2.3±1.56	1.3±0.74	2.0 (1.0;4.0)	1.0 (1.0;1.0)	<0.001

Note: Normally distributed data are presented as mean and standard deviation (SD); non-normally distributed data as median and interquartile range (IQR).

Table 2. Percentage *distribution* of *participants' characteristics at three levels:* below normal, normal and above normal

Characteristic	Reference interval	Normal n (%)	Below n (%)	Above n (%)
Systolic pressure [mmHg]	120–129	127 (41.9)	115 (38.0)	61 (20.1)
Diastolic pressure [mmHg]	80–84	83 (27.4)	179 (59.1)	41 (13.5)
Heart rate [bpm]	60–80	244 (80.5)	7 (2.3)	49 (16.2)
Total cholesterol [mg/dl]	120–200	133 (43.9)	3 (1.0)	167 (55.1)
HDL cholesterol [mg/dl]	Women >50	303 (100)	–	–
HDL cholesterol [mg/dl]	Men >40	303 (100)	–	–
LDL cholesterol [mg/dl]	<100	78 (25.7)	–	225 (74.3)
Triglycerides [mg/dl]	<150	237 (78.2)	–	66 (21.8)
Fasting glucose [mg/dl]	70–99	247 (81.5)	2 (0.7)	54 (17.8

above normal in 21.8% of participants, and above-normal fasting glucose levels were noted in 17.8%. Above-normal systolic and diastolic blood pressure was recorded in 20.1% and 13.5% of participants, respectively. Above-normal heart rate was observed in 16.2%.

A comparison of the number of women and men in each risk range for a cardiovascular incident according to SCORE showed a statistically significant relationship between elevated risk and gender (Table 3). There were more males (28%) than females (4.1%) in the higher risk ranges, i.e. in the 3–4% and 5–9% ranges.

The greatest correlations with the SCORE indexes were recorded for age, total cholesterol, and LDL cholesterol, for both females and males. Additionally, the heart rate in females and body height in males were statistically significantly negatively correlated with the SCORE index. The correlation coefficients are presented in Table 4.

Among females, the median age for those with a SCORE index of 1% and in the 3–4% range was statistically significantly higher compared to participants with a SCORE <1% ($p<0.001$ and $p=0.003$, respectively). Median total cholesterol in participants with a SCORE

Table 3. Percentage distribution of study participants across risk scoring system cut-off points (SCORE)

Gender	SCORE cut-off points					
	<1%	1%	2%	3–4%	5–9%	10–14%
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Males	59 (45.0)	31 (23.7)	3 (2.29)	16 (12.2)	21 (16.1)	1 (0.8)
Females	142 (82.6)	21 (12.2)	2 (1.2)	5 (2.9)	2 (1.2)	0
Total	201 (66.3)	52 (17.2)	5 (1.6)	21 (6.9)	23 (7.6)	1 (0.3)

Relationship between SCORE risk and gender (Chi2 test=54.3; df=5; p<0.001).

Table 4. Spearman rank order correlation coefficients between risk according to the SCORE index and individual parameters

Characteristic	Total n = 303		Males n = 131		Females n = 172	
	R	*p*	R	*p*	R	*p*
Age, years	0.57	<0.001	0.75	<0.001	0.58	<0.001
Arm circumference [cm]	0.27	<0.001	0.06	0.480	0.15	0.055
Waist circumference [cm]	0.32	<0.001	0.00	0.974	0.22	0.003
BMI	0.22	<0.001	0.08	0.386	0.16	0.033
Body weight [kg]	0.26	<0.001	−0.05	0.597	0.08	0.287
Body height [m]	0.07	0.248	−0.20	0.020	−0.07	0.338
Systolic blood pressure [mmHg]	0.39	<0.001	0.24	0.006	0.33	<0.001
Diastolic blood pressure [mmHg]	0.38	<0.001	0.32	<0.001	0.18	0.017
Heart rate [bpm]	−0.29	<0.001	0.08	0.381	−0.22	0.004
Total cholesterol [mg/dl]	0.38	<0.001	0.42	<0.001	0.33	<0.001
HDL cholesterol [mg/dl]	−0.06	0.271	0.15	0.087	0.00	0.963
LDL cholesterol [mg/dl]	0.33	<0.001	0.32	<0.001	0.31	<0.001
Triglycerides [mg/dl]	0.17	0.003	0.01	0.879	0.16	0.031
Fasting glucose [mg/dl]	0.27	<0.001	0.31	<0.001	0.09	0.265

