Tracking of Blood Pressure Among Adolescents and Young Adults in an Urban Slum of Puducherry

MB Soudarssanane, S Mathanraj, MM Sumanth, Ajit Sahai, M Karthigeyan

Abstract

Background: Early diagnosis of hypertension (HT) is an important strategy in its control. Tracking of blood pressure (BP) has been found useful in identifying persons with potential HT, particularly in youngsters. A cohort of 756 subjects (with baseline information as a cross-sectional study in 2002) was followed up in 2006 to comment on the distribution of BP and its attributes. Objectives: To track BP distribution in a cohort of adolescents and young adults, and assess the persistence of high/low normotensives; to measure the incidence of HT and study the relationship of BP with age, sex, socioeconomic status, BMI, physical exercise, salt intake, smoking and alcohol consumption.

Materials and Methods: The baseline study cohort (2002) of 756 subjects (19-24 years) in urban field area of Department of Preventive and Social Medicine, JIPMER, was followed up between May and November 2006 by house visits for measurement of sociodemographic variables, anthropometry, salt intake, physical activity and BP. Results: A total of 555 subjects from the 2002 cohort were contacted (73.4%), in that 54.5% subjects who were below 5th percentile, 93.6% subjects between 5th and 95th percentiles and 72% of those above 95th percentile previously persisted in the same cut-offs for systolic blood pressure (SBP). The corresponding figures for diastolic blood pressure (DBP) were 46.2, 92.2 and 74.1%, respectively. Shift from one cut-off to another was not significant for both SBP and DBP, proving the tracking phenomenon. Annual incidence of HT was 9.8/1000. Baseline BP was the significant predictor of current BP for the entire cohort; BMI and salt intake were significant predictors only in certain sections of the study cohort. Conclusions: Early diagnosis of hypertension even among adolescents/young adults is an important preventive measure, as tracking exists in the population.

Keywords: Adolescents/young adults, cohort study, incidence of hypertension, risk factors, tracking of blood pressure

Coronary risk factors such as hypertension, smoking, physical inactivity, obesity and improper diet are fairly widespread.(1) Cardiovascular diseases, particularly hypertension, account for high mortality in the form of cardiovascular strokes in countries like India, Taiwan and Japan.(2) In Indian adolescent school children, there is a high prevalence of obesity, hypertension, hypercholesterolemia and high fat diet.(3) Studies(4,5) from Boston and Pennsylvania had commented that the role of hypertension as a risk factor is clear, and familial aggregation of blood pressure and tracking phenomenon support the concept that children with hypertension are likely to be hypertensive as adults and will be at risk for early CHD. In Puducherry, several studies on distribution of blood pressure and prevalence of hypertension (including its determinants) have been conducted in 1991, 1996 (among adults) and 2002(6) among adolescents. As a follow up of the latest study on adolescents, this work was undertaken with the following objectives:

1. To track BP distribution among the cohort of adolescents/young adults (of the earlier 2002 study) and assess if persons who were high normal/low normal/hypertensive continue to have similar trends.
2. To assess the incidence of hypertension in the study cohort.
3. To assess the relationship between BP and hypertension in the study cohort with certain factors like age, sex, education, occupation, income, BMI, physical exercise, salt intake, smoking and alcohol consumption.

