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ORIGINAL ARTICLE

Secular trends in cardiovascular risk factors with a 36-year perspective: Observations from 38- and 50-year-olds in the Population Study of Women in Gothenburg

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Abstract

Objectives. To study secular trends in cardiovascular risk factors in four different cohorts of women examined in 1968–1969, 1980–1981, 1992–1993 and 2004–2005. *Design.* Comparison of four representative cohorts of 38- and 50-year-old women over a period of 36 years. *Setting.* Gothenburg, Sweden with ~450 000 inhabitants. *Subjects.* Four representative samples of 38- and 50-year-old women were invited to free health examinations (participation rate 59–90%, n = 1901). *Main outcome measures.* Body mass index (BMI), systolic and diastolic blood pressure (SBP, DBP), leisure time exercise, use of antihypertensive medication, smoking, levels of haemoglobin, b-glucose, s-cholesterol, s-triglycerides and HDL-cholesterol. *Results.* There was no significant difference in mean BMI from 1968–1969 versus 2004–2005. Mean leisure time exercise was significantly higher in later born cohorts; in 1968, around 15% were physically active compared with 40% in 2004. SBP and DBP, mean s-cholesterol and s-triglyceride levels were significantly lower in both 38- and 50-year-old cohorts in 2004–2005 versus 1968–1969. HDL-cholesterol (not measured until 1992–1993), showed a significantly higher mean level in 2004–2005. Reduction of risk factors was apparent in women with a high as well as low level of physical activity. Smoking declined most in women with high levels of physical activity. *Conclusions.* Several cardiovascular risk factors related to lifestyle have improved in middle-aged women from the 1960s until today. Most of the positive trends are observed in women with both low and high physical activity.

Key Words: *Cardiovascular risk factors, cohort comparisons, lifestyle, participation bias, physical activity, women*

Women's health is an expanding field of scientific activity but there are few long-term population studies focusing on trends in women's health. To our knowledge only two ongoing studies in women initiated in the 1960s or earlier exist: the Framingham Study and the Population Study of Women in Gothenburg (PSWG) [1,2], of which only the Gothenburg study was population based. Since the 1980s several population and intervention studies aimed at studying oestrogen health effects and cardiovascular health in women have been initiated [3], but there is an increasing need to study health development in a longer perspective including associations between health development and changes in environmental factors, e.g. changes in society, the economy, the labour market, and lifestyle. Over the last 36 years, there have been great changes in middle-aged women's full-time employment rate, increasing from around 40% in the 1960s to around 70% in 2005 in Sweden [4,5]. Mean age at birth of first child in Sweden has increased almost 5 years (from 24 to 29) and use of hormonal contraceptives

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Middle-aged women's cardiovascular risk factors have changed in a beneficial way since 1968.

- During the same period health-promoting changes in lifestyle have taken place, especially concerning smoking and physical activity.
- Most changes can be observed in high as well as low physical activity groups.
- Effects of primary prevention activities, especially concerning smoking, seem to be observable on the population level – a positive observation for primary health care.

at some time during fertile life has increased from around 10% to more than 70% [5]. Changes have taken place also in dietary habits and physical activity as well as stress load. All these factors probably influence women's health.

Observations during the last 20 years show that despite the fact that women's work time outside home has increased [6,7], middle-aged women's health is improving, both objectively and subjectively [8,9]. Female longevity, on the other hand, has not increased at the same rate as in men during the last decade [5]. In cohort comparisons in the Framingham study, levels of systolic and diastolic blood pressure (SBP and DBP), s-cholesterol and cigarette smoking were lower in 1984–1988 than 1957–1960 [1], but mean body mass index (BMI) and prevalence rates of overweight and hypertension were higher in 1984–1988, despite higher levels of reported physical activity.

The aim of this paper was to study development of different known cardiovascular disease (CVD) risk factors in women by comparing risk-factor levels in representative age cohorts of women examined in four examinations conducted in 1968–1969, 1980–1981, 1992–1993 and 2004–2005, with special attention to physical activity, and non-participation issues.

Material and methods

The Population Study of Women in Gothenburg 1968–1969 until 1992–1993

In 1968–1969, a representative sample of 1622 women living in Gothenburg, Sweden, was invited to a free health examination. A total of 1462 women, aged 38, 46, 50, 54, and 60 (90.1%), accepted the invitation and participated in the Prospective Population Study of Women in Gothenburg (PSWG) (Table I) [10]. There was no intervention concerning preventive components included in the health examinations apart from taking care of apparent treatable conditions. Analysis of survival rates among participants versus non-sampled women born in the same years revealed no major differences, providing additional evidence that participants were representative of the general population from which they were selected [2].

