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## Cardiovascular risk factor profiles and their social gradient from adolescence to age 74 in a Swiss region

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### Abstract

**Background.** Few European studies have investigated how cardiovascular risk factors (CRF) in adults relate to those observed in younger generations.

**Objective.** To explore this issue in a Swiss region using two population health surveys of 3636 adolescents ages 9–19 years and 3299 adults ages 25–74 years.

**Methods.** Age patterns of continuous CRF were estimated by robust locally weighted regression and those of high-risk groups were calculated using adult criteria with appropriate adjustment for children.

**Results.** Gender differences in height, weight, blood pressure, and HDL cholesterol observed in adults were found to emerge in adolescents. Overweight, affecting 10–12% of adolescents, was increasing steeply in young adults (three times among males and twice among females) in parallel with inactivity. Median age at smoking initiation was decreasing rapidly from 18 to 20 years in young adults to 15 in adolescents. A statistically significant social gradient in disfavor of the lower education level was observed for overweight in all age groups of women above 16 (odds ratios (ORs) 2.4 to 3.3,  $P < 0.01$ ), for inactivity in adult males (ORs 1.6 to 2.0,  $P < 0.05$ ), and for regular smoking in older adolescents (OR 1.9 for males, 2.7 for females,  $P < 0.005$ ), but not for elevated blood pressure.

**Conclusion.** Discontinuities in the cross-sectional age patterns of CRF indicated the emergence of a social gradient and the need for preventive actions against the early adoption of persistent unhealthy behaviors, to which low-educated girls and women are particularly exposed.

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### Introduction

In developed countries, cardiovascular diseases (CVDs) are the leading cause of mortality among adults, especially the elderly, and generate a major burden of morbidity throughout life [1]. Besides the genetic components of CVD, many of the risk factors have been identified as early as in fetal life and early childhood [2–6]. Prospective and retrospective studies have shown that risk factor levels found in childhood and adolescence correlated with those

observed later [7–9]. In addition, it has been demonstrated that the lifestyles and behaviors (such as diet, exercise, and smoking) that greatly determine the risk of CVD are often learned and adopted early in life [10]. The interest of measuring the level of risk factors in childhood and adolescence lies in the assessment of the immediate prevention potential in a given region, and in the subsequent possibility to modify the natural course of disease by helping adolescents to make healthier choices [11–13].

Ideally, studies with mixed cross-sectional and longitudinal designs would best investigate the rapid changes in CVD risk factor profiles occurring in youths, and how they relate to adult profiles. However, such studies are expensive, and the need persists for population-based data from different ethnic, cultural, and economic settings that document

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these changes. A large spectrum in the adult distribution of the risk factors has been observed in Europe, with a North–South gradient [14]. The causes and consequences of this disparity remain unestablished, in particular with regard to the early development of risk factors.

Our study region, located in the middle of Europe at the crossroads of Nordic and Mediterranean cultures, may provide an interesting insight in this respect. In Europe, health surveys similar to the National Health And Nutrition Examination Survey (NHANES) in the United States have been carried out extensively within the framework of the international MONICA project (MONItoring trends and determinants in CARDiovascular diseases), but were restricted to the middle adult-age range (35 to 64 years) [15]. In the MONICA Swiss region of Vaud-Fribourg (800,000 residents), the age range was extended from 25 to 75 years. At about the same time, a similar survey was conducted on a large sample of children and adolescents, offering the opportunity to link the two data sets.

Adults from a low socioeconomic background (and children through their parents) have been shown to adopt an adverse lifestyle more often, and therefore display higher levels of CVD risk factors [16,17]. If it appeared to be true in Switzerland too, this information could be used to target these groups for different types of interventions and to tailor general population preventive strategies to their special needs.

The objectives of this study were (1) to describe the current gender-specific cardiovascular risk factor profiles of the Swiss population over the widest possible age range (9 to 74); (2) to determine the social gradient of these risk factor profiles by considering two education levels; and (3) to assess whether significant social differences in risk factors observed in adulthood are likewise found in the younger age groups (which would give credit to the hypothesis of a social origin of CVD), or whether significant social differences are emerging among children and adolescents that are not currently observed in adulthood.

## Populations and methods

### *Health examination survey of children and adolescents*

A survey on sport and health in children and adolescents was conducted from September 1996 to March 1997 in the schools of the Canton Vaud, Switzerland. Details of the study design have been given previously [18]. A two-stage cluster sampling procedure was used to select school classes from the 4th, 6th, 8th, 10th, and 11th grades stratified by region and type of school (high school, professional school, etc.). The resulting sample comprised 3,636 subjects drawn from the reference population of 30,754 children of ages 9 to 19. Despite missing grades, all ages were represented because academic

and calendar years overlap, and also because school failures generate age lags. The participation rate was 96.2% (135 were absent from school and 3 refused), yielding 3,498 subjects for analysis. A self-administered questionnaire was distributed at school during a physical exercise session, asking about physical and sport activities, lifestyle, and socioeconomic environment. Anthropometric measurements (weight wearing underwear only on a Ross beam balance to the nearest 100 g, standing height without shoes with a portable Harpenden stadiometer to the nearest 0.1 cm) were taken by trained school nurses. Two readings of blood pressure (BP) were taken with one of three available cuff sizes according to the arm's circumference, using a regular sphygmomanometer (Erka), after a 15-min rest and in the sitting position, with diastolic BP determined at the beginning of Korotkoff phase V. Only the lowest value was recorded in the data base. A subsample of 238 4th- and 6th-graders, ages 11 to 14 (every sixth subject, with replacement of refusals by the next child on the list), had a venous blood test including fasting total serum cholesterol (TC) and high-density lipoprotein cholesterol (HDL) using a Biomérieux kit.