Materials and Methods

This cohort study was carried out in an urban field practice area of Department of Preventive and Social Medicine, Jawaharlal Institute of Post-graduate Medical Education and Research (JIPMER), Puducherry. The study population was the same 756 participants of the 2002 study (now 19-24 years), covering adolescents and young adults. Informed consent was taken from every subject in the local language (Tamil). Data collection was by house visits with a pre-tested questionnaire using the same definitions/parameters as for the reference study, for the following variables: (1) identification data: age, sex, religion, social
class [Kuppuswamy’s scale(7) - classified as social class I to V], (2) physical activity: very good [physical exercise like manual work per se or sports activity or other physical exercise for >3 h/day], moderate [1-3 h/day], mild [<1 h/day], sedentary [nil physical activity], (3) per capita salt intake, (4) history of parental diabetes mellitus/hypertension, (5) smoking: light [≤5 cigarettes/day], moderate [6-10 cigarettes/day], heavy [>10 cigarettes/day], non-smoker [never smoked], (6) alcohol consumption: occasional [once or twice a week], frequent [once or twice a month], always [>twice a week], never consumed, (7) anthropometry: Height - recorded to nearest 0.1 cm with stadiometer, weight to nearest 100 g with solar weighing machine, (8) measurement of BP: the conditions followed for measuring BP were as described by Dasgupta. The subject was asked to rest for 5-10 min if he/she had engaged in physical activity. The WHO criteria(8) were followed in recording the BP and the average of two readings recorded 3 min apart was taken as BP. Systolic BP more than 160 mmHg and/or DBP more than 100 mmHg was severe hypertension, SBP 140-159 mmHg and/or DBP 90-99 mmHg was moderate hypertension. For adolescents, values more than 95th percentile of BP were taken as hypertension. Analysis was done with Statistical Package for Social Studies (SPSS) version 13.0 using comparison of means, McNemar test, marginal homogeneity, correlation, multiple regression and paired ‘t’ test.

Results

Out of 756 members of the earlier cohort, 555 (73.41%) were studied (292 males, 263 females). Of the 201 lost to follow-up, 15 had shifted residence, 15 girls got married and resettled, 4 had died and the remaining 167 could not be contacted even after four visits. The follow-up percentage varied from 77.7% to 66.3% for individual age groups. Age-wise composition of the 555 subjects studied was almost same as the 201 lost to follow-up, as available percentage varied from 77.7% to 66.3% for individual age groups.

Table 1: Distribution of reference cohort and follow-up cohort by age and gender

| Age | M | F | T | Study cohort (2006) |
|-----|---|---|---|---------------------|
|     |   |   |   | Coverage*         |
|     |   |   |   | M | F | T | % |
| 15  | 81 | 64 | 145| 58 | 50 | 108| 74.5|
| 16  | 57 | 69 | 126| 44 | 52 | 96 | 76.1|
| 17  | 56 | 56 | 112| 47 | 40 | 87 | 77.6|
| 18  | 77 | 71 | 148| 62 | 53 | 115| 77.7|
| 19  | 80 | 62 | 142| 53 | 41 | 94 | 66.7|
| 20  | 40 | 43 | 83 | 28 | 27 | 55 | 66.3|
| Total | 391 | 365 | 756 | 292 | 263 | 555 | 73.4 |

M = male, F = female, T = total; *P = 0.109; †Four had died

Tracking of BP and incidence of hypertension

Comparing the SBP of the study and reference cohorts, persons in extreme percentiles in 2002 continued in respective categories (below 5th percentile, 5th to 95th percentiles and above 95th percentile). The shift from one cut-off to another was not significant. Of those in 5th to 95th percentile of reference cohort, 93.6% continued within the same cut-offs. More than 70% of individuals of reference cohort who were in >95th percentile continued to be so in study cohort. Similarly, DBP, 92.2% individuals of reference cohort remained in 5th to 95th percentile. In the extreme categories (<5th percentile and >95th percentile) 74.1% of subjects continued in the same. The shift from one cut-off to another was not statistically significant [Table 2]. Similarly the shift from one cut-off to another was not significant at various levels like deciles, quintiles, quartiles and tertiles. Thus, tracking is demonstrated to be significant, viz., high/low normotensives tend to persist in their respective percentiles - thereby enabling early identification.

Of the earlier 46 hypertensives, 31 (67%) continued to be so. Of the 509 normotensives, 489 (96%) continued in same range with 20 new occurrences of hypertension; that is 39.2/1000 over 4 years. Hence for 1 year the incidence was 9.8/1000 (5/555). Among 292 males and 263 females, 42 and 9 had hypertension giving incidences of 13.4 and 6.02/1000 respectively (P = 0.005) [Table 3]. Incidences among the different age groups (19-24) were 2.5, 5.5, 3.3, 9.2, 14.7 and 34.2/1000, respectively. All the 20 new hypertensives were isolated diastolic hypertension (IDH).

