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Correlates of blood pressure in 15 year olds in the West of Scotland

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Abstract

***Study objective*—The aim was to examine social and physical correlates of blood pressure in 15 year olds.**

***Design*—This was the first, baseline, sweep of a longitudinal survey of 15 year olds based on a two stage stratified clustered random sample.**

***Setting*—The Central Clydeside Conurbation, in the West of Scotland. In 1981 this had a population of 1·7 million and a standardised mortality ratio (relative to Scotland as a whole) of 109.**

***Subjects*—A random sample of households containing 15 year olds were approached by Strathclyde Regional Council; 70% agreed to have their names passed on to the MRC (15% refused, 10% could not be contacted, and 5% had moved). Of these 1177, 11% refused to participate, 3% were not contactable/had moved, and 4% did not provide full data. Complete blood pressure data are available for 959 15 year olds (464 males and 495 females).**

***Measurements and main results*—Blood pressure, pulse rate, height, weight, and room temperature were measured by nurses in the subjects' homes. Smoking, drinking, and frequency of vigorous exercise were self reported. Maternal height, birthweight, occupation of head of household, and housing tenure were reported by parents. After controlling for the other variables, systolic blood pressure was significantly associated with weight, pulse rate, and room temperature in males and with weight, pulse rate, housing tenure, smoking, and exercise in females. Diastolic blood pressure was associated with room temperature in males and with mother's height, pulse rate, and housing tenure in females. Controlling for current weight, birthweight was inversely related to systolic blood pressure in males and positively associated in females, though in neither case were these associations statistically significant.**

***Conclusions*—In males, blood pressure was mainly related to anthropometric factors whereas in females it was additionally related to socioeconomic and behavioural variables. Although not reaching significance, the weight standardised relationship between birthweight and systolic blood pressure was consistent for males, but not females, with those reported by recent British studies of children and adults. The longitudinal design of this study will allow us to examine correlates of blood pressure in the same individuals as they reach social and physical maturity.**

There has been considerable interest recently in Britain in early life antecedents of blood pressure. An inverse relationship between birthweight and blood pressure (controlling for current weight) has been reported among 5–7 year olds,[1] and among 10 year olds and 36 year olds from the 1970 and the 1946 British birth cohorts.[2] Significant differences have been reported between towns in the blood pressure of children aged 5–7 with the differences showing a similar pattern to those observed in middle aged men.[3] These findings have been interpreted as indicating the importance of early, and particularly intrauterine, determinants of blood pressure levels in adults.[4]

There have been relatively few studies of blood pressure levels in adolescents, as compared to children or adults, in Britain. Studies of teenagers have, however, drawn attention to associations between blood pressure and social class, smoking, and exercise[5–7]; studies of adults have also indicated that current social class and alcohol consumption[8] may be associated with blood pressure.

This paper reports on blood pressure levels and their correlates in a cohort of 15 year olds in the West of Scotland who are being followed up as part of a broader study of social patterns in health. The focus of the study is not on blood pressure per se but blood pressure measurements were taken as part of a series of measures of development and functioning. This study can usefully contribute to discussions of blood pressure determinants, both because of the range of social and physical measures employed and because the cohort is being followed up at age 18 and periodically thereafter. Longitudinal observations of blood pressure levels during the period in which young people move away from influences in the parental home and create their own lifestyles may be useful in assessing the relative importance of earlier as compared with later environmental influences on blood pressure. This paper presents baseline cross sectional data on a cohort of adolescents before they leave home and school.

