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Blood pressure and smoking: observations on a national cohort

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Abstract

The reasons why adult smokers have lower blood pressure than non-smokers have not been determined. It is possible that low blood pressure might precede the onset of smoking. This study investigates this hypothesis in a national cohort study in Britain.

Blood pressures and pulse rates taken on a sample of 5019 members of the British Birth Cohort Study (BCS 70) at the age of 10 years were analysed in relation to self reported smoking behaviour at age 16+ years. Prospectively, those children who had lower diastolic blood pressure or pulse rate at age 10 were more likely to have smoked by age 16+ years. Using analysis of variance, pulse rate was significantly related to smoking in young men ($p<0.001$). Seventy per cent of those with lower pulse (below the 10th centile), 58% with medium pulse, and 52% with the higher pulse (above the 90th centile) had ever smoked by age 16+ years. In young women, pulse rate ($p=0.003$), diastolic pressure ($p=0.024$), and systolic pressure ($p=0.032$) at age 10 were all significantly related to smoking at age 16. This longitudinal study found that lower blood pressure and slower pulse rate were related to the onset of smoking in children. More research is needed on this new observation.

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It is now 20 years since cross sectional studies of adults first showed that smokers had lower mean blood pressure than non-smokers.[1–3] The association between smoking and lower blood pressure has been shown to exist independently of other factors such as age and weight,[4] height and serum cholesterol,[5] alcohol and coffee intake, ethnic origin, and participation in leisure time sports.[6] There is also evidence that adolescents who are regular smokers have lower systolic blood pressure than those who have never been regular smokers by the age of 17 years, in spite of having a higher body mass index.[7]

Since smokers appear to be more likely than non-smokers to suffer from accelerated hypertension,[8–10] although not of hypertension in general, the consistent finding of lower blood pressure is perhaps surprising. Apart from the multivariate analyses mentioned earlier, a possible explanation is that regular smokers who do not smoke before or during a medical examination might experience a downward rebound of blood pressure due to nicotine deprivation.[11] The general assumption, however, appears to have been that smoking precedes blood pressure changes rather than the reverse. The hypothesis tested in this present analysis is that lower blood pressure precedes smoking and that children with lower blood pressure are, for some reason, more likely to smoke.

The British Birth Cohort Study 1970 (BCS70) provides the means for testing this hypothesis in a longitudinal study of a cohort of children. The analysis described in this paper is based on medical tests carried out at the age of 10 years in relation to smoking behaviour by the age of 16+ years.

Methods

The young people involved in this study were members of the British Birth Cohort Study,[12] which was a longitudinal study of children who were born in the week of the 5th to 11th of April 1970 in England, Scotland, and Wales. The study began at birth and the cohort was followed up at the ages of 5, 10, and 16 years. Medical examinations, data collection by interview and questionnaires, and educational tests were carried out at each stage.

A prospective analysis relating blood pressure and mean pulse rate at age 10 years to the risk of smoking by age 16+ years was carried out on 5019 cohort members (2145 males and 2874 females) for whom smoking data at age 16+ years and medical data at age 10 years were available.

The data were made available to the authors by the organisers of the British Birth Cohort Study.

Blood pressure and pulse rates were measured by a community medical officer as part of a medical examination to provide physical data on the cohort members.

MEASUREMENT OF BLOOD PRESSURE

Blood pressure was taken as a single measurement with the child seated on a chair in as relaxed a state as possible, using a sphygmomanometer with cuff a minimum of 4 inches (10 cm) deep. The cuff was wrapped around the right upper arm to encircle it completely with the rubber tube from the bladder located posteriorly, for ease of access to the right antecubital fossa. The right radial pulse was palpated and the cuff inflated to about 30 mm Hg above the disappearance of the pulse. The cuff was slowly deflated until the pulse reappeared and the cuff was then deflated. The

stethoscope was placed in the antecubital fossa over the brachial artery but not in contact with any part of the cuff. The cuff was rapidly inflated to about 30 mm Hg above the systolic pressure and then deflated at a rate of 2–3 mm Hg per second.