Relation between BP and other variables

Demography and parental history: There was a significant
association of BP with age ($r = 0.16, P = 0.001$ for SBP; $r = 0.132, P = 0.012$ for DBP). Overall, mean SBP and DBP were $117.17 \text{ mmHg}$ (range 96-150) and $78.12 \text{ mmHg}$ (range 52-100), respectively. Mean BP of the cohort increased significantly with age. This rising trend was observed in both genders but was significant only among males ($r = 0.26, P = 0.000$ for SBP and $r = 0.251, P = 0.01$ for DBP). Mean SBP among males was $118.44 \text{ mmHg}$ (96-150), and mean DBP was $79.25 \text{ mmHg}$ (60-96). Females had mean SBP and DBP of $115.76 \text{ mmHg}$ (100-142) and $76.89 \text{ mmHg}$ (52-100), respectively. The difference in mean BP among the genders was significant ($P = 0.003$ and 0.01 for SBP and DBP).

In the cohort, none were eligible to be in social class I. Mean SBP among social classes II, III, IV and V were $120.18, 120.27, 116.78$ and $113.0 \text{ mmHg}$, respectively. The respective DBP were $81, 79.95, 77.88$ and $74.44 \text{ mmHg}$. The incidence of hypertension was $36.6/1000$ in social class III and $40/1000$ in social class IV. No new cases were found in social classes II and V. This difference among the social classes was not significant.

Persons with history of parental hypertension showed significant elevation in both mean SBP ($119.92 \text{ mmHg}$) and DBP ($80.36 \text{ mmHg}$) compared to $116.69 \text{ mmHg}$ and $77.73 \text{ mmHg}$ in those without such history ($P = 0.011$). Incidence of hypertension was $50/1000$ among subjects with both paternal and maternal hypertension, and $21.2$ and $17.5/1000$, respectively, among those with either paternal or maternal history ($P = 0.04$).

Anthropometry: There was a significant increase in mean SBP and mean DBP with increasing weight ($r = 0.466$ and 0.409) and height ($r = 0.211$ and 0.184). Again, a significant correlation was found between BP and BMI ($r = 0.399$ for SBP and 0.355 for DBP). For the categories underweight, normal, overweight and obesity, the mean SBP were $113.19, 117.41, 123.49$ and $127 \text{ mmHg}$ ($P < 0.001$), and the mean DBP were $74.77, 78.47, 82.4$ and $86.70 \text{ mmHg}$, respectively ($P < 0.001$). Incidences of hypertension among underweight, normal and overweight persons were $2, 12.3$ and $13.5/1000$, respectively, which was statistically significant ($P < 0.001$). There was no significant effect of type of food intake, smoking and alcohol consumption on blood pressure among these adolescents and young adults.

Lifestyle: There was significant association between physical activity and BP ($P = 0.016$), with sedentary and mild physical activity merged into a single class interval. Here, physical activity denoted only the deliberate physical exercise by subjects (like playing, etc.) and not the whole range of activities performed by them. Mean

| Table 2: Comparisons of blood pressure and hypertension in the reference and study cohorts |
|---------------------------------------------------------------|
| **SBP new percentiles (2006)** | **SBP old percentiles (2002)** |
| <5th percentile | 5th to 95th percentile | >95th percentile | Total |
| <5th percentile | 18 (54.5%) | 17 (3.4%) | 0 | 35 |
| 5th to 95th percentile | 15 (45.5%) | 465 (93.6%) | 7 (28.0%) | 487 |
| >95th percentile | 0 | 15 (3.0%) | 18 (72.0%) | 33 |
| Total | 33 | 497 | 25 | 555 |
| MH statistic = 49, $P$-value = 0.414 (Marginal homogeneity test) |

| **DBP new percentiles (2006)** | **DBP old percentiles (2002)** |
| <5th percentile | 12 (46.2%) | 19 (3.8%) | 0 | 31 |
| 5th to 95th percentile | 14 (53.8%) | 463 (92.2%) | 7 (25.9%) | 484 |
| >95th percentile | 0 | 20 (4.0%) | 20 (74.1%) | 40 |
| MH statistic = 53, $P$-value = 0.16 (Marginal homogeneity test) |