Methods

The objectives, design and methods of the "West of Scotland Twenty-07 Study: Health in the Community" have been described in detail elsewhere.[9 10] It aims to explore the processes by which social patterns in health are produced, focusing in particular on variations in health by occupational class, gender, age, marital status, ethnicity, and area of residence. It is based on three cohorts, aged respectively 15, 35 and 55 years at the first baseline surveys in 1987/8, which are being followed up at intervals using social survey techniques. It used a two stage stratified clustered random sample design based on 52 post code sectors in the Central Clyde Conurbation, a large and heterogeneous area around and including Glasgow City, with a population of 1·7 million and a standardised mortality ratio (relative to Scotland as a whole) of 109 in 1981.[11]

The sampling frame used was Strathclyde Regional Council's Voluntary Population Survey, an enhanced electoral register containing information on the age and sex composition of each household.[12] Regional Council staff drew a random sample of 1682 households containing 15 year olds, whom they then approached for consent to pass their names on to the study team. In 15% cases the young people and/or parent refused consent; 10% could not be contacted after four attempts; and 5% had moved between the time the sample was drawn and the attempted contact. Of the 1177 who agreed to be contacted about the study, 1009 (86%) were interviewed in their own homes by a social interviewer and 996 (82%) were visited by a nurse who took various physical measurements (see below). The sex ratio (48% boys) was slightly less than that of the population of 15 year olds in the Central Clydesdale Conurbation at the 1981 census (51%). The proportion in non-manual households (41%) was higher than the 33% shown in the 1981 census for households containing a child or children aged 0–15 in the conurbation. This overrepresentation of non-manual households is attributable to response bias (middle class people usually participate more in surveys) and to changes in the social class distribution since 1981. The fact that 46% of our sample lived in owner-occupied housing compared with 42% in the original sample drawn by the Strathclyde Regional Council indicates that the social class bias may be less than is indicated by comparisons with the 1981 census. Weighting schemes to compensate for response bias have been evaluated; these produce only negligible differences in the health or social measures,[13] and therefore unweighted data are used in this analysis.

A wide range of measures of mental and physical health are being investigated in this study, including self reports (eg, of overall health status, the incidence of symptoms, and the prevalence of conditions), reports by parents, and observations or measurements made by nurses. The measures used in the present analysis are described below.

The nurses measured the subjects' pulse rate, blood pressure, height, weight, and hip and waist circumference, and recorded the temperature in the room in which the measurements were taken. Blood pressure was measured in the sitting position in the right arm after a 5 min rest, using a Hawkesley random zero sphygmomanometer. An adult size cuff (with inflatable bladder 35 × 12 cm) was used in all cases.[14] Readings were taken to the nearest even number. Systolic and diastolic phase 5 were recorded. Two readings were taken and the mean values are reported here. Measurements were made by 35 nurses who were trained for the study using a film, a double headed stethoscope, and a series of measurement exercises on each other. Height was measured using Nivotoise stadiometers, and weight (to the nearest 0·5 kg) by portable electronic scales calibrated at the local trading standards office. The body mass index used in this paper is the Quetelet index (weight in kg ÷ height^2 in metres). The full series of measurements was obtained on 959 subjects.

One or both parents were interviewed about family circumstances and the subject's early life. Information on birthweight was only sought from biological parents, and is available for 902 cases. The height of the natural mother was self reported, and is not known for cases in which a step parent was the interviewee. Behavioural data were self reported using standard questions. "Smokers" and "drinkers" are those who reported smoking or drinking "occasionally" or "regularly". Since almost all respondents reported doing sport at school, the measure of exercise used here is the frequency of vigorous exercise (causing the subject to get out of breath and sweat, and lasting more than 20 minutes at a time) taken outside school. The distribution varied markedly between males and females (72% boys reported exercising outside school once or more a week compared with 37% girls). In this paper regular exercise is defined as that occurring outside school more than once a week for males (reported by 58% boys), and ever for females (reported by 50% girls), since this categorisation maximises comparability between the sexes. Social class is based on the 1980 Registrar General's Classification of Occupations,[15] using the father's current or last occupation, or, if there was no father or if he had no occupation, the mother's current or last occupation. Housing tenure is used as an alternative measure of social class since it does not depend on employment status, nor on whether there is a father in the family.

