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Prevalence of hypertension, hypercholesterolemia, smoking and overweight in older Belgian adolescents

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Background: Risk factors in young adulthood may persist into later life and eventually lead to cardiovascular (CV) disease. The purpose of this study was to describe the prevalence of hypertension and other established CV risk factors in older adolescents. Methods: Study nurses examined 120 girls and 80 boys with a mean age of 17.4 (SD, 0.8; range 15.8–19.6 years). After 5 minutes of sitting rest, resting blood pressure (BP) of the participants was measured in triplicate by sphygmomanometry. Body height and weight were measured and body mass index (BMI) was calculated. Serum lipids, smoking and drinking status were assessed. Hypertension was diagnosed according to the criteria specified in the 1996 update of the Task Force on BP treatment in Children and Adolescents (Pediatrics 1996;98:649–58). Results: Almost 25% of the subjects currently smoked with a median daily consumption of 6 (Interquartile 4–9) and 11 (6–16) cigarettes in girls and boys, respectively. Fourty-nine (41%) girls used oral contraceptives. Systolic (118 versus 109 mm Hg, p<0.001) and diastolic BPs (70.5 versus 68.0 mm Hg, p=0.033) were significantly higher in boys than in girls. Two (2%) girls and four (5%) boys had systolic hypertension; diastolic hypertension was found in six (5%) girls and one (1%) boy. Twelve (10%) girls and six (8%) boys were overweight (>25.0 kg/m^2). Twenty (17%) girls and seven (9%) boys had hypercholesterolemia (total serum cholesterol ≥5.2 mmol/L). Overall, 50 (42%) girls and 31 (39%) boys had at least one CV risk factor, 12 (10%) girls and four (5%) boys had two risk factors, and three (3%) girls and one (1%) boy had more than two risk factors. Conclusions: In 17-year-olds living in an affluent society the prevalence of CV risk factors was high. These findings underscore the importance of health education and prevention at this age.

Keywords: adolescents, blood pressure, cardiovascular risk factors, lifestyle, overweight, total cholesterol

Hypertension, hypercholesterolaemia and overweight are usually well tolerated at younger age and are therefore barely perceived as harmful, but over time they may track and lead to excess morbidity and mortality from cardiovascular causes in middle-life.[1] Moreover, epidemiological studies have shown that cardiovascular risk factors tend to cluster within young persons[2] and clustering of CV risk factors increases the risk of coronary heart disease.[3]

Therefore, reducing cardiovascular risk among young adults should be a health priority. Consequently, establishing the prevalence of cardiovascular risk factors at this period of life is necessary to develop targeted health promotion strategies and could serve as the baseline for assessment of future trends. In the literature, specific cut-off points for the main cardiovascular risk factors such as overweight, hypercholesterolemia and hypertension in adolescents are described.[4–6] However, with the exception of overweight[7] the prevalence of these risk factors in Flemish teenagers is unknown. In a pilot study[8,9] of the feasibility of measuring biomarkers to environmental pollution, we also measured blood pressure, body weight, alcohol intake, smoking habits, and serum total cholesterol in 16–18-year-olds. The present study describes the prevalence of these classical cardiovascular risk factors.

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MATERIALS AND METHODS

The study was performed in 1999 and was part of a biomonitoring programme to investigate exposure and early health effects of common environmental pollutants in adolescents.[8,9] Eligible participants were adolescents in their last year of grammar school (in 1999), and who were life-long residents of the control area or the two suburbs. Our study protocol required 100 participants from the two suburbs combined, and 100 controls. In Peer (control area) and in Hoboken (study area), adolescents were enrolled from a large grammar school. Fieldwork coincided with the school holidays in Wilrijk, adolescents were enrolled from a local examination centre and recruited from only the area (Neerlandwijk) surrounding the main waste incinerator. A total of 207 youngsters (58.3% of those invited) agreed to participate. Seven adolescents were excluded from the study because they were not immediately available for study due to illness or holidays. The principles described in the declaration of Helsinki were fulfilled[10] and the ethics committee of the University of Leuven approved the study. Written informed consent was obtained from the adolescents and their parents.