| Hypertensives (2006) | Total |
|---------------------|-------|
| Normotensive | 489 (95.9%) |
| Hypertensive | 15 (32.6%) |
| Total | 504 |
| Hypertensives (2002) | Total |
| Normotensive | 20 (4.1%) |
| Hypertensive | 31 (67.4%) |
| Total | 51 |
| McNemar statistic: 2.6, $P$-value = 0.398 (McNemar test) |

| Table 3: Incidence/prevalence of hypertension among the study cohort of adolescents and young adults |
|---------------------------------------------------------------|
| **Variable** | **Prevalence** | **Incidence** |
| | **Per 1000** | **Number** | **Per 1000** |
| Overall | 51 | 92 | 20 | 9.8 |
| Gender | | | |
| Male | 42 | 143 | 14 | 13.4 |
| Female | 9 | 34 | 6 | 6.0 |
| Parental h/o HT | | | |
| Paternal | 4 | 121 | 2 | 21.2 |
| Maternal | 8 | 195 | 3 | 17.5 |
| Both parents | 3 | 333 | 1 | 50.0 |
| Anthropometry | | | |
| Obese | 9 | 288 | 2 | 12.3 |
| Normal BMI | 42 | 71 | 18 | 13.5 |
| Salt intake | | | |
| <10 g/d | 4 | 26 | 2 | 2.0 |
| >10 g/d | 47 | 176 | 18 | 16.5 |
| Physical activity | | | |
| Mild activity | 16 | 91 | 7 | 7.0 |
| Moderate | 31 | 126 | 7 | 11.0 |
| Very good | 4 | 32 | 6 | 10.8 |
| $n = 555$ |

$120.18, 120.27, 116.78$ and $113.0 \text{ mmHg}$, respectively. The respective DBP were $81, 79.95, 77.88$ and $74.44 \text{ mmHg}$. The incidence of hypertension was $36.6/1000$ in social class III and $40/1000$ in social class IV. No new cases were found in social classes II and V. This difference among the social classes was not significant.

Persons with history of parental hypertension showed significant elevation in both mean SBP ($119.92 \text{ mmHg}$) and DBP ($80.36 \text{ mmHg}$) compared to $116.69 \text{ mmHg}$ and $77.73 \text{ mmHg}$ in those without such history ($P = 0.011$). Incidence of hypertension was $50/1000$ among subjects with both paternal and maternal hypertension, and $21.2$ and $17.5/1000$, respectively, among those with either paternal or maternal history ($P = 0.04$).

Anthropometry: There was a significant increase in mean SBP and mean DBP with increasing weight ($r = 0.466$ and 0.409) and height ($r = 0.211$ and 0.184). Again, a significant correlation was found between BP and BMI ($r = 0.399$ for SBP and 0.355 for DBP). For the categories underweight, normal, overweight and obesity, the mean SBP were $113.19, 117.41, 123.49$ and $127 \text{ mmHg}$ ($P < 0.001$), and the mean DBP were $74.77, 78.47, 82.4$ and $86.70 \text{ mmHg}$, respectively ($P < 0.001$). Incidences of hypertension among underweight, normal and overweight persons were $2, 12.3$ and $13.5/1000$, respectively, which was statistically significant ($P < 0.001$). There was no significant effect of type of food intake, smoking and alcohol consumption on blood pressure among these adolescents and young adults.

Lifestyle: There was significant association between physical activity and BP ($P = 0.016$), with sedentary and mild physical activity merged into a single class interval. Here, physical activity denoted only the deliberate physical exercise by subjects (like playing, etc.) and not the whole range of activities performed by them. Mean

| | | | |
| Indian Journal of Community Medicine, Vol. 33, Issue 2, April 2008 | 109 |
SBP among mild, moderate and very good physical activity were 116.91, 118.59, 115.52 mmHg, respectively, and mean DBP were 78.21, 78.89 and 76.76 mmHg. Incidence of hypertension among mild, moderate and very good physical activity were 7, 11 and 10.8/1000, respectively. Mean salt intake was 10.48 g/day in the reference cohort compared to 10.84 g/day in the study cohort showing no significant difference. Mean salt intake among hypertensives was 14.8 g/day compared to 10.4 g in normotensives, ($P < 0.001$). Mean SBP among those who had an intake of $<10$ g/day was 113.2 mmHg compared to 119.5 mmHg in those who had an intake of $>10$ g/day ($P = 0.012$). Corresponding DBP values were 75.3 mmHg and 80.43 mmHg, respectively ($P = 0.001$). Mean salt intake in persons $<5$th percentile was 8.05 g compared to 15.51 g in $>95$th percentile ($P < 0.05$). Incidences of HT were 2 and 16.5/1000, respectively, which was statistically significant ($P = 0.002$).

