Trends in blood pressure over 10 years in adolescents: analyses of cross sectional surveys in the Northern Ireland Young Hearts project

David Watkins, Peter McCarron, Liam Murray, Gordon Cran, Colin Boreham, Paula Robson, Claire McGartland, George Davey Smith, Maurice Savage

Abstract

Objective To examine secular trends in blood pressure over a 10 year period between two representative cohorts of adolescents from Northern Ireland.

Design Repeat cross sectional study.

Setting Randomly selected post-primary schools from Northern Ireland.

Participants 1015 adolescents studied between 1989 and 1990, and 2017 adolescents studied between 1999 and 2001. Participants were aged 12 or 15 years.

Main outcome measures Systolic and diastolic blood pressure measured by one observer in each study.

Results The four groups for sex and age showed decreases in both systolic blood pressure (mean decrease 7.7 mm Hg to 10.0 mm Hg) and diastolic blood pressure (8.8 mm Hg to 11.0 mm Hg). These decreases were not accounted for by adjustment for potential confounders including age, height, body mass index, smoking, physical activity, aerobic fitness, and stratification. The findings were not altered by additional adjustment for social class, pubertal status, birth weight, and infant feeding. No evidence was found of systematic variation between observers.

Conclusions Substantial decreases in systolic and diastolic blood pressure over the past decade in adolescents from Northern Ireland are likely to have important benefits to public health and may help offset the increasing risk of cardiovascular disease due to increases in obesity.

Introduction

Raised blood pressure is a major risk factor for cardiovascular disease.[1] Trends in blood pressure in adolescents are a marker of the future population burden of cardiovascular disease and may be of particular relevance in areas with high disease rates.[2] We examined trends in blood pressure in representative samples of adolescents in Northern Ireland, a region with a consistently high prevalence of cardiovascular disease.[3]

Participants and methods

The first Young Hearts study (YH1990) was carried out in 1989-90 to evaluate the status of major modifiable coronary risk factors, including blood pressure, within the adolescent population of Northern Ireland. Random samples of males and females aged 12 and 15 years participated, with around 250 participants in each of the four groups for age and sex. Details of the study design are presented elsewhere.[4] A further cross sectional survey—Young Hearts 2000 (YH2000)—was carried out in 1999-2001. Around 500 adolescents in each of the four groups were recruited through post-primary schools. The primary sampling units were schools, randomly selected with probabilities proportional to school size: 16 schools took part in the first study and 36 in the second (two schools participated in both). The secondary units for study were the adolescents themselves, randomly selected from the four groups.

Blood pressure measurement

In each study, blood pressure readings were carried out by one observer. Tight clothing was removed from the arm, and blood pressure was measured with participants sitting after at least five minutes' rest using the UK random-zero Hawksley sphygmomanometer.[5] Instruments were calibrated by the same laboratory before both studies. The same standard cuff size was used in both surveys. The cuff was deflated by around 2 mm Hg each second and was completely deflated between readings. Systolic blood pressure was expressed as the Korotkoff phase I value. We used the Korotkoff IV value (muffling of pulse sounds) for participants aged 12 and the Korotkoff V value for participants aged 15. All readings were taken to the nearest 2 mm Hg. To check for any variation between observers in blood pressure measurements, the observers took readings from 50 randomly selected adolescents within the study age range from a non-participating Belfast school.

Height was measured to the nearest millimetre and weight to the nearest 100 g. Pubertal status was assessed by two methods (see bmj.com). Cardiorespiratory fitness was estimated by indirect calculation of oxygen consumption at maximal dynamic effort in a 20 m shuttle run.[6] Smoking status was assessed as part of a confidential self report questionnaire; regular smoking was defined as consumption of one or more cigarettes a week. Birth weight of participants was recalled by parents. Social class was based on the current occupation of the head of the household and classified according to the 1990 standard occupational classification of the Office of Population, Censuses, and Surveys.

Statistical analysis

We performed separate analyses for each of the four groups. Continuous variables and categorical variables in both studies were compared by t tests and χ^2 tests, respectively. Multivariate regression analysis was used to estimate the changes in mean systolic and diastolic blood pressures between the two studies. We only present the data for participants with complete data.