Registered study nurses administered questionnaires to assess lifestyle, intake of medications, and environmental tobacco smoke. Information about the job of the parents was also obtained. Socio-economic status of the family head was coded[11] and condensed into a scale with scores that ranged from 1 to 3. Smoking habits were assessed by a questionnaire and verified by determination of the concentration of cotinine in urine, a metabolite of nicotine.[12]

Height was measured to the nearest centimetre (Soenhle, Bolton, UK) and weight to the nearest 0.1 kg (Seca, North Bend, US). The body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Overweight was defined[6] as a BMI higher than 25 kg/m^2. Waist and hip circumferences were measured to the nearest centimetre with a tape measure while the subject was standing. Triceps skinfold of the left arm was measured in triplicate (Siber Hegner, Zurich, Germany).

After the subjects had rested for 5 minutes in the sitting position specially trained study nurses measured systolic and phase V diastolic blood pressures three times consecutively (Riester, Jungingen, Germany). The guidelines of the British hypertension Society were followed.[13] An appropriately sized cuff was used. The mean of the second and third measurements was considered in the study. Quality assurance and quality control of the blood pressure phenotype were implemented. Of the 800 systolic and diastolic blood pressure readings 22.1% ended on a zero, 15.3% ended on a 2, 19.9% ended on a 4, 19.1% ended on a 6 and 23.6% ended on an 8. Hypertension was defined according to the sex- and age-related standards specified in the 1996 Update of Task Force on BP Control in Children and Adolescents.[5] Adaptation of the current US standards to this study was made by referral to the US height standards.[14] The used cut-off points with their corresponding heights are given in *table 1*.

In the morning non-fasting blood samples were taken. Total serum cholesterol was determined in duplicate by an enzymatic method using commercially available enzymatic reagents (Olympus System Reagents, California, USA). Certified reference standards were run along each series of study samples. The laboratory participated in the external quality control programme for medical laboratories in Belgium. Hypercholesterolemia was diagnosed according to the guidelines of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents as a serum concentration of total cholesterol ≥5.2 mmol/L (≅200 mg/dL) and borderline high cholesterol as a serum total cholesterol ranging from 4.4 to 5.2 mmol/L (≅169 to 199 mg/dL).[4]

Database management and statistical analysis were performed with SAS software, version 6.12 (Cary, NC). Mean, standard deviation and percentiles of descriptive data were calculated. Student's *t*-test and Duncan procedure were used to estimate differences between continuous data for two or more groups respectively; chi^2-statistics for categorical data and a rank test (Wilcoxon-Rank) for not normally distributed data. Allowing for the covariates, we looked for differences between subgroups by using analysis of covariance.

Table 1 Height related cut-off points to define hypertension based on the 1996 update of task force on BP control in children and adolescents[5]

Body height (cm)	Systolic hypertension (mmHg)	Diastolic hypertension (mmHg)
Girls		
<155.1	>126	>83
155.1–158.7	>127	>83
158.8–163.0	>129	>84
163.1–167.2	>130	>85
167.2–171.2	>131	>86
Boys		
<167.7	>133	>85
167.8–171.9	>135	>86
172.0–176.2	>136	>87
176.3–180.5	>138	>88
180.6–184.4	>140	>89

RESULTS

Compared with the 200 participants, the 155 non-participants (148 non-respondents and 7 adolescents excluded from participation) had similar mean age (17.3 versus 17.4 years, p=0.67), sex distribution (68 versus 60% girls; p=0.13) and parental social class (low, medium and high 29, 63 and 8 versus 24, 65 and 12%; p=0.30).

The 200 participating adolescents had an average age of 17.4 (SD 0.8) years and consisted of 120 (60%) girls and 80 boys (40%). Of the 120 girls, 49 (41%) were taking the contraceptive pill.

In boys compared with girls, body weight, systolic and diastolic blood pressure and alcohol consumption were significantly higher, while in girls significantly higher triceps skinfold, waist-to-hip ratio, and serum cholesterol concentrations were found (*table 2*). BMI, parental social class and the proportion of smokers were comparable between genders. *Table 3* gives, for boys and girls separately, percentiles for the studied cardiovascular risk factors.