**Tracking model analysis:** Further analysis was done by clubbing the age into three groups (19-20, 21-22 and 23-24 years). The ‘Z’ scores were calculated for SBP and DBP gender-wise for the age groups [Table 4]. The baseline values for salt intake, BMI, physical activity and family history of hypertension were included in multiple regression models - with the BP values of the reference cohort of 2002 as independent variable and BP values of study cohort of 2006 as dependent variable. It was found that for each of the age-group ‘Z’ scores for BP of reference cohort was significantly predicting the BP of study cohort. However, BMI was found to significantly predict the dependent BP (both SBP and DBP) only for the age group 17-18 years, among females only. Similarly, salt intake was found to be a significant predictor only for the dependent DBP in males in 17-18 years group [Table 5].

**Discussion**

This study comments on the tracking of BP in a cohort representative of urban slum dwellers of Puducherry. Several studies have highlighted the importance of tracking BP. In the present study, more than 70% of those who were hypertensives in the reference cohort ($>95$th percentile) continued in the same range, which is similar to a Spanish study,(10) which reported that more than 70% children in the upper quartile of SBP at any previous examination remained so. The Shimane heart study(11) showed 43.5% boys and 59.1% girls in cohort 1, and 25.0% boys and 56.5% girls in cohort 2 remained in extreme quintiles.

The incidence of HT in adolescents and young adults in the present study was 0.98%. The Framingham (12) study showed an incidence of 3.3% among men aged 30-39, and Menghett(13) et al showed a high incidence

**Table 4: Descriptive statistics of blood pressure among study subjects**

| Age (years) | Gender | Mean 2002 SBP (SD) | Mean 2002 DBP (SD) | Mean 2006 SBP (SD) | Mean 2006 DBP (SD) |
|------------|--------|--------------------|--------------------|--------------------|--------------------|
| 15-16 M    | 112.77 (09.20) | 73.46 (9.20) | 114.85 (7.50) | 76.24 (7.2) |
| 17-18 M    | 113.50 (09.50) | 74.47 (9.80) | 116.81 (8.20) | 77.37 (7.3) |
| 19-20 M    | 119.34 (12.00) | 78.13 (9.80) | 121.95 (9.90) | 81.91 (7.7) |
| 15-16 F    | 112.38 (08.12) | 74.60 (8.26) | 115.31 (7.83) | 77.60 (7.8) |
| 17-18 F    | 113.40 (10.50) | 73.76 (8.30) | 115.96 (9.60) | 77.47 (7.1) |
| 19-20 F    | 115.10 (09.70) | 76.00 (8.70) | 118.30 (8.50) | 79.50 (6.9) |