### *Health examination survey of adults (MONICA project)*

Three population-based surveys (1985–1986, 1989–1990, 1992–1993) were conducted in the canton of Vaud and the adjacent small canton of Fribourg within the framework of MONICA. Data presented here come from the most recent survey. Methods have been described elsewhere [19]. The two-stage sampling procedure first consisted in drawing a sample of 51 out of 645 communes after stratification according to their size and, secondly, in drawing subjects from the population files of the commune. A commune is an administrative division comprising a village, a group of villages, or a city and their surrounding territory. Selected subjects were invited to attend a health examination and to answer a self-administered questionnaire about their sociodemographic and health-related characteristics. In Vaud and Fribourg, 3,299 individuals ages 25–74 years were invited to participate in the study, and 1,742 (53%) attended.

BP was measured twice consecutively on the right arm using a random-zero sphygmomanometer, in a sitting position after at least 15 min of rest. BP readings were recorded to the nearest 2 mmHg, with diastolic BP determined at the beginning of Korotkoff phase V. The same cuff size was used for all subjects. The lowest of the two measures were used in this analysis in order to comply with the children's survey. Standing height was measured on a SECA stadiometer to the nearest 0.5 cm, and weight to the nearest 100 g, without shoes and heavy outer garments (SECA beam balance). Venous blood samples were obtained from nonfasting participants, with TC and HDL measured in serum (Boehringer kit).

### Definition of risk categories

Overweight and obesity were defined for adults as a body mass index (BMI = weight (in kilograms)/squared height (in meters)) greater than 25 and 30, respectively. As these cut-off limits have been considered inappropriate for children and adolescents [1,20–22], we adopted those recently established in an international study and based for each gender on the age-specific BMI centile curves reaching the values of 25 and 30 at age 18 [23]. Elevated BP for adults was defined as systolic BP  $\geq$  140 and/or diastolic BP  $\geq$  90, according the latest international criteria [24]. Unfortunately, these criteria do not apply to children, whose BP is largely determined by body size and growth rate. Recently published cut-off limits for elevated BP in children are based on the 95th percentiles of the gender-, age-, and height-specific distributions of systolic and diastolic BP among American children [25], but they may not apply to European populations with different anthropometric characteristics. Therefore, we used a height-adjustment method for BP which was developed in a French population [26]. Expected BP levels were first calculated by linear regression of systolic BP and diastolic BP on height, separately for each gender. Second, projected height at age 18, given height at current age, was based on the assumption that boys and girls keep their rank in the age-specific distribution of height over time, and expected BP at age 18 was estimated from the regression model. Third, projected BP levels at age 18 were estimated by transposing the difference between observed BP and expected BP at current age. Finally, the same criteria used for adults were applied to these projected BP levels at age 18 to classify the children as having elevated or normal BP.

Smoking habits and physical activity levels were classified the same way for children and adults on the basis of common survey questions. Subjects smoking more than one cigarette per day were considered regular smokers. The question on physical activity was based on the frequency of sport practice in general (i.e., at school and during leisure time); those never practicing sports were categorized as inactive. Information related to sport activity and smoking were elicited only from 8th-graders and over.

### Social gradient

The educational system of the Canton of Vaud is based on the selection of pupils for various tracts of study at age 11 (grade 7). From there on, about 30% of children are admitted into classes leading to high school, and then to college/university. Another third follows an intermediate channel preparing either for high school or for professional schools (apprenticeship), but not university. The last third is enrolled in classes leading to apprenticeships or to unskilled jobs. Compulsory school ends at age 15, but 75% of adolescents continue beyond that age in professional centers (apprenticeship) or in high school. High school and college

were considered the “high” education level in this study, and preapprenticeship and apprenticeship the “low” education level. Since these levels have been shown to correlate well with father’s occupation, they were used as a proxy for social class in this study [27–29]. Adults were classified in the low or high education level according to whether they had completed their highest degree respectively before or after the age of 18 (the end of high school).

### Statistical methods

The cross-sectional population profiles of the anthropometric and physiological variables under study were obtained by the smoothed curves of their individual values across age, separately for each gender and educational level. Robust locally weighted regression (LOWESS technique) was used as a scatterplot smoothing method to determine these curves [30]. Multivariate logistic regression assessed the association between selected risk categories and education level after adjustment for age within broad gender and age groups. Statistical analyses were performed on SPSS [31] and STATA [32] software.

### Results

The population profile of the anthropometric measures (height, weight and BMI) and physiological parameters (SBP, DBP and blood lipids) are shown in figures 1 to 6. For the former set of variables, median levels and frequency prevalence rates of overweight and obesity, as well as those of physical inactivity are presented in Table 1 according to gender and age. For the latter set of variables, corresponding figures are given in Table 2 while similar results on smoking habits are displayed in Table 3. The increased exposure to selected risk categories (overweight, high blood pressure, inactivity and regular smoking) of persons in the low educational level, as compared with those in the high level, are shown for both genders and several age groups in the form of odds ratios (Table 4).