The median daily tobacco consumption was 6 (IQR 4–9) cigarettes in 31 smoking girls and 11 (6–16) cigarettes in 19 male

Table 2 Characteristics of the study population

	Girls n=120		Boys n=80		
Characteristics	Mean	(SD)	Mean	(SD)	p
Body length (cm)	165	(6.6)	179	(6.4)	<0.001[a]
Body weight (kg)	58.0	(9.3)	67.7	(11.9)	<0.001[a]
Body-mass index (kg/m^2)	21.2	(2.9)	21.1	(2.9)	0.65[a]
Triceps skinfold (cm)	1.7	(0.6)	1.0	(0.5)	<0.001[a]
Waist to hip circumference	0.8	(0.1)	0.7	(0.0)	<0.001[a]
Systolic blood pressure	108.5	(10.0)	117.5	(11.6)	<0.001[a]
Diastolic blood pressure	67.6	(8.3)	70.6	(8.9)	0.03[a]
Total cholesterol (mmol/L)	4.5	(0.7)	4.1	(0.8)	<0.001[a]
	Number	%	Number	%	p
Social class of parents					
Workers	34	28	13	16	
Middle class	75	63	54	68	
Learned professionals	11	9	13	16	0.08[b]
Subjects consuming alcohol	35	29	52	65	0.001[b]
Girls on oral contraceptives	49	41	–	–	

a: Data are presented as arithmetic means (SD) and compared by Student's t-test.
b: Numbers (%) are compared by a χ^2-test.

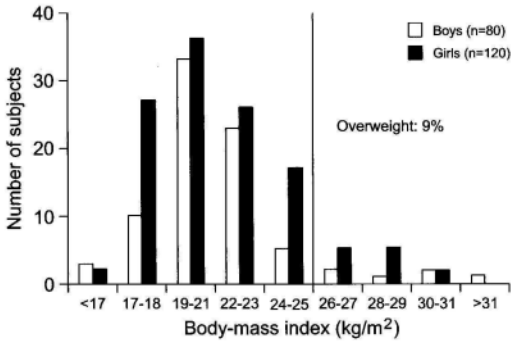

Figure 1 Prevalence of overweight

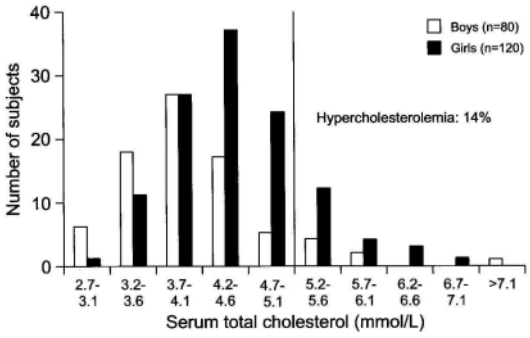

Figure 2 Prevalence of hypercholesterolemia

smokers (p=0.04). To validate the lifestyle questionnaire for smoking in teenagers, urinary concentration of cotinine was measured in the study participants. The geometric mean in 50 smokers was about 15 times the geometric mean observed in 150 non-smokers of whom 81 (54.0%) were passive smokers (309.2 versus 22.7 nmol/mmol creatinine; p<0.001). In three non-smokers without passive tobacco exposure, the urinary cotinine was higher than the limit of detection (>20 nmol/mmoL creatinine), indicating that 3 (6%) of the 200 subjects mis-reported their smoking status.

Twelve (10%) girls and 6 (8%) boys were found to be overweight (BMI >25 kg/m^2) (*figure 1*). Mean systolic blood pressure was 112 (SD: 11.5) and mean diastolic was 68.8 (SD: 8.7). Systolic blood pressure ranged from 85.3 to 144.0 mm Hg, and diastolic blood pressure from 40.0 to 88.6 mm Hg. According to the criteria specified in the 1996 Update of Task Force on Blood Pressure Control in Children and Adolescents, 2 (2%) girls and 4 (5%) boys were found to have systolic hypertension. The corresponding numbers for diastolic hypertension were 6 (5%) girls and 1 (1%) boy. Systolic blood pressure increased by 0.8 mm Hg and 1.2 mm Hg for each unit increase in BMI, in girls and boys respectively (for both p<0.01). Using diastolic blood pressure as dependent variable, an increase of 0.6 mm Hg per kg/m^2 (p=0.02) was observed in girls, but the association was not significant in boys (–0.1 mm Hg per kg/m^2; p=0.72). Adjusted for BMI serum total cholesterol was significantly higher in girls than in boys (*table 1*). Using 5.2 mmol/L serum total cholesterol as a cut-off for high cholesterol, 20 (17%) girls and 7 (9%) boys exceeded this value (*figure 2*). Borderline high cholesterol (4.4–5.2 mmol/L) was found in 41 (34%) girls and 17 (21%) boys.