The interviews were carried out over 12 months in 1987, the distribution across the year being roughly normal (56% taking place in May, June, July). There was a tendency for respondents in owner-occupied housing and from higher social class backgrounds to be interviewed earlier in the year (although this trend was only statistically significant for boys for housing tenure). From inspection of three frequency distributions across month of interview—number of interviews conducted, mean systolic blood pressure, and mean room temperature—months of interview were divided into three periods. These were summer (June and July: number of subjects = 364); spring and autumn (April, May, August, September; n = 440), and winter (January, February, March, October, November, December; n = 142). The mean room temperatures recorded in these three seasons were: summer = 20·8°C, spring and autumn = 20·1°C, and winter = 18·7°C ($F = 80{\cdot}6$, $p = < 0{\cdot}0001$).

In order to maximise comparability with studies which present data separately for males and females, and which suggest that there are sex differences in the relationship between various factors and blood pressure,[eg 5 7 16 17] we conducted our analysis separately for males and females. One way analysis of variance was used for the univariate analysis of the categorical independent variables. Simple regression and multiple regression was used to analyse the continuous variables and the categorical variables (the latter being entered as dummy binary variables). The significance of sex differences in relationships with blood pressure was tested by examining two way interactions with sex in an analysis of variance (ANOVA) combining both sexes and with the continuous variables grouped into tertiles.

Results

Mean systolic blood pressure was 114·4 (SD 12·1) mm Hg in males and 108·8 (10·9) mm Hg in females. Mean diastolic blood pressure was 65·9 (9·9) in males and 66·4 (9·7) in females.

Tables I and II present data from the univariate analysis and show, respectively, mean systolic and mean diastolic blood pressures by the categorical social and behavioural variables. Females in owner-occupied housing have *lower* blood pressure than others ($F=5.09$, $p<0.05$ for systolic; $F=4.76$, $p<0.05$ for diastolic). Females who smoke have *lower* blood pressures than those who do not ($F=3.89$, $p<0.05$ for systolic; $F=5.79$, $p<0.05$ for diastolic). However, mean pulse rate was more strongly associated with smoking among males (73·6 beats/min for smokers *v* 69·9 for non-smokers; $p<0.001$) than among females (75·6 *v* 73·8; NS). Both males and females who reported taking more frequent exercise outside school had higher systolic blood pressure, though the difference was only significant for females ($p<0.05$). There were no differences in diastolic pressures by exercise category. In males resting pulse rate was lower in those exercising more frequently (69·5 beats/min *v* 71·9; $p<0.05$); the same was true for females though the difference was not significant (73·7 *v* 74·6; NS). In males systolic blood pressure was higher in summer than in spring/autumn or winter, but not significantly so. There are no other seasonal trends discernible.

The simple regression coefficients for systolic and diastolic blood pressure by the continuous variables are presented in tables III and IV. (These tables only include subjects—413 males and 425 females—for whom data were available for all the variables; therefore the totals differ from those given in tables I and II.) Systolic blood pressure is statistically significantly correlated with weight, height, pulse rate, and body mass index in both males and females, and with room temperature in males only and with mother's height in females only. Diastolic blood pressure is significantly correlated with weight and body mass index in both sexes and with room temperature and height for males. The correlations with both systolic and diastolic pressure are mostly higher for males than for females.

Room temperature was higher in non-owner occupied households than owner occupied housholds (for males 21·5°C *v* 20·0°C, $F=9.08$, $p<0.001$; for females 20·7°C *v* 20·0°C, $F=4.31$, $p<0.05$). For females, but not males, room temperatures were higher in manual than in non-manual households (20·7°C *v* 19·9°C, $F=5.37$, $p<0.05$).

Other studies have found an inverse relationship between birth weight and mean systolic blood pressure, but only when standardised for current weight.[1,2] In these 15 year olds the weight standardised regression coefficients were −1·26 mm/kg (95% confidence interval = −3·01 to 0·47) for boys, and 0·52 mm/kg (95% confidence interval = −1·28 to 2·34) for girls. These regression coefficients are not significantly different from zero.