Systolic pressure was recorded at the appearance of faint clear tapping sounds for two consecutive beats.

Diastolic pressure was recorded as Korotkoff's fourth sound.

MEASUREMENT OF PULSE RATE

Pulse rate was taken at the start and again at the end of the examination. In each case the child was sitting and settled for 2 min before the reading was taken over a period of 1 min. For purposes of the analysis the mean of these measurements has been used in this paper.

SELF REPORTING OF SMOKING BEHAVIOUR

Smoking behaviour was self reported by the young people in a postal questionnaire at the age of 16+ years. The question used for our analysis was: *Please tell us what kind of 'smoker' you are by ticking one of the boxes below.* The responses to choose from were: I have never smoked a cigarette; I used to smoke but I haven't for 3 months or more; I smoke sometimes but not as much as one cigarette a week; I am a smoker (at least one cigarette a week). Because these responses did not give details of those who had experimented with smoking or were occasional smokers, other questions were cross referenced to add detail. From these responses, five categories of smoker were defined as followed: (1) never smoked; (2) trier, who has once had a cigarette or a puff of one; (3) ex-smoker; (4) occasional smoker; (5) regular smoker as defined above. The categories used for analysis were 'never smoked', 'smoked at some time', and 'regular smoker of at least one cigarette per week'. The smoked at some time category consisted of those who had tried a cigarette, ex-smokers, and occasional smokers. When one way analysis of variance was carried out on blood pressures and pulse rates for the three groups included in the smoked at some time category, no significant differences were found; it was therefore considered to be safe to combine them. Data on how long or how heavily the young people smoked were not available from the BCS70 cohort study.

Table 1 Mean blood pressure (mm Hg) and pulse rate (beats/min) at age 10 related to smoking behaviour in 16+ year olds

Smoke	*No*	*Diastolic blood pressure at age 10 (mean (95% CI))*	*Systolic blood pressure at age 10 (mean (95% CI))*	*Pulse rate at age 10 (mean (95% CI))*
Males:		(p=0·177)	(p=0·515)	(p<0·001)
Never	889	63·05 (62·46, 63·64)	98·47 (97·76, 99·18)	80·31 (79·66, 80·96)
Smoked at some time	840	62·27 (61·64, 62·89)	97·93 (97·20, 98·65)	78·35 (77·72, 78·99)
Regular	416	62·98 (62·01, 63·95)	97·93 (96·94, 98·92)	79·53 (78·56, 80·50)
Females:		(p=0·024)	(p=0·032)	(p=0·003)
Never	1082	62·96 (62·43, 63·49)	98·53 (97·91, 99·15)	82·96 (82·33, 83·58)
Smoked at some time	1147	61·98 (61·45, 62·51)	97·35 (96·72, 97·98)	82·33 (81·74, 82·93)
Regular	645	62·05 (61·34, 62·77)	98·14 (97·27, 99·01)	81·20 (80·44, 81·95)

CI=confidence interval.

ANALYSIS

The findings were analysed using two methods, a parametric approach and a non-parametric approach. The parametric approach consisted of one way analysis of variance, Duncan's multiple range tests, and *t* tests. For non-parametric analysis, blood pressure and mean pulse rate were categorised into groups so that χ^2 tests and relative risks could be calculated. However, because blood pressure and pulse rates have often been rounded to the nearest 10 or 5 by the medical recorder, and precise grouping was not possible, two groupings were investigated as follows: (1) those children whose readings fell approximately in the first third and last third of the measurement distribution were classified as lower and higher, respectively, leaving the remaining children classified as medium; (2) those with a measurement approximately below the 10th centile were grouped as lower, those above the 90th centile were classified as higher. The rest were classified as medium.

The cut off point for statistical significance is p=0·05. The SPSS[14] package was used for the analysis.

Results

PARAMETRIC APPROACH

Blood pressure

At age 10 years the diastolic blood pressures (DBP) ranged from 20 to 100 mm Hg. The low DBP reading of 20 mm Hg was recorded for three individuals and it is possible that rounding down of the measurements has occurred. The mean DBP was 62·52 mm Hg for the sample at the age of 10 years. Systolic blood pressures (SBP) ranged from 58 to 175 mm Hg with a mean of 98·05 mm Hg. Five individuals had an SBP measurement of 60 mm Hg or below.

