BLOOD PRESSURE LEVELS IN SOUTH INDIAN ADOLESCENTS

M. Lakshmanudu
K. Mani
P.S.S. Rao

ABSTRACT

The present study was undertaken to develop normative data for the blood pressure (BP) levels in adolescent boys and girls aged 10-17 years residing the rural and urban areas of North Arcot Ambedkar District, Tamil Nadu State. Blood pressures were evaluated as part of an ongoing study on growth and development in adolescents. A total of 7028 BP measurements collected cross-sectionally were subjected to statistical analysis. The mean systolic (SBP) and diastolic (DBP) blood pressure levels were elevated in rural children as compared to that in urban children of respective sexes during 10 and 15 years of age. The mean BP levels were higher in both the rural and urban girls as compared to their male counterparts till the age of 15, after which the trend was reversed. While the mean SBP and DBP levels for rural children of either sex were stable over the age range considered, those for urban children exhibited consistent increase with age. In urban boys, the yearly mean increments in SBP and DBP were 2.5 mm Hg and 2.0 mm Hg and that in urban girls 2.4 mm Hg and 1.7 mm Hg, respectively. It is suggested that perhaps stress factors are responsible for the elevated mean BP levels among the rural adolescents as they are generally engaged in activities that exert considerable physical and psychological stress.

Key words: *Blood pressure, Adolescents, Rural, Urban.*

The prevalence and incidence of coronary heart diseases and the resultant mortality are much higher in developed countries than in the developing countries(1). It is widely reported that cardiovascular diseases may have an origin in early childhood or even in infancy(2). Although it has been stated that essential hypertension is rare and is much less frequent among children than in adults(3), evidence exists signifying that essential hypertension begins in childhood(4,5). Although it has been reported that blood pressure levels in general are positively associated with age(6), in a few populations inhabiting industrialized countries such an association was not found(3). The World Health Organization Study Group(1) felt that the blood pressure study in children is the only way to obtain scientific evidence on factors that contribute to blood pressure elevation and on the ways to control or modify these factors. Thus, the aim of the present paper is to present reference data for the blood pressure levels of South Indian adolescents aged 10 to 17 years in relation to their demographic background.

Material and Methods

During 1969-1974 a community based research project entitled "Longitudinal Studies in Human Reproduction" financed by the NCHS, USA has been carried out by the Department of Biostatistics. The details of the study, the demographic, climatic and environmental characteristics of the area; and the cultural and socio-economic profile of the population are detailed elsewhere(7). Even since, all the children born

From the Department of Biostatistics, Christian Medical College, Vellore 632 002.

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during that period in one Rural Community Development Block–K.V. Kuppam and those from a defined area, selected randomly, of Vellore town were being followed-up for physical and intellectual growth and development. For the present investigation cross-sectional data of BP measurements obtained in 7028 children were considered.

Children's ages were computed and grouped following Tanner(8). Blood pressure was measured using an aneroid sphygmomanometer (Erka-perfect, West Germany). Each subject was made to sit in a chair comfortably, the cuff was tied around the left upper arm, the procedure explained, and the cuff inflated and deflated once so as to acclimatize the child to the process. The pressure values at the first and fourth Korotkofftic phases were recorded. Consequently, duplicate measurements were obtained on each individual and the means of these readings were recorded as SBP and DBP, as they will characterize an individual more accurately than a single measurement(9). Before the actual measurement, all the children were asked to rest for atleast 20 minutes and to observe doing it on others. The aneroid sphygmomanometers were calibrated at regular intervals by checking against a mercury sphygmomanometer. Measurement errors were then minimized by selecting cuffs of appropriate size(10,11). Further variation in blood pressure measurements was identified by selecting a sample of 30 subjects from the study area with equal preference for sex and age. Each subject had routine repeated measurements by the two observers involved in the study. The data thus obtained were analyzed using analysis of difference and analysis of variance (ANOVA), and the results presented in *Table I.*

Standard deviation of the differences, S_d, was computed(12) and the standard error of measurement $S_{(meas)}$ was obtained by dividing S_d by square root of 2(9). Also, the measures of reliability (*i.e.,* repeatability and relative bias) were got by multiplying S_d and $S_{(meas)}$ with the critical ratio 1.96, respectively. From the results it can be inferred that in 95% of cases the observers' SBP measurements were accurate to within ±2.5 mm Hg (±3.3 mm Hg for DBP) of the true value with a mean difference of 0.2 mm Hg (0.7 mm Hg for DBP).