In boys, serum total cholesterol was higher (p=0.04) in the lower social class (4.52 mmol/L) compared with the middle (4.02 mmol/L) and high (3.77 mmol/L) social class. This was, however, not confirmed in girls (4.42, 4.56, 4.35 mmol/L, p=0.49). BMI, systolic and diastolic blood pressure, alcohol and smoking habits did not differ according to social class.

Aggregation of risk factors was studied; including hypertension, overweight (BMI >25 kg/m^2), hypercholesteroleamia (≥5.2 mmol/L), and smoking (*figure 3*). Overall, 50 (42%) girls and 31 (39%) boys had at least one cardiovascular risk factor, 12 (10%) girls and 4 (5%) boys had two risk factors, and three (3%) girls and one (1%) boy had more than two risk factors. The strength of clustering was not different between genders (p=0.55).

DISCUSSION

Blood chemistry data and a life style questionnaire survey were obtained in 17-year-olds. In this specific age group, it was found that serum total cholesterol was high and comparable with American data in adolescents[4] and it was shown that about 40%

Table 3 Percentiles of established cardiovascular risk factors, by gender

	Percentiles						
	5	10	25	50	75	90	95
Girls (n=120)							
Body-mass index (kg/m^2)	17.6	18.1	19.2	20.6	22.7	25	27.9
Skinfold left triceps (cm)	1.02	1.10	1.34	1.60	2.00	2.49	2.83
Waist-to-hip ratio	0.66	0.68	0.70	0.72	0.75	0.77	0.79
Systolic blood pressure (mmHg)	93	96	102	107	115	123	126
Diastolic blood pressure (mmHg)	56	58	62	68	72	78	83
Serum total cholesterol (mmol/L)	3.48	3.65	4.07	4.39	4.92	5.45	5.75
Boys (n=80)							
Body-mass index (kg/m^2)	17.5	18	19.5	20.6	22.2	24.1	27.5
Skinfold left triceps (cm)	0.50	0.59	0.66	0.84	1.10	1.51	2.14
Waist-to-hip ratio	0.73	0.74	0.75	0.78	0.80	0.84	0.86
Systolic blood pressure (mmHg)	101	102	109	118	125	134	138
Diastolic blood pressure (mmHg)	57	58	64	72	78	81	84
Serum total cholesterol (mmol/L)	2.99	3.17	3.60	3.92	4.54	5.00	5.50

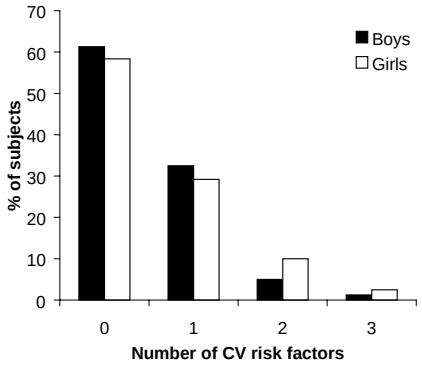

Figure 3 Clustering of risk factors, included in the analysis are overweight, hypercholesterolemia, hypertension and smoking status

of the adolescents had at least one main cardiovascular risk factor (overweight, hypertension, hypercholesterolemia or smoking tobacco). This knowledge may promote efforts at younger ages in education and screening for prevention of cardiovascular risk. The participation rate was approximately 60%. It is unlikely that the results are confounded by selection bias. Indeed, participants and non-participants showed similar distribution of characteristics in terms of important covariables, such as sex, age and parental social class. Adolescents aged 17–18 years were chosen as target population to study the feasibility of biomarkers to assess the early effects of environmental pollution[8,9] and to obtain at the same time information on main cardiovascular risk factors. This target population is of interest in preventive cardiovascular epidemiology because of (i) the early onset of cardiovascular diseases, e.g. the process of atherosclerosis,[15] (ii) the lack of data in this specific age group, (iii) possibilities for early identification of high risk individuals, and (iv) possibilities for achieving earlier modification of lifestyle in high risk persons. Moreover, in Belgium school attendance is compulsory until age 18 years and school doctors routinely examine adolescents. A disadvantage of this study is the limited sample size, which might be the reason for observing only socio-economic differences for serum total cholesterol in boys.