Though not statistically significant, for males these findings are in the same direction as those of other studies, their weight standardised regression coefficients (−1·58 for 5–7 year olds,[1] −0·38 for 10 year olds,[2] and −2·57 for 35 year olds[2]) lying within the confidence intervals in our study. However, for females our results are inconsistent with those of others since we find a positive rather than inverse relationship between birthweight and systolic blood pressure, and our 95% confidence intervals do not include the coefficients reported by others (−2·03 for 5–7 year olds,[1] −1·32 for 10 year olds,[2] and −1·83 for 35 year olds[2]).

Table I Systolic blood pressure (mm Hg): mean values within groups, males and females.

	Males			Females		
	Mean	SD	n	Mean	SD	n
All	114·4	12·1	464	108·8	10·9	495
Non-manual social class	115·8*	12·7	199	108·8	10·2	200
Manual social class	113·4*	11·5	261	109·0	11·6	287
Owner-occupiers	115·3	11·9	227	107·7*	10·3	222
Other	113·6	12·1	234	109·9*	11·5	264
Non-smoker	114·5	12·3	288	109·3*	11·0	406
Smoker	113·3	10·9	76	106·7*	10·7	89
Non-drinker	113·9	11·8	315	108·9	10·9	387
Drinker	115·1	12·5	149	108·4	11·0	108
Frequent exercise	114·7	12·0	271	110·1*	10·2	249
Less frequent exercise	113.9	12·2	192	107·6*	11·7	242
Summer	115·3	12·9	171	108·9	11·6	193
Spring/autumn	113·9	11·1	226	108·0	9·8	214
Winter	113·1	12·7	62	109·4	12·0	80

*$p<0.05$

Table II Diastolic blood pressure (mm Hg): mean values within groups, males and females.

	Males			Females		
	Mean	SD	n	Mean	SD	n
All	65·9	9·9	464	66·4	9·7	495
Non-manual social class	66·9	9·6	199	67·0	9·4	200
Manual social class	65·2	10·1	261	66·2	10·0	287
Owner-occupiers	66·2	9·8	227	65·5*	9·5	224
Other	65·7	9·9	234	67·4*	9·9	264
Non-smoker	65·9	10·1	388	66·9*	9·7	406
Smoker	65·3	8·7	76	64.2*	9·6	89
Non-drinker	65·9	9·8	315	66·5	9·8	387
Drinker	65·6	10·7	149	66·1	9·7	108
Frequent exercise	65·3	10·0	271	66·7	9·7	249
Less frequent exercise	66·8	9·5	192	66·3	9·8	242
Summer	66·0	9.9	171	66·8	9·8	193
Spring/autumn	65·6	9·5	226	66·1	9·3	214
Winter	65·8	10·8	62	65·7	10·7	80

*$p<0.05$

The results of a multiple regression analysis of systolic and diastolic blood pressure, entering all the variables used in the preceding analyses (except for body mass index, since weight and height are components of the index and are thus already included in the multiple regression), are also shown in tables III and IV.

After controlling simultaneously for all the other variables, systolic blood pressure remains significantly associated with weight and pulse rate in both sexes, with weight having a greater effect on male pressures than on females pressures. Room temperature remains significantly associated with systolic pressure in males, and housing tenure, smoking, and exercise remains associated with systolic pressure in females. The effect of height disappears in both sexes.

In males, room temperature is the only variable that predicts diastolic pressure after controlling for all the other variables; in females, mother's height, pulse rate, and housing tenure remain significantly associated. Less of the variance in diastolic pressure (5·6% for females and 6·7% for males) was explained than of that in systolic pressure (15·1% and 19·4% respectively).