Pulse rate

At age 10 years the mean pulse rate ranged from 50 to 150 beats/min, with a mean of 81·07 beats/min.

Smoking behaviour at age 16+ years

By 16+ years, 39·3% (n=1971) said they had never smoked, 39·6% (n=1987) had smoked at some time, and 21·1% (n=1061) were regular smokers of at least one cigarette per week.

Blood pressure and pulse rates at age 10 years related to smoking behaviour at age 16+ years

When pulse rates and blood pressure measurements taken at the age of 10 years were considered in relation to smoking behaviour of 16 year olds (table 1), there were gender differences. For the females (using one way analysis of variance) there were significant differences between the means of the smoking groups for all three medical measurements. Duncan's multiple range test indicated significant differences between the 'never smoked' and the

Table 2 Smoking behaviour by age 16+ years related to blood pressure levels (mm Hg) and pulse rate (beats/min) at age 10, categorised into three approximately equal groups. Values are means (n)

	Diastolic blood pressure at age 10			*Systolic blood pressure at age 10*			*Pulse rate at age 10*		
Smoke	*20–59 (lower)*	*60–65 (medium)*	*66–100 (higher)*	*58–90 (lower)*	*91–100 (medium)*	*101–175 (higher)*	*35–74·5 (lower)*	*75–82·5 (medium)*	*83–150 (higher)*
Males:	(p=0·192)			(p=0·460)			(p=0·028)		
Never	37 (194)	43 (383)	42 (312)	39 (265)	43 (320)	43 (304)	38 (261)	42 (309)	45 (319)
At some time	43 (223)	38 (339)	38 (278)	41 (279)	38 (281)	39 (280)	44 (302)	39 (285)	35 (253)
Regular	20 (102)	19 (164)	20 (150)	21 (141)	19 (144)	18 (131)	18 (127)	20 (146)	20 (143)
Totals	519	886	740	685	745	715	690	740	715
							35–77·5	*78–85·5*	*86–150*
Females:	(p=0·323)			(p=0·024)			(p=0·080)		
Never	35 (268)	37 (429)	40 (385)	34 (316)	39 (403)	40 (363)	35 (331)	37 (362)	41 (389)
At some time	41 (314)	40 (461)	39 (372)	44 (410)	39 (399)	37 (338)	40 (375)	41 (398)	39 (374)
Regular	24 (181)	23 (260)	21 (204)	22 (208)	22 (231)	23 (206)	25 (233)	22 (217)	20 (195)
Totals	763	1150	961	934	1033	907	939	977	958

'smoked at some time' groups for DBP and SBP. Significant differences were also shown between the never smoked group and the regular smokers for DBP and pulse rate. These findings were supported by similar results from the *t* tests.

For the young men, pulse rate at the age of 10 years was related to smoking behaviour by 16+ years. Using Duncan's multiple range test, there were significant differences in pulse rate between those who had smoked at some time and those who had never smoked.

For both young men and women the DBP, SBP, and pulse rate were always higher in the never smoked group than in the smoked at some time or regular smoker groups.

NON-PARAMETRIC APPROACH

Uptake of smoking related to blood pressure and pulse rate at age 10 years

When the male mean pulse rate was distributed into three approximately equal groups (table 2), those children who had the lower diastolic/systolic blood pressure or slower pulse rate at age 10 years were most likely to have tried smoking or to have become regular smokers by age 16+ years, regardless of gender. The mean pulse rate was significantly associated with an increased risk of ever having smoked by age 16+years in the young men, with 62% of those with the lower pulse rate smoking by the age of 16+ years, compared with 58% of the medium and 55% of the higher rate (p=0·035).

Using the same type of grouping, the relationship between pulse rate and smoking at age 16+ years was barely significant in the females (p=0·049): 65% with slow, 63% with medium, and 59% with high pulse rate smoked.