#### Height, weight, and body mass index

The population profile of height was characterized by a steep increase across the childhood and adolescence age range, followed by a stabilization and a slight decrease across adult cohorts (Fig. 1). The gender-specific height curves were nearly superimposable in the age range 9–14 years, but diverged beyond. Considering median values, height leveled off beyond age 14 at 164–165 cm in women and beyond age 17 at 177–178 cm in men (Table 1). The slow decrease in median height with age observed in adults corresponded to a difference of 7 cm in men and 5 cm in women between those of ages 25–34 and those of ages 65–74. A social gradient in the height curves was apparent, starting at adolescence and maintained throughout adult-

Table 1  
Median values of weight, height, BMI, and prevalence rates of overweight, obesity and inactivity by gender and age groups, Vaud–Fribourg 1992–1997

Age (completed years)	Sample size <i>n</i>	Weight (kg) (median)	Height (cm) (median)	BMI (kg/m <sup>2</sup> ) (median)	Overweight [23] (%)	Obesity [23] (%)	Inactivity (%)
Male							
9	123	32.7	139.0	16.8	17.1	2.4	NA
10	178	34.2	142.0	17.2	14.6	0.6	NA
11	164	39.4	149.0	17.8	13.4	0.6	NA
12	180	42.5	153.0	18.0	13.9	2.8	NA
13	136	49.0	163.0	18.7	12.5	2.9	12.6
14	200	55.7	168.0	19.7	14.0	2.5	9.0
15	141	59.5	173.0	19.7	11.3	4.3	11.6
16	178	63.7	176.0	20.6	10.7	1.1	9.6
17	191	66.6	177.0	21.1	12.0	1.6	10.5
18–19	174	68.4	178.0	21.4	10.9	1.1	17.0
25–34	196	74.7	177.0	24.0	35.7	5.6	33.7
35–44	230	79.3	176.0	25.6	55.7	13.5	46.7
45–54	194	79.8	174.0	26.4	67.5	20.1	52.8
55–64	137	81.6	173.0	27.1	71.5	17.5	50.7
65–74	86	79.4	170.0	27.3	76.7	30.2	61.2
Female							
9	154	32.2	138.0	16.9	18.8	3.9	NA
10	194	33.8	141.0	16.9	16.5	4.6	NA
11	176	40.7	150.0	17.9	15.9	2.3	NA
12	196	45.3	155.0	18.7	11.7	2.0	NA
13	148	49.8	160.0	19.1	10.1	0.0	15.9
14	189	53.7	164.0	20.1	12.7	2.1	14.1
15	163	54.9	164.0	20.7	9.8	0.0	17.2
16	193	58.0	164.0	20.9	10.9	1.0	21.5
17	145	57.7	164.0	21.2	11.0	1.4	20.0
18–19	123	59.2	165.0	21.4	12.2	1.6	23.5
25–34	214	59.8	163.0	22.3	20.6	5.6	44.6
35–44	244	59.4	163.0	22.6	28.3	5.3	44.3
45–54	208	63.7	161.0	24.4	44.2	9.6	49.0
55–64	127	66.4	161.0	25.9	60.6	17.3	53.2
65–74	106	65.8	158.0	26.5	68.9	19.8	68.3

Note. NA, not available.

hood. With regard to median height, adults in the low educational level were shorter by 3 cm than those in the high educational level (data not shown).

The weight curve also showed a rapid increase across childhood and adolescence, but with a clear separation of the gender-specific curves starting in adolescence, and a further increase throughout adulthood (Fig. 2). Males were heavier than females by about 0.5 kg at age 10 (median weight), 4.5 kg at age 15, and 15 kg in the adult age groups (25 to 74 years). There was an inversion of the social gradient in weight at age 20 in women and at age 40 in men. Median weight was higher among the high-educated adolescents (boys and girls) and men over 40 than among their less-educated counterparts, while the opposite was true among adult women.

The population profile of BMI followed the age pattern of weight (Fig. 3). No consistent gender or social difference in BMI was apparent in childhood and adolescence. A clear separation in gender-specific BMI curves was observed only in adulthood, with men having higher BMI levels than

women. A social gradient emerged in young adults of both genders in favor of the more educated group, which tended to disappear with age for men but to widen for women.

#### *Overweight, obesity, and physical inactivity*

The prevalence rates of overweight (including obesity) exhibited a J-shaped curve in relation with age, starting at 17–18% in children age 9, followed by 9–10% in adolescents ages 15–16, and then jumping in early adulthood to 36% in men and 20% in women, followed by a gradual increase in the adult age range up to 77% in men and 69% in women. The proportion of obesity in the overweight category increased between 35–44 and 65–74 years, from 24 to 39% in men, and from 19 to 29% in women (from Table 1). Adult men were much more frequently overweight than women, especially in their main active years (between 25 and 44). Furthermore, the proportion of overweight subjects increased faster across men's cohorts, starting somewhere between 19 and 25 years, but only after 45 in women.