**Table 5: Multiple regression models for blood pressure tracking**

| Age   | Sex | Constant | 2002 BP (Z score) | 2002 salt | 2006 BMI | 2002 physical activity* | Family history† |
|-------|-----|----------|-------------------|-----------|----------|------------------------|-----------------|
|       |     | k  p   | $\beta$ p | $\beta$ p | $\beta$ p | $\beta$ p | $\beta$ p |
| Systolic blood pressure |
| 15-16 M | 0.27 0.5 | 0.86 0.00 | -0.02 0.7 | -0.06 0.25 | 0.04 0.4 | -0.008 0.87 |
| 17-18 M | 1.01 0.03 | 0.85 0.00 | -0.03 0.4 | 0.064 0.22 | 0.04 0.4 | -0.05 0.35 |
| 19-20 M | -0.47 0.2 | 0.88 0.00 | 0.006 0.9 | 0.07 0.19 | -0.03 0.62 | 0.06 0.25 |
| 15-16 F | -0.19 0.7 | 0.52 0.00 | 0.053 0.5 | -0.08 0.34 | 0.13 0.12 | -0.11 0.89 |
| 17-18 F | -1.28 0.02 | 0.7 0.00 | 0.02 0.7 | 0.177 0.01 | 0.01 0.88 | 0.03 0.7 |
| 19-20 F | -0.57 0.3 | 0.7 0.00 | -0.006 0.9 | 0.085 0.31 | -0.12 0.18 | 0.06 0.47 |
| Diastolic blood pressure |
| 15-16 M | 0.69 0.2 | 0.7 0.00 | 0.025 0.7 | -0.1 0.16 | -0.04 0.57 | -0.14 0.89 |
| 17-18 M | 0.70 0.2 | 0.77 0.00 | 0.12 0.05 | -0.07 0.23 | -0.02 0.71 | -0.05 0.43 |
| 19-20 M | -0.25 0.6 | 0.83 0.00 | -0.56 0.58 | 0.48 0.6 | -0.006 0.72 | 0.07 0.27 |
| 15-16 F | -0.61 0.3 | 0.78 0.00 | -0.035 0.58 | -0.019 0.7 | 0.03 0.72 | 0.04 0.38 |
| 17-18 F | -1.6 0.01 | 0.68 0.00 | -0.045 0.54 | 0.184 0.02 | 0.06 0.45 | 0.08 0.27 |
| 19-20 F | 0.49 0.4 | 0.73 0.00 | -0.028 0.72 | -0.48 0.63 | -0.93 0.35 | -0.015 0.87 |

*Severe exercise - 4, moderate exercise - 3, mild exercise - 2, sedentary - 1; †No family history - 1, maternal history - 2, paternal history - 3, both parents - 4 (physical activity and family history are coded as above since they are ordinal variables)
of 6.5% among 293 children in the age group of 11-14. In the present study on adolescent and young adults, a significant increasing trend of BP was seen only among males. This is similar to the Turkish study (14) and Zambian study (15) studies on school children showing rise of BP with age. The latter study showed a significantly elevated mean SBP and DBP among males than females. This is comparable to other studies on populations of 13-18 years, (16) 15-24 years (17) and 15-25 years. (18) Although the present study did not find a significant association of mean BP with social class, the findings in a South Indian community (19) showed such significance.

There was a gradient of significant association of BP and HT with physical activity in the present study on adolescents as also observed by Pittsburgh study. (16) Physical fitness appears to be a graded, independent, long-term predictor of mortality from cardiovascular causes in healthy, middle-aged men. (21)

The present study found significant rise in both SBP and DBP with increasing BMI in both genders, comparable with the findings from adolescents 17 years in Jerusalem. (20) whereas another study (16) reported weight-dependent rise in BP only among males with respect to SBP alone. Several studies reported the association of BP with both weight and height. (16,21-23) Prevalence of HT was 0.5 to 3 times higher among the overweight. (24) Taiwan study (25) which followed 7685 males for over 30 years recorded an increase in incidence of HT with increasing ponderosity. The Framingham study (12) showed increased prevalence of obesity in subjects with HT as well increase in BP in established obesity. Similar findings were reported among adolescent populations in India, (26) Hungary (27) and France. (28) Such association in early childhood with SBP alone was reported by Minneapolis children’s BP study (29) and British cohort. (30) Pittsburgh study (16) study reported similar association only in SBP among males. Other studies on populations of 4-18 years (14) and 7-16 years (15) also identified weight as a major determinant of BP. Childhood weight gain was positively associated with adult BP. (31) Another study (33) showed that elevated BMI in childhood predicted risk of hypertension in young adulthood.

Subjects with history of parental hypertension had higher BP and higher incidence of hypertension. Zimbabwean study (34) showed that parental history before age 60 was related to offspring’s hypertension. This relationship was stronger when compared to both parental histories versus none similar to the present study. Another Zimbabwean study (35) showed parental history of hypertension influenced both resting and reactivity BP.

In this study, BP was significantly predicted by baseline salt intake only in 17-18 years group in males. There is evidence that high salt intake increases BP. (32) Low sodium was reported to lower BP. (33) Likewise there was a significant predictability of BP by baseline BMI only in 17-18 years in both genders.