ELPS

This is the abridged version of an article that was posted on bmj.com on 29 June 2004: http://bmj.com/cgi/doi/10.1136/bmj.38149.510139.7C

Department of Child Health, Queens University of Belfast, Institute of Clinical Science, Royal Victoria Hospital, Belfast BT12 6JB
David Watkins *consultant*
Maurice Savage *professor*

Department of Epidemiology and Public Health, Queen's University, Belfast
Peter McCarron *senior lecturer*
Liam Murray *senior lecturer*
Gordon Cran *senior lecturer in medical statistics*

Department of Applied Medical Sciences and Sports Studies, University of Ulster, Newtownabbey BT37 0QB
Colin Boreham *professor of sport and exercise science*

Northern Ireland Centre for Diet and Health, University of Ulster, Coleraine BT52 1SA
Paula Robson *research fellow*
Claire McGartland *research associate*

Department of Social Medicine, University of Bristol, Bristol BS8 2PR
George Davey Smith *professor of clinical epidemiology*

Correspondence to: Dr David Watkins, Stepping Hill Hospital, Stockport SK2 7JE david.watkins@stockport-tr.nwest.nhs.uk

BMJ 2004;329:139–41

Table 1 Mean (SD) systolic and diastolic blood pressures in participants from Young Hearts studies, 1990 and 2000

Age; blood pressure reading (mm Hg)	Males		P value	Females		P value
	1990	2000		1990	2000	
12 years:	n=247	n=530		n=248	n=514	
Systolic	111.0 (11.6)	102.9 (11.6)	<0.001	111.5 (12.2)	104.2 (12.1)	<0.001
Diastolic	67.9 (9.5)	59.1 (8.7)	<0.001	70.9 (9.1)	60.4 (8.6)	<0.001
15 years:	n=249	n=485		n=252	n=482	
Systolic	123.3 (12.4)	113.2 (12.8)	<0.001	118.3 (11.8)	109.9 (11.1)	<0.001
Diastolic	73.4 (9.4)	62.5 (8.4)	<0.001	74.3 (8.8)	64.5 (8.7)	<0.001

All data were analysed with SPSS for Windows version 11.0.

Results

The response rate for the second study was lower than that for the first (65.3% compared with 79.3%). Reasons for non-participation were similarly distributed between both studies. On the basis of limited self reported anthropometric data from non-participants, body mass index (weight (kg)/(height (m)^2)) was 0.9 lower in non-participants than in participants.

Although there was disagreement between the observers for some blood pressure readings, there was no evidence of systematic variation between them. We found no evidence that observer effect had influenced blood pressure measurement (data not shown).

We found consistent differences in mean blood pressure between both sexes, males tending to have higher systolic and lower diastolic blood pressure than age matched females (table 1). These findings remained largely unchanged between the two studies.

Mean height increased substantially in the four groups (by 1.9 cm to 3.0 cm, $P<0.001$ for each group) as did mean weight (by 1.5 kg to 4.2 kg, $P<0.001$ to $P=0.04$), with the largest increases among 12 year olds (see bmj.com). Mean body mass index only increased significantly in 12 year old females. Mean birth weight changed little between the first and second study (3372 g versus 3408 g, respectively; $P=0.10$). The proportion of females of both ages who smoked regularly increased. Mean maximal aerobic fitness and mean habitual physical activity showed more favourable trends in males. The proportion of participants who were breast fed as infants increased in all four groups over the 10 year period, as did the proportion from a non-manual background (59.2% versus 72.8%; $P<0.001$).

Substantial decreases were found consistently across all four groups for both systolic blood pressure (mean unadjusted decrease 7.7 mm Hg to 10.0 mm Hg) and diastolic blood pressure (8.8 mm Hg to 11.0 mm Hg); this represents an annual decline of 0.73 mm Hg to 1.01 mm Hg and 0.89 mm Hg to 1.09 mm Hg, respectively (table 2). Additional modelling, controlling for age, height, body mass index, smoking status, physical activity, stratification of school, breast feeding, and fitness, and then additionally controlling for birth weight, social class, and pubertal status, had negligible effects on the results presented in table 2 (data not shown).