Table 2  
Median values of blood pressure and lipids, by gender and age groups, Vaud–Fribourg 1992–1997

Age (completed years)	Systolic blood pressure (mmHg) (median)	Diastolic blood pressure (mmHg) (median)	Elevated blood pressure <sup>a</sup> (%)	Sample size <i>n</i>	Total cholesterol (mmol/liter) (median)	HDL (mmol/liter) (median)
<b>Male</b>						
9	106	70	19.5	0	NA	NA
10	104	70	15.6	0	NA	NA
11	106	72	14.0	29	4.7	1.4
12	108	70	7.7	21	4.3	1.2
13	112	74	11.0	20	4.6	1.4
14	116	76	15.5	35	4.1	1.1
15	118	76	18.4	0	NA	NA
16	120	80	19.3	0	NA	NA
17	122	80	18.6	0	NA	NA
18–19	124	80	23.8	0	NA	NA
25–34	124	76	21.5	192	5.5	1.2
35–44	126	80	25.8	223	6.0	1.2
45–54	128	84	33.0	191	6.3	1.2
55–64	134	84	47.8	134	6.5	1.2
65–74	149	82	69.8	85	6.3	1.2
<b>Female</b>						
9	104	72	13.7	0	NA	NA
10	104	68	11.3	0	NA	NA
11	106	70	8.5	15	4.9	1.3
12	106	72	6.1	30	4.6	1.4
13	110	74	4.7	37	4.3	1.3
14	108	76	8.4	27	4.7	1.4
15	110	76	9.8	0	NA	NA
16	114	77	7.3	0	NA	NA
17	117	80	15.2	0	NA	NA
18–19	116	78	9.4	0	NA	NA
25–34	112	70	1.9	205	5.2	1.5
35–44	115	74	9.8	239	5.4	1.5
45–54	120	78	16.8	206	6.0	1.5
55–64	128	80	31.5	127	6.6	1.4
65–74	140	80	54.7	100	6.9	1.4

<sup>a</sup> SBP  $\geq$  140 and/or DBP  $\geq$  90, with adjustment to height for children and adolescents (see Populations and methods). The sample size for blood pressure at each age is the same as in Table 1 (column 2).

From 35 years on, more than half of the men were found to be overweight, while the same was true for women only after 55.

The prevalence rates of physical inactivity in men remained constant around 9–12% in adolescents until age 17, before steadily rising across higher age groups with a doubling between 18 and 25 (from 17 to 34%). A similar pattern prevailed in women with a more rapid take-off in adolescence and comparable prevalence rates in middle-age (35 to 64 years). Overweight (including obesity) displayed a clear social gradient, with the odds of having a BMI over 25 being at least 50% higher among subjects from the low educational level compared to those from the high level. Odds ratios were highest in adults ages 25 to 44. After 44 years, the social gradient was only observed for women. Similarly, physical inactivity tended to be more frequent in the low education group, except for boys ages 16 to 19. The highest social gradient, with odds ratios above 2, was found for adults over 45 (Table 4).

### Blood pressure and lipids

The population profile of systolic blood pressure (Fig. 4) was characterized by a rapid increase across childhood and adolescence, a leveling-off in the young adult age range (25–45 years), and a further rise in older adults. The gender-specific curves were similar for children, but started to diverge in adolescence. They were then kept separate in adults, with men having higher levels of systolic BP than women (by a median of 8 mmHg). An inverse social gradient of systolic BP was observed in adolescents and young adults ages 15–35 according to gender, with a tendency toward higher levels among low-educated men and high-educated women. A crossover in the systolic BP curves between the two educational levels occurred in women after age 34.

In comparison to systolic BP, a similar age pattern was observed for the gender-specific population profile of diastolic BP, but a different social gradient (Fig. 5). Low-educated

Table 3  
Smoking habits, by gender and age groups, Vaud–Fribourg 1992–1997

Age (completed years)	Never smokers	Ex-smokers (%)	Occasional smokers (%)	Regular smokers (%)	Number of cigarettes per day <sup>a</sup> (mean)	Median age at start <sup>b</sup>
<b>Male</b>						
13	79.6	4.6	8.3	7.4	6.3	—
14	80.0	4.0	6.5	9.5	7.2	—
15	66.0	2.7	10.9	20.4	8.0	—
16	59.8	3.2	15.9	21.2	8.1	—
17	59.2	2.5	15.4	22.9	9.2	—
18–19	50.0	3.2	17.6	29.3	10.9	15.0
25–34	47.4	11.9	3.6	37.1	20.5	17.0
35–44	31.9	27.5	6.6	34.1	23.0	17.0
45–54	34.7	38.9	6.2	20.2	20.1	18.0
55–64	38.2	32.4	5.1	24.3	19.4	18.0
65–74	36.0	46.5	3.5	14.0	14.5	18.0
<b>Female</b>						
13	73.1	7.7	12.3	6.9	4.8	—
14	68.0	7.1	16.2	8.6	5.3	—
15	63.1	5.7	13.6	17.6	8.5	—
16	54.7	6.4	20.2	18.7	8.8	—
17	57.5	5.5	15.1	21.9	9.0	—
18–19	54.1	3.0	14.8	28.1	9.2	15.0
25–34	43.2	15.5	7.0	34.3	16.5	17.0
35–44	44.9	15.6	8.2	31.3	18.1	19.5
45–54	56.6	17.6	3.9	22.0	18.3	20.0
55–64	69.3	8.7	4.7	17.3	13.3	20.0
65–74	85.3	6.8	0	9.7	8.5	25.0

Note. The sample size at each age is the same as in Table 1 (column 2).

<sup>a</sup> Smokers only.

<sup>b</sup> This variable was omitted below 18, because it would be biased toward lower ages, as many children have not yet been exposed to the risk of smoking.

adolescents and young adults of both sexes had higher levels of diastolic BP. This social gradient tended to vanish in middle-aged adults and emerged again in older adults.

The prevalence rates of elevated BP followed a J-shaped curve in relation to age and paralleled overweight rates (Table 2). Even after adjustment for height, elevated BP was found relatively frequently in children (20% in boys and 14% in girls at age 9), then was least common among preadolescents of ages 12–13, and became increasingly prevalent across age groups in adolescence and adulthood. Men had higher prevalence rates over women by about 15%. The social gradient of elevated BP was weak except for young boys (Table 4).