**Limitations**

1. Since the cohort follow-up was done after 4 years, the annual incidence of hypertension was calculated from the 4 years incidence, assuming uniform yearly incidence. About 201 (26.3%) subjects (out of the 2002 cohort of 756 subjects) could not be approached even after 4 visits. Although the age composition of this 201 was comparable with the 555 of the present cohort, it is still possible that this loss to follow-up might have some effect on the results depending on the distribution of other variables.

2. The major proportion of baseline 2002 cohort consisted of adolescents (15-19 years) and some young adults (20 years). The follow up 2006 cohort consisted of lesser proportion of adolescents (19 years) and major proportion of young adults (20-24 years). The definition of hypertension differs for adolescents (-95th percentile) and for adults (SBP > 140, DBP > 90). The incidence of HT was calculated individually for adolescents/young adults as two different groups and the combined incidence for the whole group was taken as addition of these two incidences.

3. Likewise, any differential drop outs with respect to age, BMI, social class, alcohol intake, smoking, physical activity and family history of hypertension might have further limitations in interpretation of results; these aspects are specifically addressed in a paper from a subsequent study.

4. In addition measurement of physical activity which included only exercise might have limited accuracy but was used to ensure comparability with the earlier cohort. Similarly the per capita salt intake was calculated as an average of the family intake since a specific dietary measurement was not within the scope of this study.

**Conclusion**

Tracking is a very useful tool in early diagnosis of pre-hypertension and hypertension even among adolescents/young adults (19-24 years). The overall mean SBP and DBP were 117.17 mm Hg (range 96-150) and 78.12 (range 52-100), respectively, and annual incidence of hypertension was 9.8/1000. Baseline BP (both SBP and DBP) was the significant independent predictor of BP. Other variables like BMI and salt intake were significant predictors of BP only in a section of the study population. Hence, pertaining to adolescents/young adults, these may be termed as early risk factors.