In 1980–1981 a follow-up examination was conducted (participation rate 78.9%) [11]. Two new age groups, aged 26 and 38 in 1980–1981, were recruited, with the purpose of conducting cross-sectional comparisons over time. Also, women born in 1930, who moved to Gothenburg between 1969 and 1980 and belonged to the same date of birth as the original cohort, were invited to the 1980–1981 examination, which implied that 50-, 38- and 26-year-old women examined in 1980–1981 were representative of the female population in Gothenburg in 1980–1981. Follow-up examinations were also conducted in 1992–1993 (participation rate 70.1%), when two of the cohorts were 38 or 50 [2].

Examination 2004–2005

In 2004–2005 a new study of 38- and 50-year-old women was conducted, in which women born in 1966 were examined for the first time, and most of the sample born in 1954 was newly recruited, the remainder having participated in 1992–93 (Table I). A total of 343 women aged 38 and 503 aged 50

Table I. Examinations and participation rates of 38- and 50-year-old cohorts in the Population Study of Women in Gothenburg 1968–2005 (age group born 1954 was only 26 years old when examined first time in 1980–1981).

	1968–1969 examination			1980–1981 examination			1992–1993 examination			2004–2005 examination		
Year of birth	Age	n	%	Age	n	%	Age	n	%	Age	n	%
1966										38	207	(60)
1954							38	61	(72)	50	293	(58)
1942				38	122	(85)	50	93	(76)			
1930	38	372	(91)	50	355	(82)						
1918	50	398	(91)									

living in Gothenburg were invited to a free health examination (7 women were excluded because of difficulties in speaking and understanding Swedish). As in 1968–1969, the sample was obtained from the Revenue Office Register and the sampling method was based on dates of birth to make it representative. Among 38-year-olds, all women born on days 6, 12, 18, 24 (until June) were selected; among 50-year-olds, days 3, 9 (until April) and 30 were also added to the selection. The survey was performed over a six-month period. During the first month of the study women were contacted by post and followed up with a phone call when the phone number was available. In addition, those 50-year-olds who had previously participated in the PSWG were invited regardless of whether they lived in Gothenburg. As of 1 December 2004, invitations to women who had no listed telephone number were stopped due to low contact rate.

A total of 500 women (207 38-year-olds and 293 50-year-olds) accepted the invitation (60% and 58% respectively; 73% and 70% of all women reachable by telephone) and participated in 2004–2005 (Figure 1). Physical examinations were conducted according to the same protocol at all examinations.

Social and lifestyle-related variables

Registry-based information in 2004–2005. For all subjects in examination in 2004–2005, regardless of participation, information concerning income (SKr year 2004), place of living (address), marital status (unmarried, married, divorced, widowed), and migrant status (born in Sweden or abroad and/or moved to Sweden) were obtained from the local fiscal authority. Information concerning hospital care during 2001–2003 on group level was obtained from the National Hospital Register.

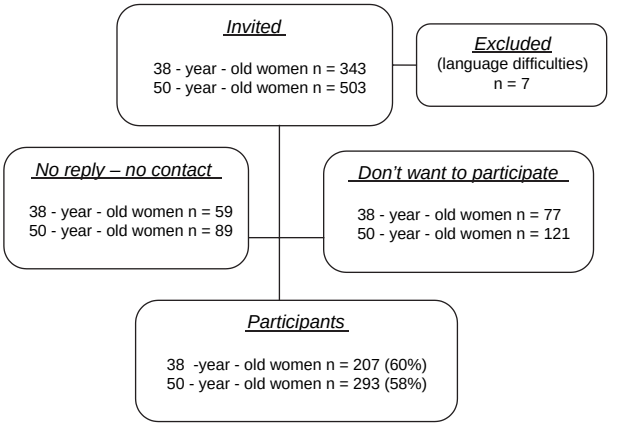

Figure 1. Flow chart of the 2004–2005 examination in the Population Study of Women in Gothenburg.

Questionnaire-based information

Socio-economic status (SES). The participants reported their own occupations and, if they were married, their husbands' occupations. This information was transformed into three socio-occupational levels: large-scale employers and officials of high or intermediate rank were identified as belonging to the "high social group", small-scale employers, officials of lower rank, and foremen as belonging to the "middle social group", and skilled and unskilled workers were identified as belonging to the "low social group" [10].

Physical activity. Subjects were classified as being physically active during leisure time if they reported usually, during the last year, spending more than four hours a week gardening, running, dancing, playing golf, tennis, or similar activities (physician interview).