Table 5. Gender differences in study characteristics across *cardiovascular* risk cut-off points

Characteristic	SCORE cut-off points					
	Males			Females		
	<1%	3%–4%	5%–9%	<1%	1%	3%–4%
Age, years	35.5	50 $p<0.001$	50 $p<0.001$	40	50 $p<0.001$	55 $p=0.003$
Total cholesterol [mg/dl]	195	233.5	257 $p<0.001$	195	245 $p=0.007$	233
LDL cholesterol [mg/dl]	126	128.5	162 $p=0.004$	113	145 $p=0.022$	143
Diastolic blood pressure [mmHg]	75	81 $p=0.039$	82 $p=0.045$			
Fasting glucose [mg/dl]	92	95	97 $p=0.024$			

The p-values of the post-hoc test for Kruskal-Wallis ANOVA.

index of 1% was statistically significantly higher compared to <1% of participants ($p=0.007$). Median LDL cholesterol in participants with a SCORE index of 1% was statistically significantly higher compared to <1% of participants ($p=0.022$). The results are summarized in Table 5.

The median age of males with SCORE index 3–4% and 5–9% was statistically significantly higher than <1% of participants ($p<0.001$ and $p<0.001$, respectively), as was median diastolic blood pressure ($p=0.039$ and $p=0.045$, respectively). Median total cholesterol in participants with a SCORE index between 5–9% was statistically significantly higher compared to <1% of participants ($p<0.001$), as were median LDL cholesterol ($p=0.004$) and median fasting glucose ($p=0.024$). The results are summarized in Table 5.

Discussion

There is general agreement that cardiovascular diseases are the largest contributor to health inequalities both globally and specifically in the Polish population. Health-Adjusted Life Expectancy (HALE) is much shorter in the Polish population than in other in many European populations. The difference to the EU average is significant at 4.8 years for men and 2.1 years for women (Gujski et al. 2013). As a way of reducing these disparities and improve health care of the general population, a program for the prevention of cardiovascular diseases (CHUK) was implemented in 2008 (Tomasik 2014). The present study examined participants of this program and showed that 17.4% of females and 55% of males had an elevated risk of a cardiovascular incident within the next 10 years (1% or higher SCORE index). Detailed findings indicated that 24 men (16.8%) had high and very high risk index between ranging between 5% and 14%, and 2 women had high risk index between 5% and 9%. As many as 96.5% of females and 97.5% of males had an above normal level in at least one of the biochemical parameters analyzed. This finding corroborates the results of the "POLKARD Cardiovascular Disease Prevention and Treatment Program for 2017–2020" and "The Program for Prevention of Arteriosclerosis and Heart Disease through Education of People with Elevated Cardiovascular Risk Factors (Kordian) for 2017–2023."

As expected, the current study confirmed the influence of gender and age on the anthropometric and biochemical parameters, as well as the SCORE index indicators of increased risk of CVDs. Men were more vulnerable to CVD (e.g. myocardial infarction, hypertension) than women of a similar chronological age. Furthermore, the mean age of increased risk for women was 42.8 years, and for men it was 42.5 years. This finding is concurs with Tomasik (2014) who also pointed two characteristics, gender (men and postmenopausal women) and age (men >45 years, women >55 years) as the most serious risk factors of CVDs. This is a global problem has been constantly addressed by the WHO (Social inequalities in health in Poland, 2011). The WHO Regional Office for Europe study for Poland states that "health inequalities are mainly caused by social factors shaping the conditions in which people are born, brought up, work or receive treatment", and also that "health inequalities appear in all age groups and affect both genders, but they tend to be smaller for women than for men" (Social Inequalities in Health in Poland, 2011, pp. 13–14).