**Acknowledgement**

The authors thank the ICMR for sponsoring this project.
References

1. Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation 1998;97: 596-601.
2. WHO: World Health Statistics Annual (1984)
3. Gupta R, Goyle A, Kashyap, et al. Prevalence of atherosclerosis risk factors in adolescent school children. Ind Heart J 1998;50:511-5.
4. Zinner SH, Martin LF, Sacks F, et al. A longitudinal study of BP in children. Am J Epidemiol 1974;100:437-42.
5. Falkner B. Role of sodium in essential hypertension in genetically hypertensive adolescents. In: Gaddis et al. editors Hypertension in young and old. New York: Grune and Stratton; 1981. p. 29.
6. Soudarssanane MB, Karthigeyan M, Stephen S, Sahai A. Key predictors of high blood pressure and hypertension among adolescents: a simple prescription for prevention. Ind J Community Med 2006;31:164-9.
7. Kuppuswamy B. Manual of socioeconomic status scale (Urban). Delhi: Mansayan; 1962.
8. Dasgupta DJ, et al. BP in a community at a higher altitude (3000 meters) at Pooh (North India). J Epidemiol Community Health1982;36:251-5.
9. World Health Organization: 1978, Arterial hypertension. Technical Report Series, No 628.
10. Sanchez-Bayle M, Munoz-Fernandez MT, Gonzalez-Requejo A. A longitudinal study of blood pressure in Spanish schoolchildren. Working group of cardiovascular risk factors in childhood and adolescence. Arch Dis Child 1999;81:169-71.
11. Nishio T, Mori C, Saito M, et al. Tracking of blood pressure, height, weight and left ventricular muscle volume in children - the Shimane Heart Study. Jpn Circ J 1986;50:1321-4.
12. Dannenberg AL, Garrison RJ, Kannel WB. Incidence of hypertension in the Framingham study. Am J Public Health 1988;78:676-9.
13. Menghetti E, D’Addesia D, Censi L, et al. Hypertension in schoolchildren: research carried out in a Secondary School in Rome and observations on dietary patterns. Minerva Pediatr 2004;56:311-6.
14. Irgil E, Erkenci Y, Ayetekin N, Ayetekin H. Prevalence of hypertension among school children aged 13-18 years in Gemlik, Turkey. Eur J Public Health 1998;8:176-8.
15. Ng’andu NH. Blood pressure levels of Zambian rural adolescents and their relationship to age, sex, weight, height and three weight-for-height indices. Int J Epidemiol 1992;21:246-52.
16. Trevor J Orchard, Hedley AJ, Mitchell JRA. The distribution and associations of blood pressure in an adolescent population. J Epidemiol Community Health 1982;36:35-42.
17. Simmons D, Barbour G, Congleton J, et al. Blood pressure and salt intake in Malawi: an urban rural study. J Epidemiol Community Health1986;40:188-92.
18. Upadhyay BN. Study of some aspects of blood pressure in the area of rural health centre, Attabira. Ind J Prev Soc Med 1973;4:57-62.
19. Gilberts EC, et al. Hypertension and determinants of blood pressure with special reference to socioeconomic status in a rural South Indian Community. J Epidemiol Community Health 1994;48:258-61.
20. Sandvik L, Erikssen J, Thaulow E, et al. Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. 1993;328:533-7.
21. Guild WR. Evaluation of blood pressure and physical fitness in adolescents. Med Clin North Am 1965;49: 495-503.
22. Wilks RJ, McFarlane-Anderson N, Bennett FL, Reid M, Forrester TE. Blood pressure in Jamaican children: relationship to body size and composition. West Indian Med J 1999;48:61-8.
23. Morrison JA, Khoury P, Kelly K, et al. Studies of blood pressure in schoolchildren (ages 6-19) and their parents in an integrated suburban school district. Am J Epidemiol 1980;111:156-65.
24. Stamler J, Cagginuia Aw, et al. Relation of body mass index and alcohol, nutrient, fiber and caffeine intake to blood pressure in the special intervention and usual care groups in the Multiple Risk Factors Intervention Trial. Am J Clin Nutr 1997;65 Suppl:338-65.
25. Paffenborg RS Jr, Hyde RT, et al. The association of changes in physical activity level and other lifestyle characteristics with mortality among men. N Engl J Med 1993;328:538-45.
26. Thakor HG, Kumar P, Desai VK. An epidemiological study of hypertension amongst children from various primary schools of Surat city. Ind J Community Med 1998;23:110-5.
27. Torok E, Gyarfás I, Csukas M. Factors associated with stable high blood pressure in adolescents. J Hypertension Suppl 1985;3 Suppl 3:389-90.
28. Aullen JP. Obesity, hypertension and their relationship children and adolescents. An epidemiological study in schools (authors transl). Sem Hop. 1978;54:637-43.
29. Sinaiko AR, Donahue RP, Jacobs DR, Prineas RJ. Relationship of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults. The Minneapolis Children’s Blood Pressure Study. Circulation 1999;99:471-6.
30. Hardy R, Wadsworth MEJ, Langenberg C, Kuh D. Birth weight, childhood growth, and blood pressure at 43 years in a British birth cohort. Int J Epidemiol 2004;33:121-9.
31. Holland FJ, Stark O, Ades AE, Peckham CS. Birth weight, childhood growth, and blood pressure at 43 years in an integrated suburban school district. Am J Epidemiol 1999;99:61-8.
32. Elliot P, Stamler J, Nichols R, Dyer AR, Stamler R, Kesteloot H, Marmot M. Intersalt revisited: further analyses of 24 hour sodium excretion and blood pressure within and across populations. Intersalt Cooperative Research Group. BMJ 1996;312:1249-53.
33. Beard TC, et al. Randomized control trial of a no added sodium diet for mild hypertension. Lancet 1982;2:455-8.
34. Lascaux-Lefebvre V, Ruidavets JB, Arveiler D, Amouyel P, et al. Influence of parental history of hypertension on blood pressure. J Hum Hypertens 1999;3:631-6.
35. Sherman JJ, McCubbin JA, Matenga J. Effects of parental history of hypertension and urbanization on blood pressure in Zimbabweans. Int J Behav Med 1998;5:48-62.

Source of Support: ICMR. Conflict of Interest: None declared.