Total cholesterol followed a regular upward trend with age, stabilizing after age 55 in men, and reaching a plateau between ages 30 and 40, then increasing again and crossing the men's curve at age 55 in women (Fig. 6). A clear separation of the gender-specific HDL curves emerged at adolescence, with men having lower levels of HDL than women.

### Smoking

Adolescents at the time of the survey (1996–1997) reported to have started smoking much younger (median age around 15) than did adults from older cohorts (median age 18–25). At age 13, about 7% of children of both genders were smoking reg-

ularly, and 8% of boys and 12% of girls occasionally (Table 3). The proportion of regular smokers doubled between 14 and 15 years of age, while that of occasional smokers remained stable. The peak in regular smoking occurred in young adults (age range 25–34), and then the proportion of ex-smokers started to increase among older cohorts, paralleling the slow decrease in the proportion of regular smokers.

Overall, tobacco consumption was higher for men than for women, although young low-educated women smoked more heavily than young high-educated men (Fig. 7). Adults of age 45 and over smoked about the same amount of cigarettes whatever their level of education, but a social gradient appeared in younger cohorts, with a higher daily consumption in low-educated subjects (about 22 cigarettes vs 16 for men, and 18 vs 14 for women). Controlling for age, the odds of smoking doubled for low-educated boys ages 16 to 19 compared to high-educated boys, and almost tripled for girls this age (Table 2). This social gradient was present, but not significant, at all other ages.

### Discussion

This study provides a direct comparison of the cardiovascular risk factor levels between children/adolescents and adults in Switzerland. Because it is based on cross-sectional

Table 4  
Age-adjusted odds ratios for selected cardiovascular risk categories by educational level, Vaud–Fribourg 1992–1997

Age group (years)	Overweight <sup>a</sup>		Elevated blood pressure (140/90) <sup>b</sup>		Inactivity		Regular smoker	
	OR <sup>c</sup>	P	OR <sup>c</sup>	P	OR <sup>c</sup>	P	OR <sup>c</sup>	P
<b>Male</b>								
11–12	2.34	*	3.03	*	NA	NA	NA	NA
13–15	2.12	**	1.33	NS	1.40	NS	1.29	NS
16–19	1.39	NS	1.08	NS	0.93	NS	1.92	***
25–44	2.26	***	1.01	NS	1.58	*	1.53	NS
45–64	1.32	NS	1.44	NS	2.01	**	1.42	NS
<b>Female</b>								
11–12	1.86	NS	1.43	NS	NA	NA	NA	NA
13–15	1.54	NS	1.09	NS	1.41	NS	1.06	NS
16–19	2.39	***	0.84	NS	1.57	NS	2.70	***
25–44	3.27	***	2.49	NS	1.32	NS	1.17	NS
45–64	2.26	**	1.62	NS	2.19	*	1.47	NS

<sup>a</sup> BMI ≥ 25, with correction for children and adolescents according to Cole et al. [23] (see Populations and methods).

<sup>b</sup> SBP ≥ 140 and/or DBP ≥ 90, with adjustment to height for children and adolescents (see Populations and methods).

<sup>c</sup> ORs are given for the low educational level, with the high educational level as the reference category.

Note. NA, not available; NS, not significant. Odds ratios were not computed for children below 11 because there were all in the same education level, or for adults above 64 because there were not enough subjects in the high-risk categories (women in particular).

- \*  $p < 0.05$ .
- \*\*  $p < 0.01$ .
- \*\*\*  $p < 0.005$ .

surveys, the age pattern of risk factors across consecutive cohorts should not be mistaken for a life span perspective on their natural development. However, as far as anthropometric and physiological parameters are concerned, cross-sectional

differences in risk factor levels between age groups are more likely to reflect age effects than cohort effects. First of all, the age-related evolution of these variables is mainly driven by rapid physical changes during childhood and adolescence, and at menopause for women, whereas it may be affected to a greater extent by variations in environment and lifestyle during adulthood. But then, only small changes in age-specific mean levels have been observed in the study region over the MONICA monitoring period (1984–1993) [19]. This implies in particular that the time-course development of these risk factors in today’s children and adolescents is likely to follow approximately the age patterns observed in today’s adults.

For many variables (height, weight, BP, and HDL), average levels as well as gender differences increased rapidly with age in adolescents and tended to stabilize among adults. Such patterns reflect the predominant effect of somatic growth and sexual maturation, which proceed at different rates in boys and girls. These processes determine not only the development of height and weight, but also that of many physiological and metabolic parameters (BP and blood lipids) related to body size [33,34]. A social gradient in growth pattern was also observed, with children in the higher education level growing faster and adults with higher educational achievement being taller on average. These differences could be partially explained by genetic factors, as first- and second-generation immigrants from Southern European countries tend toward both shorter stature and lower education level. Unfavorable environmental and nutritional conditions also affect children of lower socioeconomic status more heavily during fetal life and infancy [2,35]. These conditions seem to have generally improved over time in Switzerland, since younger adult cohorts tend to be on average taller than older ones (as mirrored by the