The differences between the sexes in association with systolic blood pressure were significant for weight ($p<0·1$), housing tenure ($p<0·05$), and smoking ($p<0·05$). There were no significant interactions with sex in relation to diastolic blood pressure.

Discussion

Mean values for both systolic and diastolic blood pressure in this study were lower than those reported for similar age groups by most of the US studies,[18 19] and than those produced by pooling results from 79 studies from all over the world.[20] They are however similar to those reported for Greece and Italy.[18] The systolic values are also lower than the 122 for boys and 113 for girls reported among 15 year olds in a Nottingham general practice.[7] These lower levels may be due to the smaller stature of this Scottish sample (mean height was 171·6 cm for boys and 161·7 cm for girls). Unfortunately many studies do not report height data.

In this sample, associations between the factors examined and blood pressure differed between males and females. As has been reported in other studies,[7] in males the strongest associations were with anthropometric measures such as weight and height, and more of the variance in blood pressure (particularly systolic blood pressure) was explained by the available data than it was for females. In females associations with blood pressure were additionally shown for mother's height, housing tenure, smoking, and exercise outside school. Females who took more exercise outside school, and those who did not smoke, had significantly higher systolic pressures. Similar findings on lowered systolic pressures among female smokers in this age group have previously been reported.[16] The sex difference in the association with smoking cannot be explained by higher consumption among the girls (female smokers reported lower mean cigarette consumption than male smokers: 32·8 per week compared to 40·3 per week respectively). It might,

Table III Systolic blood pressure: simple regression coefficients, and regression coefficients controlling for the other variables

	Males (n=413)				*Females (n=425)*			
	Simple regression coefficient	*SEM*	*Multiple regression coefficient*	*SEM*	*Simple regression coefficient*	*SEM*	*Multiple regression coefficient*	*SEM*
Body mass index (kg/m^2)	1·50‡	0·19	—	—	0·72‡	0·17	—	—
Birthweight (kg)	0·44	0·97	−0·45	0·85	1·61*	0·94	0·63	0·95
Weight (kg)	0·43†	0·05	0·50‡	0.06	0·28‡	0·06	0·26‡	0·06
Height (cm)	0·26‡	0·08	−0·09	0·09	0·16*	0·09	−0·07	0·11
Mother's height (cm)	−0·00	0·09	−0·15	0·08	0·19*	0·09	0·18	0·09
Room temperature (°C)	−0·49*	0·25	−0·54*	0·22	−0·25*	0·22	−0·28	0·22
Pulse rates (beats/min)	0·12*	0·06	0·17†	0·05	0·25‡	0·06	0·27‡	0·06
Summer	−1·77	1·22	−1·86	1·09	−0·60	1·08	−0·92	1·13
Winter	−0·82	1·19	−1·34	1·55	1·30	1·43	1·49	1·48
Social class	−2·41*	1·28	−1·24	1·13	0·58	1·07	−0·22	1·14
Housing tenure	−1·81	1·18	0·64	1·17	2·25*	1·05	3·22†	1·14
Smoking	−1·95	1·65	−2·13	1·42	−2·68*	1·44	−3·43*	1·43
Drinking	−1·51	1·28	0·88	1·13	−0·98	1·29	−0·72	1·25
Exercise	−1·37	1·37	−1·57	1·15	−2·86†	1·05	−2·42*	1·01

Categorical variables: non-smoker = 0, smoker = 1; frequent exercise = 0, less frequent = 1; non-manual class = 0, manual = 1; owner occupier = 0, other = 1; non-drinker = 0, drinker = 1; summer = 0, spring/autumn/winter = 1; winter = 1, spring/autumn/summer = 0
*$p<0·05$; †$p<0·01$; ‡$p<0·001$

Table IV Diastolic blood pressure: simple regression coefficients, and regression coefficients controlling for the other variables

