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Cohort Profile

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Cohort Profile: The JS High School study (JSHS): a cohort study of Korean adolescents

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Abstract

Major aetiologies of atherosclerotic cardiovascular diseases begin in childhood and atherosclerotic vascular abnormalities can be observed among children and adolescents. Adolescent cohort studies have important advantages because they can observe earlier changes in vascular structure and function. The purpose of the JS High School study (JSHS) is to identify biomarkers predicting or indicating early structural and functional vascular change in adolescents. The JSHS is a prospective cohort study of a Korean adolescent population. The target population of the JSHS was first-graders (aged 14 to17 years) at a high school of South Korea. Enrolment and baseline examinations were conducted in years 2007, 2010, 2011 and 2012. Among the total eligible population of 1115 students, 1071 (96.1%) participated in the study and completed all baseline examinations. Informed consent forms were obtained from each participant and his/her parent or guardian. Baseline examinations include: questionnaires on demographics, health behaviours, medical history, and depression symptoms; fasting blood analysis; anthropometric measurement; body impedance analysis; blood pressure measurement; radial artery tonometry; bone densitometry; pulmonary function tests; and carotid ultrasonography. Participants enrolled from 2007 through 2012 were re-examined after 30 months of follow-up, and those who enrolled in 2012 were re-examined after 24 months of follow-up. The corresponding author may be contacted for potential collaboration and data access.

Key Messages

- Higher blood pressure may be associated with atherosclerotic change in adolescents.
- Higher pulse pressure may be associated with atherosclerotic change in healthy male adolescents.
- Lower serum vitamin D concentration may be associated with insulin resistance in healthy male adolescents.

Why was the study set up?

Although most apparently healthy adolescents are free of atherosclerotic vascular changes, some adolescents may present accelerated vascular change because of the presence of risk factors or specific diseases.[1] Several epidemiological studies have reported that the major aetiologies of atherosclerotic vascular diseases may begin in childhood and atherosclerotic vascular abnormalities can be observed among children and adolescents.[2–9] Autopsy studies of children and young adults who have died from non-cardiovascular causes have also demonstrated direct evidence of the early development of atherosclerosis, with findings of fatty streaks[10] and fibrous plaque.[11–13] In children and adolescents, indirect evidence for early development of atherosclerosis has been found in studies that detected vascular changes associated with cardiovascular disease in adulthood.[14–19] These include changes in vessel anatomy, as well as mechanical changes and physiological changes.[15] Adolescent cohort studies have an important advantage because they can observe earlier changes in vascular structure and function. Adolescent cohorts are also helpful when investigating new biomarkers and risk factors, because their study populations are less exposed to major vascular risk factors.

Over the past several decades, the Korean population has experienced a rapid epidemiological transition in cardiovascular disease.[20] Moreover, obesity and cardiovascular risk factors are becoming more prevalent among Korean children and adolescents.[21,22] Accordingly, atherosclerotic cardiovascular disease is expected to become a bigger health problem in the future. Thus, it is important to assess the cardiovascular risk profiles of Korean adolescents and their impact on cardiovascular disease later in life. However, early vascular changes and associated factors remain largely understudied in Korea. The JS High School study (JSHS) is a prospective cohort study aiming to observe earlier change in vascular structure and function in Korean adolescents, as well as identify its predictors thereof.

Who is in the cohort?

We recruited an adolescent cohort that consists of first-year students at a high school in a rural community of South Korea. Enrolment and baseline examinations were conducted in April 2007, June 2010, June 2011 and November 2012. The JSHS was initially designed to recruit 850 participants until 2011, based on power calculation for detecting risk factors or predictors of vascular structural changes, such as increased arterial wall thickening. However, we recruited only 830 participants until 2011 and attrition at first follow-up was higher than expected. Thus, we extended the recruitment period until 2012. Finally, of the total 1115 available first-year students, 1071 students agreed to participate and completed all physical examinations, blood laboratory tests and self-reported questionnaires. The overall response rate was 96.1%, although it gradually decreased over the enrolment period: 99.7%, 98.2%, 94.7% and 91.3% for the 2007, 2010, 2011 and 2012 subcohorts, respectively (Table 1).