Smoking habits. "Smokers" were identified as those women who were smoking ≥ 1 cigarette per day (physician interview).

Physical examination

Anthropometric measurements. Body height and body weight were measured with the subjects wearing only briefs. BMI was calculated body weight in kg/m^2 where m represents body height in metres.

Blood pressure. SBP and DBP measurements were performed after five minutes' rest in the sitting position.

Blood sampling. Blood samples were drawn in the fasting state for determination of concentrations of blood glucose (or, in 2004–2005, plasma glucose), s-triglycerides, total-cholesterol, and HDL-cholesterol (1992–1993 and 2004–2005) concentrations. Laboratory analyses were comparable between the examination years and correction for p-glucose measures compared with b-glucose was undertaken.

Hypertensive treatment. The women were interviewed about whether they were on pharmacological antihypertensive treatment.

Statistical methods

Student's t-test or Fisher's exact test was used to test differences between means, and regression coefficients to indicate the magnitude of changes per year.

Linear regression analyses were performed to test cohort trends, and differences in trends, as well as possible divergences of demographic pattern between participants and non-participants. Logistic regression analyses were used when dichotomous variables were tested concerning cohort trends. The SAS system was used in the statistical analyses.

Results

Analysis of participants versus non-participants in the 2004–2005 examination

There were no statistically significant differences between 38- and 50-year-old cohorts concerning participation rates in the 2004–2005 examination or between participants and non-participants concerning districts of residential and civil status (Table II). However, a significant difference was observed concerning income and immigration status, with lower mean income and higher share of immigrants in the non-participant group. Hospital admissions at the group level between participants and non-participants (excluding pregnancy and childbirth) showed no significant differences (Table II). Having been admitted to hospital increased the probability of belonging to the non-participants and increasing number of admission days increased the probability of belonging to the non-participants; 10 or more days of admission to hospital corresponded to a 58.4% non-participation rate, as compared with a 47.8% non-participation rate for subjects with no hospital admissions, $p = 0.03$. There were no significant differences between participants and non-participants concerning admission diagnoses except for cardiovascular diseases in 50-year-olds, $p = 0.03$ (higher rate in non-participants) (registry-based comparisons only done for 2004–2005 cohort).

Analyses of secular trends from 1968–1969 to 2004–2005

There was no significant difference in BMI from 1968–1969 versus 2004–2005, as both weight and height were higher in later born cohorts (Table III). SBP and DBP differed significantly in both age groups, corresponding to a change of -0.2 and -0.3 mmHg per year in 38- and 50-year-old women, respectively. Mean frequency of use of antihypertensive medication was not significantly different in 1968–1969 versus 2004–2005; specifically, in 38-year-old women, 0.8% used antihypertensive medication in 1968–1969 compared with 1.9% in 1992–1993 and 2.5% in 2004–2005, OR for higher frequency = 1.5 (CI 0.9–2.4). In 50-year-old women, 4.5% in 1968–1969, 7.3% in 1980–1981, 9.4% in 1992–1993 and 7.0% in 2004–2005 used antihypertensive treatment, OR = 1.2 (CI 0.95–1.4).

The percentage of women with high leisure time exercise was significantly higher in later born cohorts (also significant when controlling for SES) (see Table III). Concerning blood lipid levels, mean total cholesterol and s-triglyceride levels were significantly higher in both cohorts in 1968–1969 versus 2004–2005. HDL-cholesterol, (not measured until 1992–1993), showed a significantly higher mean level in

Table II. Participants and non-participants in the examination 2004–2005 of 38- and 50-year-old women in the Population Study of Women in Gothenburg.

	Participants 2004–2005 38 years old n (%)		Non-participants 2004–2005 38 years old n (%)		Participants 2004–2005 50 years old n (%)		Non-participants 2004–2005 50 years old n (%)		Total participants n (%)		Total non-participants n (%)		p
	n	%	n	%	n	%	n	%	n	%	n	%	
	207	(60)	136	(40)	293	(59)	210	(41)	500	(59)	346	(41)	
Marital status[1]													
unmarried	94	(45)	55	(40)	66	(23)	53	(26)	160	(32)	108	(32)	
married	88	(42)	56	(41)	152	(52)	104	(50)	240	(48)	160	(47)	
divorced	25	(12)	25	(18)	65	(22)	43	(21)	90	(18)	68	(20)	
widowed	–		–		10	(3)	6	(3)	10	(2)	6	(2)	0.9
Income													
over median	108	(52)	59	(43)	167	(57)	73	(35)	275	(55)	132	(38)	
below median	99	(48)	77	(57)	126	(43)	137	(65)	225	(45)	214	(62)	0.00
Place of living													
Lower socioeconomic district	43	(21)	43	(30)	60	(22)	54	(28)	103	(21)	97	(29)	0.1
Hospital admission rate	16	(8)	17	(13)	40	(14)	30	(14)	56	(11)	47	(14)	0.3

Note: [1]Information on four non-participants missing.