	Males (n=413)				*Females (n=425)*			
	Simple regression coefficient	*SEM*	*Multiple regression coefficient*	*SEM*	*Simple regression coefficient*	*SEM*	*Multiple regression coefficient*	*SEM*
Body mass index (kg/m^2)	0·42*	0·17	—	—	0·32*	0·15	—	—
Birthweight (kg)	1·19	0·81	0·64	0·85	0·75	0·83	0·69	0·87
Weight (kg)	0·14†	0·05	0·11	0·06	0·10*	0·05	0·11	0·06
Height (cm)	0·14*	0·07	0·06	0·09	0·01	0·08	−0·17	0·10
Mother's height (cm)	0·08	0·08	0·01	0·08	0·13*	0·08	0·19*	0·09
Room temperature (°C)	−0·69‡	0·20	−0·73‡	0·22	−0·11	0·20	−0·18	0·21
Pulse rates (beats/min)	0·08*	0·05	0·10	0·05	0·09	0·05	0·11*	0·05
Summer	0·10	1·02	−1·12	1·09	−0·49	0·95	−0·25	1·04
Winter	0·88	1·45	0·46	1·55	−0·34	1·25	−0·50	1·37
Social class	−1·37	0·99	−0·73	1·13	−0·70	0·94	−1·68	1·05
Housing tenure	−0·62	0·99	1·11	1·17	1·95*	0·93	3·15†	1·05
Smoking	−0·58	1·37	−0·56	1·42	−1·46	1·26	−2·00	1·32
Drinking	−0·22	1·07	−0·32	1·13	−0·02	0·92	0·28	1·16
Exercise	1·60	1·13	1·38	1·15	−0·79	0·93	−0·56	0·93

Categorical variables: non-smoker = 0, smoker = 1; frequent exercise = 0, less frequent = 1; non-manual class = 0, manual = 1; owner occupier = 0, other = 1; non-drinker = 0, drinker = 1; summer = 0, spring/autumn/winter = 1; winter = 1, spring/autumn/summer = 0
*$p<0·05$; †$p<0·01$; ‡$p<0·001$

however, be explained by females having started to smoke earlier, given their relatively greater social maturity at this age, but unfortunately we do not have data on the age our subjects started smoking, although we are seeking this information at our current contact with this cohort. Other studies of the effects of sports activity have either shown lower systolic pressures among exercise takers[7] or no relationship with exercise.[17 21]

The association with housing tenure cannot be explained by variations in room temperature. Housing tenure is, in Scotland at least, a good proxy measure for socioeconomic circumstances and is often found to be correlated with health indices as closely or more closely than occupationally based measures of social class.[22] A recent paper on 15 year olds in Finland has shown that systolic blood pressures among girls, but not boys, were significantly associated with family socioeconomic circumstances such as years of education of father and gross family income.[17] Our data therefore seem to confirm findings from elswhere that blood pressure in females may be more highly correlated with socioeconomic and behavioural factors than blood pressure in males. From these cross sectional data it is not clear whether these associations in females are due to relatively recent (or current) social or material environmental circumstances, or to perinatal or lifetime exposure to these circumstances.

In contrast to recent studies of children and adults[1 2] no significant association was found between systolic pressure and birthweight even after controlling for current weight, although for males we found a non-significant inverse association that is consistent with the findings of these studies. For females our findings are not consistent with those of other studies. Our birthweight data were retrospectively reported, but so were the data used in other studies,[1] and it has been shown that maternal reports of birthweight are reasonably reliable.[23 24] We therefore do not think it likely that our findings are due to unreliable birthweight data. They may, however, be due to the effects of puberty and differential rates of maturation. Because we are following up this cohort at age 18 and beyond, it will be possible to see whether significant associations with birthweight emerge as the cohort reaches adulthood, ie, whether they have been obscured by pubertal changes. Equally, it will be possible to study the relative importance of behavioural factors (smoking, alcohol consumption, and exercise patterns), socioeconomic factors, and early life experiences on blood pressure at different stages of the life cycle.

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