The JSHS cohort has a narrow age distribution because it was restricted to the first-year students. At baseline, 0.4% were 14 years old, 58.2% were 15 years old, 41.3% were 16 years old and 0.2% were 17 years old. Among the 1071 participants, 52.0% were male and 48.0% were female. Although study participants were recruited from a single high school, their anthropometric and blood pressure distributions were similar to those in the Korean National Growth Charts.[23] Cigarette smoking (males 8.1%; females 0.6%) and alcohol drinking (males 10.8%; females 5.1%) were uncommon in this cohort. According to the Korean Youth Risk Behavior Survey, cigarette smoking (males 16.4%; females 6.9%) and alcohol drinking (males 23.0%; females 17.5%) were more frequent among general Korean adolescents of the same age.[24] Socioeconomic status of the JSHS cohort seems to be a little higher than average. More than half (55%) of the JSHS students reported that their fathers were educated for more than 12 years, whereas the corresponding rate was 44% in the Korean Youth Risk Behavior Survey.[24] Allergic rhinitis (28.6%), atopic dermatitis (16.9%), and allergic eye disease (12.0%) were the most common chronic conditions of the JSHS participants. The study protocol was approved by the Institutional Review Board of Severance Hospital at Yonsei University College of Medicine (Approval No. 4-20100169). Written informed consent was obtained from each participant as well as from his/her parent or guardian. Informed consent forms were distributed to eligible students at least 1 week prior to the examination, so

Table 1. Number of participants at baseline and follow-up examinations in the JSHS

Year of enrolment	Baseline examination		First follow-up examination
	Eligible population	Participants (response rate)	Participants (follow-up rate)
2007	286	285 (99.7%)	253 (88.8%)
2010	282	277 (98.2%)	208 (75.1%)
2011	283	268 (94.7%)	209 (78.0%)
2012	264	241 (91.3%)	214 (88.8%)
Total	1115	1071 (96.1%)	884 (82.5%)

the participating students and their parents had enough time to understand the purpose and process of the study.

How often have they been followed up?

All cohort members were enrolled for baseline examination during their first year in high school, and were asked to take the first follow-up examination during their third year in high school, usually after completing their scholastic aptitude test for college admission. Participants enrolled in 2007 through 2012 completed the first follow-up examination after 30 months on average, and the follow-up rate was 80.7% (670 of 830). Participants enrolled in 2012 completed the first follow-up examination after 24 months, but their follow-up data are not yet analysed. Among the 160 participants who did not participate in follow-up examination, 20 transferred to other schools and the remaining 140 expressed no intention to continue to participate. The first follow-up examination includes anthropometric measurements, blood pressure measurements, fasting blood analysis, carotid ultrasonography, radial pulse wave analysis and self-administered questionnaires on health-related lifestyle, personal and family disease history and depression score. Among male participants, those who were lost to follow-up tended to weigh more (67.8 kg vs 64.5 kg; $P = 0.027$), be cigarette smokers (13.5% vs 4.8%; $P = 0.017$), exercise less frequently (76.4% vs 88.4%; $P = 0.020$) and have higher carotid intima-media thickness (0.597 mm vs 0.569 mm; $P = 0.001$) at baseline, compared with those who were retained (Table 2). However, between lost and retained female participants, no significant difference was observed in anthropometric measures, health behaviours or cardiovascular risk factors. Therefore, effects of bias due to differential loss to follow-up should always be considered, especially when

Table 2. Selected baseline characteristics for those who participated in follow-up examination and those who did not