Examining the lower and upper 10th percentiles the same basic relationship was seen in diastolic blood pressure and pulse rate, that is, there were fewer who had never smoked in the lower categories than in the other categories. Mean pulse rate was significantly associated with an increased risk of ever having smoked by age 16+ years in the young men, with 70% of those with the lower pulse rate smoking by the age of 16+ years, 58% with the medium, and 52% with the higher rate (p=<0·001).

For the young women, the relationship was not significant (p=0·204): 66% with slow, 62% with medium, and 58% with high pulse rate were smoking.

The relative risks of ever smoking ('smoked at some time' or regularly) by age 16+ years are shown in table 3.

Discussion

Those young people who had low diastolic blood pressure and slow pulse rates at age 10 years were the most likely to have smoked by age 16+ years. Low pulse rate was especially significant, particularly in the young men. It seems probable that the difference in the smoking related diastolic pressure between males and females was real, because it has also been found in other studies.[6]

Few explanations have been proffered to explain this finding, the acute effect of smoking being to raise blood pressure and pulse rate. One suggestion is that smokers refrain from smoking before medical examinations in which blood pressure would be measured, which

Table 3 Relative risks and 95% confidence intervals of ever smoking (smoked at some time or regular) by age 16+ years, with respect to gender

	Measure	*Risk group*	*Base*	*Males (RR (95% CI))*	*Females (RR (95% CI))*
Three approximately equal groups of lower, medium and higher	Diastolic BP at age 10 years	Lower third	Medium Higher	1·103 (1·010, 1·204) 1·083 (0·989, 1·185)	1·035 (0·966, 1·108) 1·082 (1·006, 1·165)
	Systolic BP at age 10 years	Lower third	Medium Higher	1·075 (0·986, 1·171) 1·067 (0·978, 1·163)	1·085 (1·015, 1·160) 1·103 (1·028, 1·183)
	Mean pulse rate at age 10 years	Slower third	Medium Higher	1·067 (0·981, 1·161) 1·123 (1·028, 1·226)	1·029 (0·962, 1·100) 1·090 (1·016, 1·170)
Using the 10th and 90th centiles to form three groups of lower, medium, and higher	Diastolic BP at age 10 years	Lower tenth	Medium Higher	1·150 (1·046, 1·265) 1·122 (0·977, 1·288)	1·065 (0·984, 1·154) 1·096 (0·970, 1·239)
	Systolic BP at age 10 years	Lower tenth	Medium Higher	0·946 (0·827, 1·081) 1·019 (0·848, 1·224)	1·079 (0·983, 1·184) 1·053 (0·924, 1·199)
	Mean pulse rate at age 10 years	Slower tenth	Medium Higher	1·205 (1·094, 1·329) 1·332 (1·139, 1·558)	1·048 (0·960, 1·144) 1·121 (0·987, 1·272)

RR=relative risk; CI=confidence interval; BP=blood pressure.

could cause a sharp drop.[11] Another suggestion is that it is the result of reduced stroke volume.[13]

The study is a pilot and has several limitations which would need to be surmounted in further prospective or retrospective research before these very new findings could be confirmed. The first, and main, limitation of the study is the need for a multivariate analysis which includes such factors as socioeconomic status, location, and micro and macro factors known to influence a young person's decision to smoke. There is also a need for validation of the self reported smoking habits, both at the earlier and at the later ages. Saliva cotinine assay could now be used for this purpose, whereas it was not available for BCS70. There is no guarantee that 10 year olds do not smoke when they say they do not. Such cotinine measures would also validate exposure to smoke. The duration of smoking behaviour also needs to be ascertained. It is possible, too, that young people who had high blood pressure at the age of 10 years might have received more medical attention and have been advised and helped to be non-smokers.

All these aspects would need to be included in further research. The differences found in this study are relatively small, but they are statistically significant. While unlikely in themselves to be of clinical significance, they are important indicators for future lines of investigation. We are planning a more detailed study which would allow the desirable background data to be collected and the smoke exposure to be validated by biochemical means. The findings of the present study should be seen as an indicator of the need for further research rather than as a definitive statement.

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