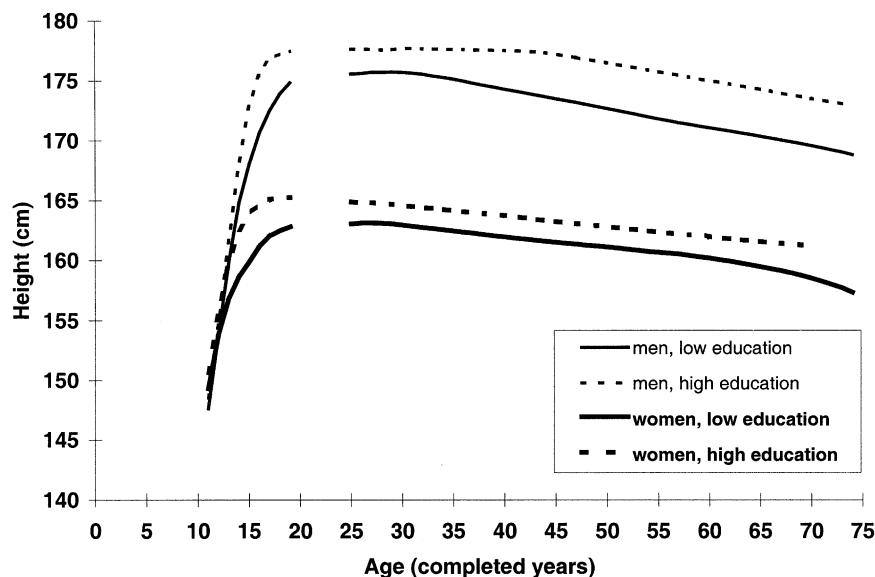


Fig. 1. Smoothed curves of height according to age, gender and education level, Vaud–Fribourg 1992–1997.

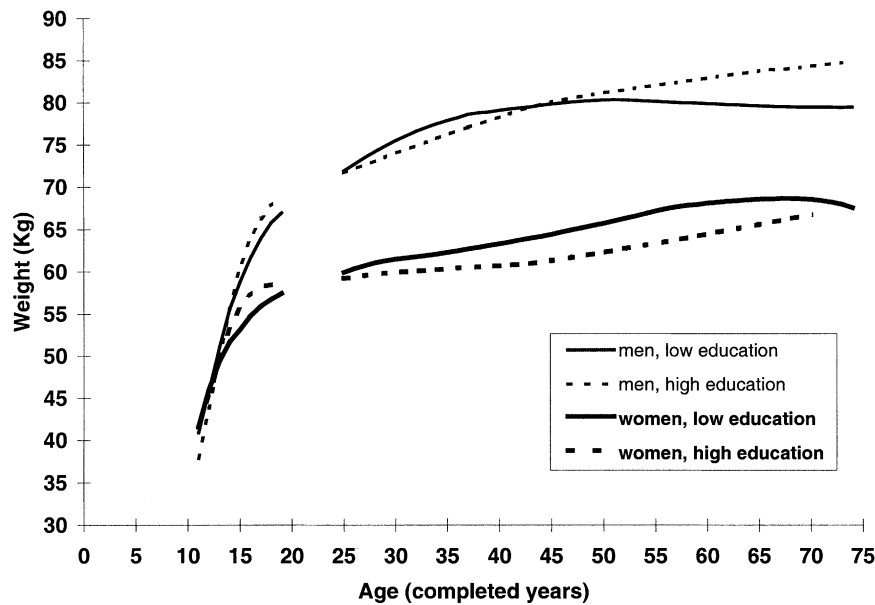


Fig. 2. Smoothed curves of weight according to age, gender and education level, Vaud-Fribourg 1992–1997.

slow regression in height with increasing age across these cohorts).

The developmental stage (using height, for example) should be accounted for in the assessment of CVD risk factor levels in children and adolescents. However, appropriate adjustment turns out to be difficult, because weight-for-height indicators commonly used for adults display large fluctuations during the growth process and cannot be used to define age-independent risk categories [9]. In this study, we applied adult cut-off limits of BMI and BP to the projected values at age 18 of observed values at earlier ages.

The use of these criteria resulted in J-shape age patterns for the prevalence rates of obesity and elevated BP, with more children and older adolescents classified at risk than young adolescents. The assumption of body development tracking may be wrong, in that neither prepubertal height and weight percentiles nor BP and BMI data may actually be predictive of later rank. In any case, the transition from childhood to adolescence appears to be a pivotal point in developing and maintaining healthy lifestyle and dietary habits.

Disruptions were observed in our comparison of risk factor levels between adolescents and young adults (other

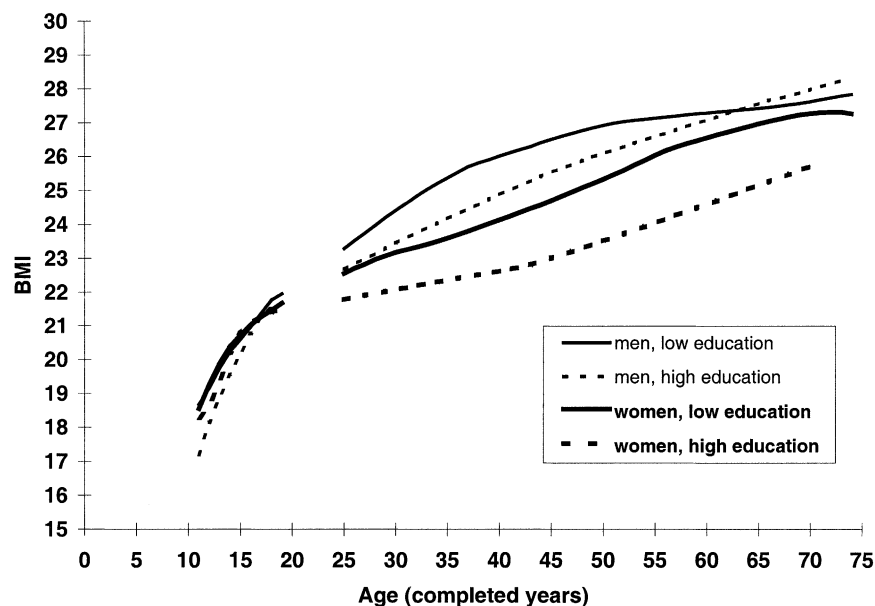


Fig. 3. Smoothed curves of BMI according to age, gender and education level, Vaud-Fribourg 1992–1997.