Baseline characteristics	Male, $n = 424$		P	Female, $n = 406$		P
	Participants, $n = 335$	Non-participants, $n = 89$		Participants, $n = 335$	Non-participants, $n = 71$	
Anthropometrics						
Age, years	15.8 ± 0.3	15.9 ± 0.3	0.141	15.8 ± 0.3	15.9 ± 0.3	0.060
Height, cm	171.1 ± 5.4	172.1 ± 5.2	0.144	160.0 ± 5.0	158.8 ± 5.1	0.062
Weight, kg	64.5 ± 10.3	67.8 ± 12.7	0.027	54.1 ± 7.3	53.8 ± 7.1	0.783
Waist circumference, cm	74.0 ± 8.1	75.1 ± 9.0	0.251	69.3 ± 6.7	69.2 ± 7.2	0.909
Health behaviours						
Smoking	16 (4.8)	12 (13.5)	0.017	3 (0.9)	0 (0.0)	1.000
Alcohol drinking	39 (11.6)	12 (13.5)	0.839	16 (4.8)	3 (4.2)	1.000
Regular exercise	296 (88.4)	68 (76.4)	0.020	268 (80.0)	55 (77.5)	0.435
Known diseases						
Hypertension	5 (1.5)	1 (1.1)	0.084	1 (0.3)	0 (0.0)	0.620
Chronic gastritis	2 (0.6)	0 (0.0)	0.199	2 (0.6)	0 (0.0)	0.751
Chronic bronchitis	2 (0.6)	1 (1.1)	0.236	3 (0.9)	1 (1.4)	0.422
Allergic rhinitis	102 (30.4)	24 (27.0)	0.852	82 (24.5)	24 (33.8)	0.268
Atopic dermatitis	44 (13.1)	11 (12.4)	0.655	65 (19.4)	11 (15.5)	0.768
Allergic eye disease	36 (10.7)	7 (7.9)	0.552	43 (12.8)	7 (9.9)	0.777
Blood pressure						
SBP, mmHg	112.6 ± 11.8	114.3 ± 13.1	0.238	102.7 ± 9.9	102.7 ± 13.1	0.977
DBP, mmHg	59.4 ± 6.9	60.3 ± 6.9	0.237	59.3 ± 6.7	58.3 ± 7.8	0.242
Pulse rate, per min	74.0 ± 11.4	72.3 ± 11.8	0.221	75.8 ± 10.0	74.4 ± 11.1	0.309
Fasting blood analysis						
HbA1c, %	5.29 ± 0.25	5.29 ± 0.25	0.896	5.25 ± 0.25	5.29 ± 0.26	0.213
Cholesterol, mg/dl	148.2 ± 26.7	147.1 ± 20.8	0.672	160.9 ± 25.7	161.0 ± 23.0	0.962
TG, mg/dl	83.1 ± 31.1	84.6 ± 31.7	0.689	78.3 ± 26.9	79.6 ± 24.8	0.708
HDL, mg/dl	41.4 ± 8.6	41.0 ± 7.7	0.677	47.6 ± 9.4	46.1 ± 8.2	0.225
CRP, mg/l	0.36 [0.14–0.87]	0.29 [0.15–0.79]	0.795	0.19 [0.10–0.58]	0.26 [0.10–0.57]	0.234
Carotid ultrasonography						
Intima-media thickness, mm	0.569 ± 0.058	0.597 ± 0.070	0.001	0.535 ± 0.114	0.513 ± 0.092	0.092

Data expressed as mean ± SD, number (percent), median [25th to 75th percentiles].
Only 830 participants who were enrolled in 2007, 2010 and 2011 were compared.
TG, total trigycerides.

analysing the effects of behavioural risk factors. Moreover, it should be kept in mind that the reasons for and impacts of follow-up loss may differ between male and female adolescents.

The second follow-up examinations are added after 7 to 10 years after the baseline examinations. To minimize loss to follow-up, the JSHS Study will maintain regular personal contact through phone calls, e-mails, and post mail. We also got permission from each participant to use their identification number for linkage to nationwide health databases, including the National Health Insurance Claim Database, National Cancer Registry and Causes of Death Statistics.

What has been measured?

Data have been collected through self-reported questionnaires, interviews, physical examinations and laboratory tests according to predetermined protocol. Table 3 shows the list of questionnaire-based measurements, physical examinations and laboratory tests according to year of enrolment. For all subcohorts, baseline measurements include anthropometry, resting blood pressure, electrocardiogram, fasting blood analysis, carotid ultrasonography and questionnaires on health-related lifestyle, medical history, family history of major disorders, and depressive symptoms. Fasting blood analysis includes blood counts, liver enzymes, glucose and lipid profiles, and inflammatory markers. Carotid artery ultrasonography was performed to evaluate structural vascular change by measuring intima-media thickness and presence of plaque. In addition to the above-mentioned core measurements, pulmonary function tests have been conducted for 2007, 2010 and 2011 subcohorts; radial pulse wave analysis has been conducted for 2010 and 2011 subcohorts, and body composition analysis has been conducted for 2011 and 2012 subcohorts.