Piepoli et al. (2016, p. 849) state that "age is the most significant component of risk in all short-term (5 or 10 years) assessment algorithms." Matyjaszczyk (2013) analyzed the effect of gender of Polish subjects on the presence of cardiovascular disease and cardiovascular risk (CV) factors: hypertension, diabetes, hyperlipidemia, physical activity, smoking, and a positive family history, and showed that male gender showed a relatively higher risk for hypertension by 1.9 times (CI 95% 1.3 – 2.8). In contrast, based on the ESC (European Society of Cardiology) guidelines for cardiovascular disease prevention, it should be noted that "women are at a lower CV (cardiovascular) risk than men, but women reach a similar CV risk level to men 10 years later" (Piepoli et al. 2016, p. 830).

Obesity has been identified as an important risk factor for CVD development. On this note, (BMI) is a good marker of healthy or unhealthy weight. Other factors including waist circumference (WC) as a visceral fat indicator or body fat content correlating with BMI also exert influence on this risk and should be considered in cardiovascular risk prevention programs (Biesalski and Grimm 2012; Stupnicki and Tomaszewski 2016). In our study, female median value of the BMI (Me=24.5) was within the normal range of 18.50–24.99, while the corresponding value for males (BMI=26.9) classified them as being overweight. The health consequences of an elevated BMI as a risk factor for cardiovascular incident may result in the occurrence of more incidences of future CVD. A study by Bray (2004), citing the results of the Nurses' Health Study, reveal that in the United States women with a BMI greater than 29 are 3.3 times greater risk of coronary heart disease than women with a BMI less than 21. Piepoli et al. (2016) suggest that maintaining a healthy body weight positively affects metabolic risk factors; blood pressure, blood lipid levels, glucose tolerance and lowers CV risk. According to the authors, overweight and obesity are associated with an increased risk of CVD-related deaths, as well as overall mortality, which is lowest for BMI in the 20–25 range (in individuals younger than 60 years).

Excess body fat not only predisposes many cardiovascular risk factors (Kannel et al. 2002), but is also an independent risk factor (Hubert et al., 1983). Obe-

sity worsens the prognosis of patients diagnosed with coronary artery disease (Dagenais et al. 2005) and increases the risk of acute coronary syndromes (Wolk et al. 2003). Rashid et al. (2003) identify obesity as an independent risk factor for ischemic heart disease (CHD). Similarly, Klein and Romijn (2008) report that obesity is associated with lipid abnormalities (especially abdominal obesity) that may lead to an increased risk of CVD (Bray, 2004). Based on the 1999–2002 USA National Health and Nutrition Examination Survey, Bays et al. (2013) indicate that 62.5–68% of obese individuals have dyslipidemia, and that 38.3% of individuals with dyslipidemia are obese (Rinkūnienė 2015).

As noted by Molisz et al. (2015), the primary markers of CVD risk include systolic blood pressure, diastolic blood pressure, and the Systematic Coronary Risk Evaluation (SCORE) index. According to the WHO, hypertension is the most common cause for cardiovascular disease and is a major independent risk factor for ischemic heart disease, ischemic heart failure, stroke, peripheral artery disease and kidney failure., Therefore, treatment of hypertension significantly reduces the risk of these CVD complications (Lewington et al. 2002). In our study, physical examinations indicated that among both men and women only 41.9% results of systolic BP, 27% results of diastolic BP, 80.5% of heart rate results were within the population norm ranges consistent with the 2015 Polish Society of Hypertension (PTNT), European Society of Cardiology (ESC), and European Society of Hypertensiology (ESH) 2018 guidelines (Hypertension NFZ Report, 2019). It is worth noting that approximately 62% of cardiovascular disease cases and 49% of ischemic heart disease cases can be linked to elevated blood pressure (Whitworth 2003). By contrast, Lewington et al. (2002) indicate that high blood pressure (both systolic and diastolic) is associated with a higher mortality from stroke, regardless of the age group, and for those aged 40–69 years, a difference in systolic blood pressure of 20 mm Hg (or about 10 mm Hg for diastolic blood pressure) can represent more than a twofold difference in mortality.