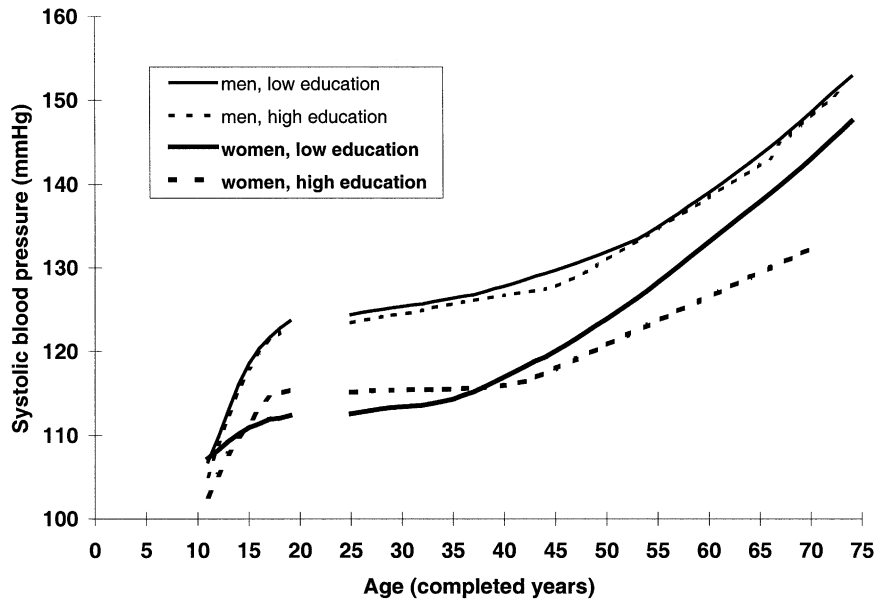


Fig. 4. Smoothed curves of systolic blood pressure according to age, gender and education level, Vaud-Fribourg 1992–1997.

than the age gap in the data). The most important was the steep rise in the prevalence rates of overweight and leisure-time physical inactivity. The parallel age patterns of overweight and sedentary lifestyle strongly suggest a link between the two. This link was reinforced by the emergence of an unfavorable social gradient concomitant to the abandon of regular exercise during adolescence and young adulthood, somewhat delayed in boys who maintained physical exercise for a longer time (around 90%) in both education levels, while decreasing gradually with age for girls, as has been shown in other studies [36]. Factors other than physical inactivity may contribute to the strong social gradient of overweight observed in women, such as a higher compliance to lean body standards and increased resources and opportunities to achieve them for high-educated women, who are likely to have higher incomes.

Cohort effects in smoking habits, i.e., the decreasing prevalence of women who have never smoked and the increasing precocity of initiation in the younger generations, are gradually exposing a larger proportion of adolescents to a high risk of CVD (as well as cancer and respiratory diseases), in particular among those in the low education level. The latter will presumably smoke greater lifetime amounts of cigarettes than their counterparts in high school and college, amplifying the pattern observed in their parents' generation. A comparable cross-sectional age pattern in the rates of regular smokers was found in both sexes, but the rate of ex-smokers was higher in men, suggesting that women are more reluctant to quit. Even if the prevalence of smoking is lower than in other countries, unless the incentives to smoke are strongly contended with, the prospects of tobacco con-

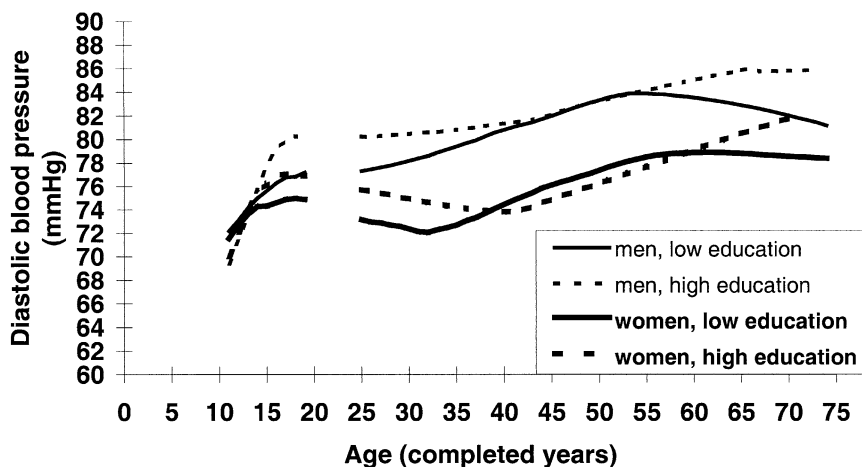


Fig. 5. Smoothed curves of diastolic blood pressure according to age, gender and education level, Vaud-Fribourg 1992–1997.