The protocol of the baseline measurement is summarized as follows. A questionnaire was distributed to eligible students at least 1 week before the examination. Participants were asked about their demographic factors, health behaviours, medical history, family history and depressive symptoms. Demographic factors included parents' education, marriage, household income and occupation. Health behaviours included cigarette smoking, alcohol consumption and physical activity. Medical history included previous diagnosis of hypertension, dyslipidaemia, tuberculosis, chronic gastritis, ulcer, diabetes, liver disease, cholelithiasis, chronic bronchitis, depressive disorder, cancer or allergic diseases. Family history included diagnosis of or deaths from hypertension, diabetes, ischaemic heart disease, stroke and cancer among the participant's parents and siblings. Symptoms of depression were assessed using the 21-item Beck Depression Inventory.[25]

Anthropometric measures, performed using the same devices throughout this study, were taken by a trained examiner. Standing height was measured to the nearest 0.1 cm on a stadiometer and body weight was measured to the nearest 0.1 kg on a digital scale (Seca 763; SECA, Hamburg, Germany) while wearing the school uniform. Waist circumference was measured to the nearest 0.1 cm at the level of the superior iliaccrest at the end of a normal expiration. Resting blood pressure and pulse rate were measured with an automated oscillometric device (Dinamap1846 SX/P; GE Healthcare, Waukesha, WI, USA). Participants were seated in the examination room for at least 5 min before blood pressure measurement and then an appropriately sized cuff was applied snugly around the right upper arm at heart level. Two readings at 5-min intervals were obtained and averaged to determine systolic blood pressure (SBP) and diastolic blood pressure (DBP) for each individual. When the two readings differed or more, additional readings were obtained after 5 min and the last two readings were averaged. Electoricardiography (ECG) was performed in the supine position using a standard 12-lead ECG machine (PageWriter Trim III Cardiograph, Eindhoven, The Netherlands). An overnight fasting blood sample was collected after at least an 8-h fast. Collected blood samples were processed, refrigerated immediately, transported in cold storage to the central laboratory, and analysed within 24 h. Measured blood biomarkers include complete blood counts, protein, albumin, urea nitrogen, creatinine, aspartate and alanine aminotransferases, gamma-glutamyltransferase, total bilirubin, glucose, insulin, HbA1c, total cholesterol, triglycerides, high-density lipoprotein (HDL) cholesterol and C-reactive protein. Carotid artery intima-media thickness (IMT) and the presence of plaque in both the left and right carotid arteries were assessed with high-resolution B-mode ultrasound scanning imaging (SSAD-3500SV; Aloka, Tokyo, Japan).

Pulmonary function testing was performed by trained technicians using a volume displacement spirometer (model 1022; Sensor Medics; Yorba Linda, USA). After instruction and a practice attempt, each subject performed a minimum of three (maximum of eight) forced expiratory manoeuvres to provide estimates of forced vital capacity (FVC), forced expired volume in one second (FEV_1), FEV_1/FVC and forced expiratory flow between 25–75% (FEF 25–75). Radial artery pulse was analysed using an automated radial pulse waveform analyser (HEM-9000AI, Omron Healthcare, Kyoto, Japan) to estimate augmentation index and central systolic blood pressure. Bone mineral density was measured at the right forearm and calcaneus (heel) using mobile X-ray bone densitometry (EXA-3000, Osteosys, Seoul, Korea). Body composition

Table 3. Summary of questionnaire, physical examinations and laboratory tests in the JSHS

Variables	Sub-cohort by year of enrolment							
	2007		2010		2011		2012	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Demographic factors								
Date of birth	X	X	X	X	X	X	X	X
Parents' education	X	X	X	X	X	X	X	X
Parents' marriage	X	X	X	X	X	X	X	X
Parents' household income	X	X	X	X	X	X	X	X
Parents' occupation	X	X	X	X	X	X	X	X
Health behaviours								
Cigarette smoking	X	X	X	X	X	X	X	X
Alcohol consumption	X	X	X	X	X	X	X	X
Physical activity	X	X	X	X	X	X	X	X
Depressive symptoms	X	X	X	X	X	X	X	X
Medical history	X	X	X	X	X	X	X	X
Family history	X	X	X	X	X	X	X	X
Menstruation history								
Age at menarche	X	X	X	X	X	X	X	X
Regularity of menstruation	X	X	X	X	X	X	X	X
Duration of menstrual flow	X	X	X	X	X	X	X	X
Anthropometrics								
Body weight	X	X	X	X	X	X	X	X
Standing height	X	X	X	X	X	X	X	X
Waist circumference	X	X	X	X	X	X	X	X
Hip circumference	X	X	X	X	X	X	X	X
Thigh circumference	X	X	X	X	X	X	X	X
Skinfold thickness	X	X	X		X			
Body composition analysis				X	X	X	X	X
Blood pressure	X	X	X	X	X	X	X	X
Radial pulse analysis			X		X			
Bone mineral density			X	X	X	X	X	X
Electrocardiography	X		X		X		X	
Pulmonary function test	X		X		X			
Carotid ulatrosoundgraphy	X	X	X	X	X	X	X	X
Fasting blood sample								
Group A	X	X	X	X	X	X	X	X
Group B			X		X	X	X	
Group C				X	X	X	X	X
Group D				X	X		X	

Depressive symptoms: back's Depression Inventory (BDI)-I.