Table 2 Decreases in mean blood pressure over 10 years in participants of Young Hearts studies, 1990 and 2000. Values are means (95% confidence intervals)

Age and sex	Systolic blood pressure (mm Hg)		Diastolic blood pressure (mm Hg)	
	Unadjusted decrease	*Adjusted decrease	Unadjusted decrease	*Adjusted decrease
12 years:				
Males	8.1 (6.4 to 9.9)	9.5 (8.0 to 11.1)	8.8 (7.4 to 10.2)	9.7 (8.4 to 11.0)
Females	7.7 (5.9 to 9.5)	10.4 (8.7 to 12.0)	10.5 (9.1 to 11.8)	11.9 (10.6 to 13.1)
15 years:				
Males	10.0 (8.1 to 12.0)	11.6 (9.8 to 13.3)	11.0 (9.6 to 12.4)	11.6 (10.3 to 12.9)
Females	8.4 (6.7 to 10.2)	8.7 (7.0 to 10.3)	9.8 (8.5 to 11.1)	10.2 (8.9 to 11.5)

P<0.001 for all groups (unadjusted and adjusted).

*Adjusted for body mass index, age, height, physical activity score, self reported smoking, and stratification.

Discussion

Large decreases in blood pressure have occurred among adolescents aged 12 and 15 years from Northern Ireland over the decade from 1990. The magnitude of the trends is greater than previously reported, and could not be accounted for by several important mediating or confounding factors.

Our study was population based, and participants were selected randomly. The response rate was lower for the second of the two studies (YH2000), and although there was some evidence that non-participants were thinner than participants, this bias would have tended to moderate the declines in blood pressure. We attempted to check for variations between observers and instruments. Although this validation exercise was small and limited, it showed no substantial effect from variation between observers. Birth weight was based on parental recall, which has been shown to give a reliable estimation of recorded birth weight in participants in YH1990.[7] Assessments of pubertal status are likely to be poor and arbitrary measures of the range of sexual maturity (see bmj.com), but adjustment for pubertal status did not alter the findings and, moreover, we do not think that age at puberty will have shifted to anything except a negligible degree over the 10 years between the studies. While some caution is indicated in assessing the declines, the lack of systematic variation between observers, the use of random-zero calibrated sphygmomanometers, coupled with the consistency with published literature, indicate that the findings are unlikely to be artefactual and that bias is unlikely to explain more than a modest proportion of the declines in blood pressure noted.

Factors responsible for these secular decreases in blood pressure have not yet been established. The downward trend seems to be occurring despite positive associations between blood pressure in children and height[8] and indices of fatness,[9] both of which increased between the two Young Hearts studies (and may account for the greater adjusted mean decreases compared with the unadjusted decreases). Similar findings have been observed in the Health Survey for England, when increases in body mass index were accompanied by decreases in blood pressure.[10]

Birth weight, as the most accessible marker of intrauterine growth, has shown a consistent inverse association with subsequent blood pressure.[11] An estimated increase in birth weight of around 1000 g would be required to produce a 2 mm Hg decrease in systolic blood pressure in people aged 50,[11] and even this effect size has been questioned, with the suggestion that the inverse association may reflect the impact of

What is already known on this topic

Trends in blood pressure in early life are a marker of subsequent cardiovascular risk

Studies have shown secular decreases in blood pressure in adults, but evidence for younger populations is less consistent

What this study adds

Decreases in blood pressure, not explained by change in body composition or birth weight, have occurred in adolescents in Northern Ireland over the past decade

The major determinants of adult blood pressure seem to be set in early life

Potentially modifiable determinants need to be ascertained

selective emphasis of particular results and inappropriate adjustment for confounders.[12] The relatively small secular changes in mean birth weight (from −11 g to 94 g for the different groups) between our two cohorts would not by themselves explain the magnitude of decreases in blood pressure.

Alterations in salt intake may be important. In adolescents randomised in infancy to a low or a normal sodium diet systolic and diastolic blood pressure were lower after 15 years in those in the intervention arm, suggesting that sodium restriction in infancy may have greater effects on later blood pressure than salt reductions in adulthood,[13] and although these findings are based on incomplete follow up, they are, nevertheless, provocative.

Our observations suggest that several of the major determinants of adult blood pressure are set in train in early life. It is therefore encouraging that blood pressure levels seem to have fallen over time in this population, and there are likely to be considerable public health benefits in such a population decrease if it is sustained into adult life.

Contributors: See bmj.com

Funding: The Young Hearts 2000 project was funded by a grant from the Department of Health and Social Services in Northern Ireland. PMcC is funded by a Department of Health public health career scientist award.