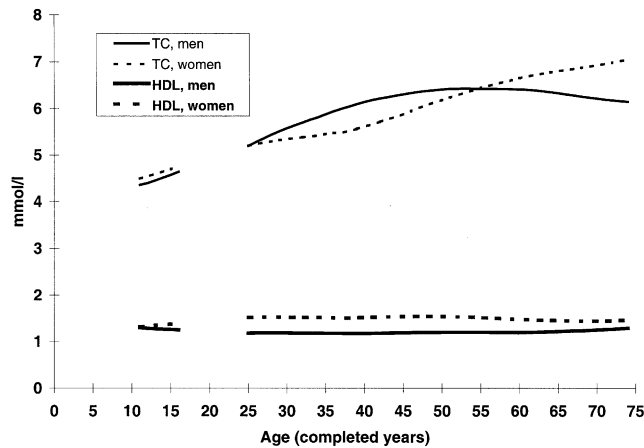


Fig. 6. Smoothed curves of total cholesterol (TC) and HDL according to age, gender and education level, Vaud-Fribourg 1992–1997.

sumption in Switzerland consist in the widening of the observed social gradient and gender differences due to the vulnerability of the less-educated adolescents to their environment (peer pressure, advertising, and social norms) [37]. Currently, a comprehensive strategy to prevent smoking by youths is lacking in this country, with no information campaigns, no price policy, and no restriction on advertising [38]. Switzerland even recently appeared in a WHO report as one of the most favorable places for the tobacco industry to develop its activities [39].

To what extent the school selection system in Vaud leads to the emergence of earlier and wider social differences in behaviors, lifestyles, and cardiovascular risk is difficult to assess. Social gradients in leisure-time physical inactivity, overweight, and smoking have been reported to emerge at adolescence in several studies [16,21,40]. Furthermore, adolescents who dropped out of the educational system were not surveyed; a previous study in Vaud showed that they adopt adverse lifestyles more frequently and, therefore, are likely to contribute to the social gradient in cardiovascular risk factors [41].

In the international context, the cardiovascular risk profile of adults in the study region can be compared to those observed in the other 38 MONICA collaborating centers [14]. Swiss adults were characterized by low rates of CVD incidence and mortality, and with respect to risk factors, by low levels of BP, intermediate levels of BMI and smoking, and high levels of TC. Similar international data based on standardized measurements are scarce for children and adolescents. Compared to American children, Swiss children had comparable height-adjusted BP levels, lower BMI levels, and higher TC [21,42,43]. As for daily smoking between 11 and 15 years. Switzerland ranked in the lowest tertile among the 28 participating countries in the WHO international study on Health Behaviors in School Children [44]. These findings suggest

that the cardiovascular risk profile did not demonstrate a substantial intergenerational shift at the international level.

There are limitations to some of the indicators used in this study. Our very general measure of physical activity did not specify the intensity or amount of energy expenditure [45], and high-risk categories for risk factors in adolescence were constructed on an experimental basis in absence of well-established methods. There were also slight differences in measurement techniques between the two surveys. For blood lipids in particular, absolute levels may not be strictly comparable, but differences in measurement should not affect trends and gender differences which are the focus of this article, nor the emergence of risk patterns in childhood that display a logical continuity with adults' curves. Finally, our definition of social class only encompassed one of its dimensions (education).

In conclusion, our study demonstrated that useful information can be drawn from the cross-sectional cardiovascular risk factor profiles of a given population over the largest possible age range. There was evidence for the emergence of a social gradient in terms of CVD risks, and for the need for preventive actions against the early adoption of unhealthy behaviors and lifestyles. Exercise in adolescence should be more vigorously promoted and sustained, in particular among people who received a low education, and this independently of the amount of physical activity they may have while working [46]. Environmental measures should be emphasized, such as the diversification of the sports choices and curricula within and outside the education system. In addition to its effect on weight regulation, physical activity has been shown to trigger bone mineral acquisition (reducing the risk of hip fracture in the elderly) and to correlate with healthier dietary habits and other positive health-related behaviors [47–49].

Young girls and women from low social background in

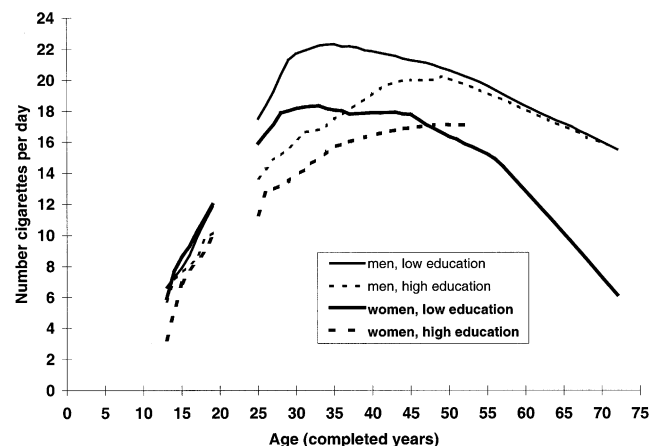


Fig. 7. Smoothed curves of the number of daily cigarettes consumption according to age, gender and education level, Vaud-Fribourg 1992–1997.

Vaud-Fribourg should be especially encouraged to adopt a less sedentary lifestyle and healthier dietary habits. Since diet and other health-related behaviors are transmitted by parents as early as infancy, health promotion programs directed to young families and starting at delivery should be funded, with special—but nonexclusive—emphasis on low socioeconomic groups. This study provides a much needed attempt at continuity between children, adolescent, and adult research, since as in clinical practice or in prevention activities, these populations are usually studied separately [12].

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