Medical history: physician-diagnosed, hypertension, dyslipidaemia, tuberculosis, chronic gastritis, gastric ulcer, diabetes, liver disease, cholelithiasis, chronic bronchitis, depressive disorder, cancer, allergic diseases.

Family history: diagnosis or death among parents and siblings, hypertension, dyslipidaemia, ischaemic heart disease, stroke, diabetes, cancer.

Group A: haemoglobin, white blood cells, red blood cells, haematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), platelets, protein, albumin, blood urea nitrogen, creatinine, total bilirubin, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyltransferase, glucose, insulin, haemoglobin A1c, total cholesterol, triglycerides, high-density lipoprotein cholesterol and C-reactive protein.

Group B: fibrinogen and fibrin d-dimer.

Group C: serum 25(OH)D and calcium.

Group D: leptin, osteocalcin, osteprotegerin and parathyroid hormone.

data, including body fat mass, percent body fat, lean mass, fat-free mass, skeletal muscle mass and appendicular fat-free mass, were estimated using a bioelectric impedance analyser (InBody 370, Biospace, Seoul, Korea).

What has it found?

Baseline characteristics of the study participants are summarized in Table 4. Mean age of the participants was 15.9 years for male ($n = 557$) and female ($n = 514$) participants

Table 4. Distribution of selected baseline characteristics in the JSHS

Variables	Total ($n = 1071$)	Male ($n = 557$)	Female ($n = 514$)
Anthropometrics			
Age, years	15.9 ± 0.4	15.9 ± 0.4	15.9 ± 0.4
Height, cm	165.9 ± 7.8	171.5 ± 5.2	159.7 ± 5.0
Weight, kg	60.0 ± 10.7	65.3 ± 10.6	54.3 ± 7.4
BMI, kg/m^2	21.7 ± 3.0	22.2 ± 3.2	21.3 ± 2.6
Waist circumference, cm	71.2 ± 7.9	73.6 ± 8.1	68.6 ± 6.7
Hip circumference, cm	93.9 ± 5.9	94.4 ± 6.5	93.3 ± 5.2
Thigh circumference, cm	50.7 ± 5.1	51.5 ± 5.2	49.9 ± 4.9
Health behaviours			
Smoking	48 (4.5)	45 (8.1)	3 (0.6)
Alcohol drinking	86 (8.1)	60 (10.8)	26 (5.1)
Regular exercise	836 (78.2)	473 (85.2)	363 (70.6)
Prevalent diagnoses			
Hypertension	9 (0.8)	8 (1.5)	1 (0.2)
Chronic gastritis	6 (0.6)	3 (0.5)	3 (0.6)
Chronic bronchitis	11 (1.0)	6 (1.1)	5 (1.0)
Allergic rhinitis	304 (28.6)	170 (30.7)	134 (26.2)
Atopic dermatitis	180 (16.9)	79 (14.3)	101 (19.7)
Allergic eye disease	128 (12.0)	60 (10.8)	68 (13.3)
Blood pressure			
Systolic blood pressure, mmHg	109.8 ± 13.0	115.1 ± 12.8	104.0 ± 10.6
Diastolic blood pressure, mmHg	60.8 ± 7.6	61.4 ± 7.8	60.2 ± 7.4
Pulse rate, per min	74.7 ± 10.7	73.4 ± 11.0	76.1 ± 10.2
Carotid ultrasonography			
Intima-media thickness, mm	0.553 ± 0.084	0.572 ± 0.06	0.534 ± 0.101
Fasting blood analysis			
Haemogbin, g/dl	14.3 ± 1.3	15.3 ± 0.8	13.3 ± 0.9
Haematocrit,%	44.3 ± 4.3	47.5 ± 2.8	40.9 ± 2.7
RBC, Mil/UI	4.88 ± 0.43	5.18 ± 0.32	4.56 ± 0.27
WBC, Th/Ul	7.02 ± 1.90	6.95 ± 1.87	7.10 ± 1.94
Platelet, Th/Ul	264.5 ± 56.6	261.5 ± 58.3	267.8 ± 54.6
Glucose, mg/dl	87.2 ± 7.1	88.2 ± 7.1	86.2 ± 6.9
Insulin, uIU/ml	8.62 ± 3.13	8.63 ± 3.29	8.62 ± 2.94
HbA1c, %	5.25 ± 0.24	5.26 ± 0.24	5.25 ± 0.24
Cholesterol, mg/dl	155.3 ± 26.3	148.7 ± 24.6	162.5 ± 26.2
TG, mg/dl	80.5 ± 30.2	82.1 ± 31.3	78.7 ± 28.9
HDL, mg/dl	46.9 ± 10.8	44.2 ± 10.0	49.9 ± 10.9
Protein, g/dl	7.72 ± 0.34	7.73 ± 0.35	7.72 ± 0.34
Albumin, g/dl	4.88 ± 0.22	4.9 ± 0.2	4.85 ± 0.23
BUN, mg/dl	13.0 ± 2.7	13.6 ± 2.7	12.4 ± 2.6
Creatinine, mg/dl	0.92 ± 0.11	1.00 ± 0.09	0.84 ± 0.07
Bilirubin, mg/dl	0.90 ± 0.34	0.93 ± 0.35	0.86 ± 0.33
ALT, IU/l	14 [12 to18]	17 [13 to 21]	12 [11 to 15]
AST, IU/l	20 [17 to 22]	21 [19 to 23]	18 [16 to 21]
γ-GTP, IU/l	12 [11 to 16]	14 [11 to 18]	12 [10 to 14]
CRP, mg/l	0.30 [0.14 to 0.70]	0.35 [0.17 to 0.77]	0.26 [0.12 to 0.61]