Table III. Mean of BMI, systolic and diastolic blood pressure, and percentage of antihypertensive medication, leisure time exercise, smoking, and gainful employment in 38- and 50-year-old cohorts in the 1968–1969, 1980–1981, 1992–1993, and 2004–2005 examinations, respectively. Regression coefficient indicates mean change/year.

	1968–1969		1980–1981		1992–1993		2004–2005			
Variable/age	n	mean	n	mean	n	mean	n	mean	p	Regr. Coeff
BMI										
38 years	372	23.4	121	22.9	61	23.6	202	24.0	0.13	0.01
50 years	398	24.8	355	24.7	92	24.8	292	24.8	0.77	0.00
Systolic blood pressure mmHg										
38 years	372	123	122	123	61	118	202	117	<0.000	−0.16
50 years	398	138	354	135	92	134	291	128	<0.000	−0.26
Diastolic blood pressure mmHg										
38 years	372	81	122	83	57	74	190	74	<0.000	−0.21
50 years	398	88	354	87	89	82	271	79	<0.000	−0.26
		%		%		%		%		
Hypertensive medication										
38 years	372	1	122	1	61	2	207	3	0.11	
50 years	398	5	355	7	92	9	293	7	0.18	
High leisure time exercise										
38 years	372	11	122	24	61	36	204	41	<0.000	
50 years	397	15	355	23	92	26	289	39	<0.000	
Smoking										
38 years	371	47	122	38	61	34	204	11	<0.000	
50 years	397	37	355	39	92	33	291	23	<0.000	
Gainful employment										
38 years	372	50	122	86	61	95	207	93	<0.000	
50 years	398	66	355	83	92	90	293	89	<0.000	

2004–2005 (Table IV). Cholesterol and triglyceride levels in 2004–2005 showed a 30% lower mean value compared with 1968–1969. On the other hand, no significant difference in mean levels of b-glucose was observed. Through most examinations, there was a significant association between SES and the variables s-triglycerides, BMI, and leisure time exercise.

There was a statistically significant difference between trends in mean DBP, triglycerides, and

Table IV. Mean of hemoglobin and glucose as well as blood lipids in 38- and 50-year-old cohorts in the 1968–1969, 1980–1981, 1992–1993 and 2004–2005 examinations, respectively. HDL–cholesterol was not measured until 1992–1993 examination. Regression coefficient indicates mean change/year.

	1968–1969		1980–1981		1992–1993		2004–2005			
Variable/age mmol/l	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	p	Regr. coeff.
B-haemoglobin										
38 years	371	131(10)	122	131(13)	61	128(14)	203	131(11)	0.0001	−1.6
50 years	398	137(11)	350	133(11)	89	129(10)	291	133(12)	0.0001	−1.4
B-glucose										
38 years	371	4.0(0.8)	121	3.9(0.4)	59	4.5(1.9)	203	4.0(0.6)	0.49	0.02
50 years	397	4.2(0.9)	349	4.1(0.5)	88	4.3(0.9)	289	4.2(0.5)	0.36	0.02
S-triglycerides										
38 years	371	1.1(0.4)	121	1.0(0.8)	60	1.0(0.6)	204	0.8(0.5)	0.0001	0.1
50 years	398	1.3(0.6)	348	1.2(0.6)	88	1.2(0.6)	292	1.0(0.5)	0.0001	−0.1
Total cholesterol										
38 years	371	6.3(0.9)	121	5.7(0.9)	60	5.0(0.9)	204	4.6(0.8)	0.0001	−0.6
50 years	398	7.2(1.1)	348	6.5(1.1)	88	5.8(0.9)	291	5.3(1)	0.0001	−0.6
HDL-cholesterol										
38 years					56	1.5(0.4)	204	1.7(0.4)	0.0001	0.2
50 years					83	1.6(0.5)	291	1.8(0.5)	0.02	0.1

Table V. Trends regarding decrease/increase of different variables between birth cohorts in the low physically and high physically active groups, and test for difference in time trends between the low physically and high physically active group, respectively, controlled for age and SES. Time trends are expressed as regression coefficients (OR for smoking) and CI, indicating reduction/increase per year (1968–2004).