Competing interests: None declared.

Ethical approval: This study was approved by the research ethics committee of Queen's University of Belfast. Written consent for participation was obtained from each participant and the participant's parent or guardian.

1 Stamler J, Stamler R, Neaton JD. Blood pressure, systolic and diastolic, and cardiovascular risks. US population data. *Arch Intern Med* 1993;153:598-615.
2 McCarron P, Davey Smith G, Okasha M, McEwen J. Blood pressure in young adulthood and mortality from cardiovascular disease. *Lancet* 2000;355:1430-1.
3 Uemura K, Pisa Z. Trends in cardiovascular disease mortality in industrialized countries since 1950. *World Health Stat Q* 1988;41:155-78.
4 Boreham C, Savage JM, Primrose D, Cran G, Strain J. Coronary risk factors in schoolchildren. *Arch Dis Child* 1993;68:182-6.
5 Wright BM, Dore CF. A random-zero sphygmomanometer. *Lancet* 1970;337-8.
6 Boreham CA, Paliczka VJ, Nichols AK. A comparison of the PWC170 and 20-MST tests of aerobic fitness in adolescent schoolchildren. *J Sports Med Phys Fitness* 1990;30:19-23.
7 Walton KA, Murray LJ, Gallagher AM, Cran GW, Savage MJ, Boreham C. Parental recall of birthweight: a good proxy for recorded birthweight? *Eur J Epidemiol* 2000;16:793-6.
8 Kotchen JM, McKean HE, Neill M, Kotchen TA. Blood pressure trends associated with changes in height and weight from early adolescence to young adulthood. *J Clin Epidemiol* 1989;42:735-41.
9 Berenson GS, Wattigney WA, Webber LS. Epidemiology of hypertension from childhood to young adulthood in black, white, and Hispanic population samples. *Public Health Rep* 1996;111(suppl 2):3-6.
10 Department of Health. *Health survey for England: trend data for children 1995-1998, children's reference tables '98.* London: Department of Health, 2002.
11 Huxley RR, Shiell AW, Law CM. The role of size at birth and postnatal catch-up growth in determining systolic blood pressure: a systematic review of the literature. *J Hypertens* 2000;18:815-31.
12 Huxley R, Neil A, Collins R. Unravelling the fetal origins hypothesis: is there really an inverse association between birthweight and subsequent blood pressure? *Lancet* 2002;360:659-65.
13 Geleijnse JM, Hofman A, Witteman JC, Hazebroek AA, Valkenburg HA, Grobbee DE. Long-term effects of neonatal sodium restriction on blood pressure. *Hypertension* 1997;29:913-7.

(Accepted 6 May 2004)

doi 10.1136/bmj.38149.510139.7C

Petrarch, physicians, and controlled trials

On 20 July 2004 the 700th birthday of Francesco Petrarch (1304-1374) will be celebrated.

Petrarch, a founding father of humanism, is known for his poetry and correspondence. Because most medieval physicians defended scholasticism, he was not a friend of the medical profession. Many of his letters attacked them, calling them butchers and accusing them of being "more apt to diminish the substance than the sufferings of their patients, and to lighten their purses of gold rather than their bodies of evil humors."[1] His vigorous, yet witty, criticism was probably justified and may still be relevant.

Pushing his views even further, he wrote in a letter to Boccaccio in 1364, as stated by Lilienfeld: "I once heard a physician, of great renown amongst us, express himself in the following terms: . . . 'I solemnly affirm and believe, if a hundred or a thousand men of the same age, same temperament and habits, together with the same surroundings, were attacked at the same time by the same disease, that if one half followed the prescriptions of the doctors of the variety of those practicing at the present day, and that the other half took no medicine but relied on Nature's instincts, I have no doubt as to which half would escape.'"[2] He was suggesting the design of what would probably have been the first randomised clinical trial in medical history.

Olivier Nardi *consultant cardiologist, European Hospital Georges Pompidou, Paris, France*

1 Pétrarque. *Rerum Senilium IV-VII* [in Latin and French]. Paris: Les Belles Lettres, 2003.
2 Petrarch F. *Rerum Senilium V 3.* Cited by: Lilienfeld AM. Ceteris Paribus: the evolution of the clinical trial. *Bull Hist Med* 1982;56:1-18.