Data expressed as mean ± standard deviation, number (percent), or median [25th to 75th percentiles].

Smoking, ≥100 cigarettes in life; drinking, ≥1 time/month; exercise, ≥1 time/week; RBC, red blood cells; WBC, white blood cells; HbA1C, haemoglobin A1c; cholesterol, total cholesterol; TG, triglycerides; BUN, blood urea nitrogen; bilirubin, total bilirubin; ALT, alanine aminotransferase; AST, aspartate amiotansferase, γ-GTP, γ-glutamyl transpeptidase; CRP, C-reactive protein.

at baseline. Male participants were more likely to smoke cigarettes, drink alcohol and exercise regularly, compared with female participants. Height, weight, SBP and carotid IMT were relatively higher in male participants, whereas body fat mass was higher in female participants. Analyses for the first follow-up examinations are ongoing. Currently, the main results to date of the JSHS are summarized as follows.

First, a cross-sectional analysis for the 2007 subcohort showed that higher blood pressure levels may be associated with increased carotid IMT (Figure1).[26] Adjusted odds ratios for increased IMT were 1.70 ($P = 0.003$) per 12.4 mmHg SBP and 1.25 ($P = 0.125$) per 7.0 mmHg DBP. When the analyses were performed by sex, increased IMT was associated with both SBP (odds ratio, 2.67; $P = 0.003$) and DBP (odds ratio, 1.68; $P = 0.019$) in females, but not with either SBP (odds ratio, 1.46; $P = 0.093$) or DBP (odds ratio, 0.99; $P = 0.972$) in males.[26] Second, another cross-sectional study showed that higher pulse pressure may be associated with increased carotid IMT (Figure 2).[27] There was a significant correlation between pulse pressure and carotid IMT before (Pearson coefficient r = 0.204;