	n	Regr. coeff.	CI	p for cohort trend	p for difference low/high group
Systolic blood pressure mmHg					
Physical activity low	1061	−0.23	−0.30 to −0.16	0.0001	
Physical activity high	347	−0.16	−0.27 to −0.04	0.008	0.33
Diastolic blood pressure mmHg					
Physical activity low	1057	−0.33	−0.38 to −0.28	0.0001	
Physical activity high	344	−0.39	−0.52 to −0.27	0.000	0.21
S-triglycerides mmol/l					
Physical activity low	1054	−0.006	−0.008 to −0.004	0.0001	
Physical activity high	343	−0.003	−0.005 to −0.001	0.015	0.13
S-cholesterol mmol/l					
Physical activity low	1054	−0.049	−0.053 to −0.046	0.0001	
Physical activity high	342	−0.051	−0.057 to −0.044	0.0001	0.71
B-glucose mmol/l					
Physical activity low	1053	−0.002	−0.004 to 0.004	0.99	
Physical activity high	337	0.005	−0.001 to 0.01	0.01	0.09
Smoking		OR			
Physical activity low	1060	0.98	0.97 to 0.99	0.0001	
Physical activity high	347	0.95	0.94 to 0.97	0.0001	0.005

smoking between examination years in the group of women with high physical leisure time activity compared with the group with low physical activity, also when taking into consideration that later born cohorts generally had lower mean values and were more physically active. However, since a significant association between leisure time exercise and SES could be discerned in most examinations, controlling for SES was carried out, whereby no significant difference remained for DBP and s-triglycerides, but decline of smoking remained significantly more pronounced in the group of 38-year-old women with high physical activity (see Table V).

Discussion

Cohort comparisons concerning cardiovascular risk factors in men and women have been published earlier, but rarely for such a long time span as 36 years. Cohort comparisons have been performed in a Swedish part of the MONICA study describing random samples of men and women aged between 25 and 64 showing trends from 1985 to 2002 of increase of mean BMI, SBP, and DBP [12]. Total cholesterol concentration and levels of LDL-cholesterol declined between 1985 and 1995 for all ages but s-triglyceride levels increased for men and women between 1985 and 1995, levelling off between 1995 and 2002. Prevalence of smoking decreased from 39% to 25% in women from 1985 to 2002. In a Finnish study of secular trends between 1986 and 2001 in 24-year-old subjects, BMI and s-triglyceride levels increased in young adults and, at the same time, the levelling off of s-cholesterol was slow [13]. In an Austrian study, from 1985 to 2005, SBP, DBP, s-cholesterol, and triglyceride levels declined markedly in the later born cohorts in both men and women, but b-glucose levels were higher [14]. The lowering of population risk factor levels could reflect both lifestyle and other changes in society as well as birth cohort effects, e.g. pre- and postnatal as well as early exposures [14,15].

In our study, no significant differences in mean BMI were observed between earlier and later born cohorts, in contrast to observations of secular trends in other age groups. Both in younger and in older cohorts, increases in BMI have been observed in other studies [12–14,16].

A marked decline in cigarette smoking frequency was noted between 1992 and 2004, especially in the 38-year-old cohorts, but the trend was present in all four examinations during the 36-year period. Similar trends have been reported in other studies [16]. The proportion of women active in leisure time exercising was significantly higher in later born cohorts, as also has been observed in the MONICA study [12]. In our study, when controlling for SES, differences in risk factors became attenuated in the group of women more physically active compared with the group less physically active. Only smoking still showed significance, indicating a social gradient in the beneficial changes.

The main weakness of this study is the declining participation rates throughout the years, initially 90%, declining to around 60% in 2004–2005. Comparable participation rates have been observed

in other population surveys [14,17]. This can partly be explained by changes in society; i.e. women spend more time outside the home and also seem to have less spare time [3]. In the 2004–2005 examination participation rate was higher in women with higher income and those born in Sweden. There were no differences in hospital admission rate, marital status, or places of living between participants and non-participants. Taken all together, non-participants were more likely to belong to a lower socioeconomic group as observed in most population studies, but it seems acceptable to consider the results as reflecting the true trends given their accordance with other studies. However, we cannot exclude the possibility that improvement in CVD risk factors could be biased.

In conclusion, trends in lifestyle changes in 38- and 50-year-old cohorts of women have been substantial during the last 36 years and in a healthier direction, especially concerning physical activity and smoking. This could be due to changes in living conditions not only in adult life but also in early life. Most of the positive trends in CVD risk factors were observed in groups with both low and high physical activity levels.

Ethical approval

The study was approved by the Ethics Committee of University of Gothenburg.

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There were no conflicts of interest.

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