The two studies, Treating to New Targets Trial (TNT) (Bangalore 2010) and the International Verapamil SR – Trandolapril Study (INVEST) indicate that reducing blood pressure to 130–140/80–90 mmHg has significant benefits for the patients, with values below 110–120/60–70 mmHg associated with an elevated risk of death from ischemic heart disease (Cooper-DeHoff et al. 2010). Furthermore, Bray (2004) points out that obese individuals often have elevated blood pressure, and that hypertension and overweight affect heart function and increase the risk of heart failure. Results from the Swedish Obesity Study (what year?) show that hypertension was present in 44–51% of obese individuals. Another study by Modan et al. (1985) further confirm the relationship between hypertension and glucose intolerance, reporting that 83.4% of the individuals between the ages of 35 and 70 had insulin resistance or glucose intolerance due to obesity; second, that obesity was present in 69% of those with hypertension. Similar estimates are provided by Wolk et al. (2003), who state that 65% of the risk of hypertension in women is due to obesity, and can be as high as 78% in men. Data from the Diabetes Control and Complications Trial (DCCT) (Nathan et al. 1993) and the

United Kingdom Prospective Diabetes Study (UKPDS) found that the better the glycemic control, the greater the benefit in reducing distant macrovascular complications (Holman et al. 2008). In the CVD Prevention Study, both the men and the women achieved a fasting glucose of 81.5%, indicating a successful prognosis and the absence of a possible cardiovascular incident. According to Drzewoski (2011), early disturbances in glucose metabolism pose a greater risk of vascular damage. Fasting blood glucose levels above 100 mg/dL but below the threshold accepted for the diagnosis of diabetes, are associated not only with an increased risk of developing diabetes, but also cardiovascular disease (Expert Committee on the Diagnosis and Classification of Diabetes Mellitus 2003)

Proper blood cholesterol levels are an indicator of good health. A lipidogram is used to determine total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides. Cholesterol levels are affected by many genetic and environmental factors (physical activity, diet, alcohol, cigarettes, comorbidities). Based on the patient's general health and test results, the risk of CVD can be determined with subsequent medical treatment. Our study results of HDL cholesterol and triglycerides were within the reference range, whereas the values of total cholesterol and LDL cholesterol were slightly elevated in both women and men.

The aim of CVD prevention is to reduce the incidence of CVD related morbidity, and to prevent disability and premature death. Good health is beneficial to society in general. Thus, the maintenance of good health needs to be considered in different research contexts in order to recognize those factors that promote the onset of CVD (i.e. lack of knowledge or awareness, unhealthy lifestyle habits) among men and women.

Study limitations

The major limitation of this study was that the analyzed population was restricted to the patients of a single clinic and did not include all patients who were invited to take part in the program. It is not known how many patients did not take part in the study. Consequently, there are no data on their gender or health status of these individuals.

Conclusions

The results of the current study confirmed the widespread problem of substantial CVD risk among adults in Poland. Factors significantly increasing the risk of cardiovascular incident were the SCORE index, age, and total cholesterol and LDL cholesterol. Males had significantly less favorable values in these parameters compared to females in a similar age range. Females had lower levels of risk of a cardiovascular incident according to the SCORE index compared to males of a similar age. In this case, the national CVD prevention program is of prime importance. An effective strategy is needed to increase the participation of adults in the CVD prevention program and to increase the availability of the program, as it is currently limited only to those clinics that have voluntarily enrolled in the program. Secondly, the disproportionately higher risk of CVD among Polish men shows that the prevention program should be particularly focused on motivating men to take part in the tests; second, systematically introducing measures to reduce CVD risk factors.

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Authors' contribution

KM, MM and MS designed research; KM and MM conducted research; KM, MS analyzed data; KM and MS wrote the paper. MS had primary responsibility for final content. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interests.

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