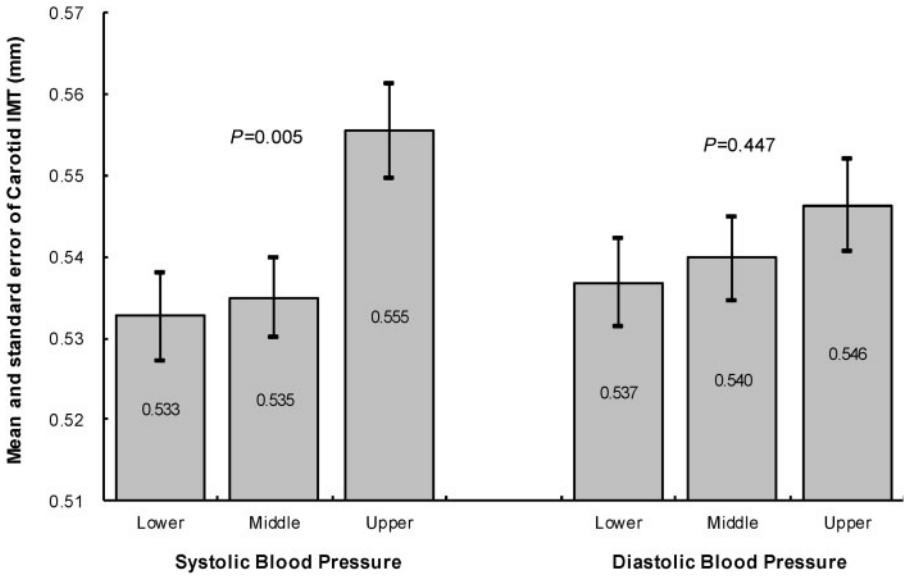

Figure 1. Risk for increased carotid intima-media thickness according to blood pressure level.

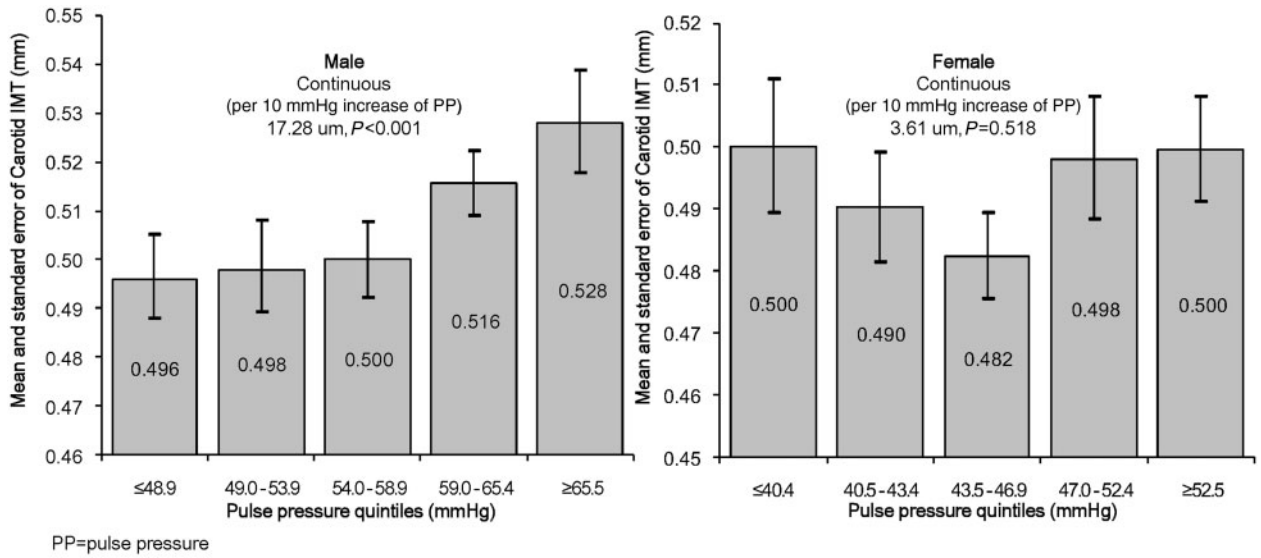

Figure 2. Relationships between pulse pressure and carotid intima-media thickness (IMT) in adolescents.

Adjusted for age, waist circumference, fasting plasma glucose, and total/HDL cholesterol ratio.

$P = 0.001$) and after ($r = 0.148$; $P = 0.020$) adjustment for sex. When adjusted for sex, age, waist circumference, fasting blood glucose and total/high-density lipoprotein cholesterol ratio, a 10-mmHg increase in pulse pressure was associated with increase of IMT in the overall cohort ($P = 0.003$) and in males ($P < 0.001$), but not in females ($P = 0.518$).[27] Third, study of the 2011 subcohort showed that serum 25-hydroxy vitamin D [25(OH)D] level may be inversely associated with insulin resistance (Figure 3).[28] In males, every 10-ng/ml decrease in 25(OH)D level was associated with a 0.25-unit increase in the homeostatic model assessment insulin resistance index (HOMA-IR) ($P = 0.003$) after adjusting for age and BMI. Compared with those in the highest quartile, males in the lowest 25(OH)D quartile were at significantly higher risk for insulin resistance: unadjusted odds ratio of 4.06 [95% confidence interval (CI), 1.26 to 13.07]; age- and BMI-adjusted odds ratio 3.59 (95% CI, 1.03 to 12.57). However, 25(OH)D level was not significantly associated with insulin resistance among females.[28]

What are the main strengths and weaknesses?