Overweight during adolescence has been recognized as a predictor of long-term morbidity and mortality[16] and is associated with impairment of vascular function as reflected by carotid artery stiffness and endothelial function.[17] Tracking overweight from adolescence into adulthood has been reported[16] with tracking coefficients of 0.49 to 0.56. Overweight (>25 kg/m^2) prevalence in our adolescents was 9% compared with approximately 25% in 18-year-old Americans, as observed by consulting the Third Health and Nutrition Examination Survey. In the same sample, obesity defined as a body-mass index higher than 30 kg/m^2 was found in about 10% of 18-year-old Americans compared with 2% in our sample.

According to the standards published in the task force report on high blood pressure,[5] in this present adolescent study, 3.0% of adolescents had systolic hypertension and 3.5% had diastolic hypertension. In a recent study[18] on Minneapolis schoolchildren, which used the same definitions, systolic hypertension was found in 2.7% and diastolic hypertension in 2.0% in 10 to 15-years-old youngsters. We did not obtain multiple blood pressure measurements on different days. This may have influenced the prevalence. Indeed with subsequent visits high blood pressure readings tend to decrease due to accommodation to the measurements procedure[18–20] and the statistical phenomenon of regression towards the mean.[21] Although relatively few adolescents are hypertensive,[5] research indicates that high blood pressure has origins in childhood.[22] Findings from the Bogalusa Heart Study in the USA demonstrated that childhood blood pressure levels at or above the 80th percentile, not necessarily in hypertensive ranges, were associated with an increased prevalence of elevated blood pressure during adulthood.[22] A follow-up study,[23] showed that blood pressure in a group of male students at the age of 20.5 years, was associated with the incidence of cardiovascular diseases in the following 41.3 years. These findings suggest that elevated blood pressure during youth may have later clinical significance. Our results affirm the importance of an increase in BMI on the blood pressure in older teenagers.

Elevated blood levels of lipids are probably the most important biochemical risk factors for arteriosclerosis and available data indicate that coronary arteriosclerosis usually starts in adolescence.[15,24] Total cholesterol was above or equal to 5.2 mmol/L in 17% of girls and in 9% of boys. This cut-off point corresponds to the upper 95th percentile in the American young adult population determined by the paediatric panel of the US National Cholesterol Education Program.[4] A study[25] tracking serum cholesterol found that 70% of children who exceeded the 90th percentile on two measurements had adult levels above 5.2 mmol/L (~200 mg/dL). In a prospective study by Klag et al.[1], 1107 men were followed, mean age at baseline was 22 years, the difference between the 25th and 75th percentiles of the total cholesterol level was 0.9 mmol/L at baseline and was associated with an increase of 72% in risk for cardiovascular mortality during a median follow-up of 30.5 years. The risks were similar whether the events occurred before or after the age of 50.

Although the prevalence of tobacco use by girls and boys was the same, the number of cigarettes consumed per day was higher in boys than girls. In a recent study,[26] in 18 to 24-year-old US college students, 32.9% of the respondents currently used tobacco, compared to almost 25% in this study. The smoking prevalence in adolescents differs around the world, among 13 to 16-year-old teenagers the prevalence ranged from a high of 33% to a low of 10%.[27–29] Even a low level of tobacco use is a cause for concern, as research on passive smoking has shown.[6,30–32] With respect to lung cancer susceptibility, it was recently hypothesized that adolescence, which is known to be the period of greatest development for the lung, may constitute a critical period in which tobacco carcinogens induce genetic alterations that make the adolescent smoker more susceptible to the effects of continued smoking.[33]

The present study showed that cardiovascular risk factor prevalence was as high as 40% in an affluent West European country. Therefore, there is a need to achieve a reduction in cardiovascular disease risk factors in young adults according to our data. In Belgium, school attendance is obligatory until the age of 18 and a public health network exists in which school doctors routinely examine adolescents. From such a network of school health examinations an approach of individual prevention could be achieved. Unfortunately, the school health examinations in Belgium do not include blood sampling for the measurement of blood cholesterol. The professionalization of the armed forces in Western Europe has led to the disappearance of systemic health checks on young men. Therefore, prevalence data of cardiovascular risk factors in adolescents are needed for more European regions. The broader geographic base of such studies may allow the demonstration of important environmental causes of disease from early age on, and such studies are necessary for the establishment of regional priorities for public health interventions.

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