The JSHS employed a prospective design at the beginning of this study, aimed at following up adolescence into adulthood; (i) this cohort will yield on the association between major cardiovascular risk factors and vascular alterations at the stage of adolescence; and (ii) baseline and follow-up data will be analysed to investigate tracking phenomena of cardiovascular risk factors from adolescence to adulthood, and the effects of adolescent risk factors on adulthood vascular disease. The JSHS is, therefore, expected to make an important contribution to theory and model formation in research on adolescent and adult health.

One of the weaknesses of this study is the relatively small sample size. This study was designed to achieve enough statistical power to identify risk factors for intermediate phenoptypes or subclinical atherosclerosis. Thus, it may not observe a sufficient number of clinical cardiovascular events for these to be studied appropriately. In addition, the study findings may have some limitations in terms of generalizability as some of the sociodemographic factors and health behaviours of the participants differed from those of the general population of Korean adolescents. However, body size and blood pressure of the study participants were similar to those from national representative data.

Can I get hold of the data? Where can I find out more?

The JSHS is being conducted mainly at the Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Korea, which is responsible for the collection, the management and distribution of the data. Further

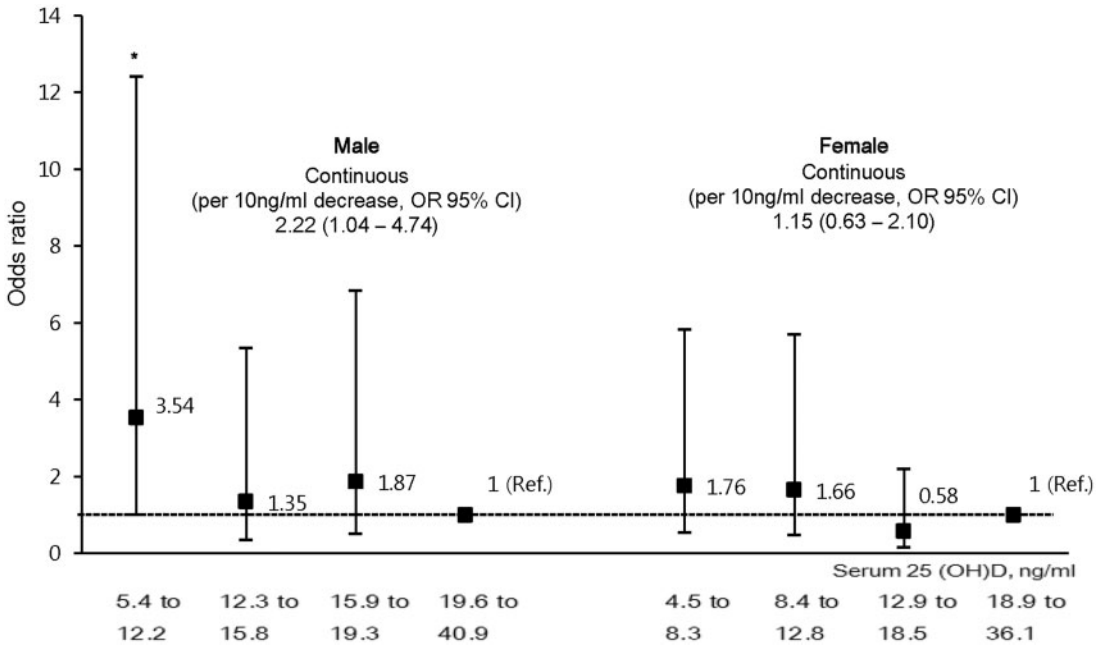

Figure 3. Serum 25(OH)D level and the risk of increased insulin resistance.

Defined as homeostasis model assessment insulin resistance ≥75 percentile value (male, 2.09; female, 1.99). Adjusted for age, body mass index, smoking, drinking, and regular exercise.
*$P < 0.05$.

information can be requested by e-mailing the principal investigator [hckim@yuhs.ac].

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Author contributions

D.P.C. and J.Y.L. contributed to study design, data acquisition, data analysis, interpretation and drafting of the manuscript. H.C.K. contributed to study concept and design, data acquisition, data analysis, interpretation, drafting and critical revision of the manuscript and the supervision of JSHS.

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