TABLE I–*Analysis of Difference for Systolic and Diastolic Blood Pressure Levels (n = 30)*

Observer number	Average of two measurements		Difference between two measurements			Relative bias	Repeatability
	Mean	SD	Mean	S_d	$S_{(meas)}$		
Systolic BP							
1	107.4	12.3	0.13	1.3	0.92	1.80	2.55
2	107.8	12.4	0.20	1.8	1.28	2.51	3.53
Diastolic BP							
1	77.1	11.0	0.00	1.9	1.35	2.65	3.75
2	77.2	11.0	0.67	2.4	1.70	3.33	4.70

The estimate of repeatability reflect that in 95% of cases two measurements of SBP made by either of the observers will not differ by more than ±3.5 mm Hg (±4.7 mm Hg for DBP). These values are much smaller (for both SBP and DBP) than those obtained by the two community nurses for the Scottish children of Shetland (13) implying greater reliability in the present study. Analysis of variance showed that within and between observer variations contribute insignificantly ($p>0.05$) to the variability of the blood pressure levels in the present study.

Results

Blood pressure levels in urban and rural children of successive age groups differed significantly. Hence, further analysis of blood pressure levels was performed controlling for area of residence. In the present rural sample, 98.0% were Hindus, 0.8% Muslims and the remaining 1.2% Christians. In the urban sample 85% were Hindus, 7% Muslims, 6% Christians, and the remaining 2% other religious groups. The mean SBP and DBP levels among the urban children of same sex and age across various religious groups did not differ significantly ($p>0.05$). The small numbers of rural children from Muslim and Christian groups do not facilitate such a comparison. Hence, children from all the religious sects were pooled for further analysis.

Descriptive statistics of SBP and DBP levels for rural children were computed and presented by age and sex in *Tables II & III,* respectively. Among rural boys the mean SBP was 103.2 mm Hg at age 10 and rose slowly to 107.6 mm Hg at 17 years. A poor correlation coefficient (r) of 0.08 was obtained for SBP with age. The mean difference in SBP between age groups 16 and 17 only was statistically significant. DBP also showed a trend similar to SBP. Correlation of diastoles with age was of the magnitude–0.03. Among the rural girls, the mean SBP scattered around 107 mm Hg over the ages considered ($r = 0.02$) and the mean diastolic pressure levels varied from 77 to 80 mm Hg, and did not show any association ($r = 0.08$) with age. The rural boys and girls of corresponding ages differed in their mean SBP values, which were statistically significant at 1% probability level at all the age groups except at 17. Nearly a similar trend was noticed for DBP at a probability of 5%.

Blood pressure statistics for urban children are given in *Tables II & III*. A linear increase in systolic and diastolic blood pressures is recorded with increasing age for urban boys which is reflected by significant ($p<0.05$) correlation coefficients of 0.54 and 0.46, respectively. At age 10 their mean SBP was 92 mm Hg which has gradually increased at a rate of 2.5 mm Hg per year to 109.7 mm Hg at age 17. The yearly mean increment was 2 mm Hg in DBP. Coefficient of variation decreased as age increased for both SBP and DBP. A high statistical significance ($p<0.001$) was obtained, through analysis of variance for between age group variations of both SBP and DBP. Among urban girls a SBP of 92.5 mm Hg at age 10 shot up to 109 mm Hg at age 17 with an average increase of 2.4 mm Hg per year. Similarly, an increase of 1.7 mm Hg per year is noticed for DBP starting at 66.5 mm Hg for age 10. As noticed for boys the coefficient of variation decreased as age increased for both SBP and DBP in girls too. In both the pressures, between age group variations were significant ($p<0.001$). Significant correlation coefficients of 0.46 and 0.42 were obtained for age of the girls with their SBP and DBP

TABLE II—*Means (m) with Standard Deviations (SD) and Percentiles of Diastolic Blood Pressure (DBP) Levels in Adolescents by Gender and Area of Residence (Sample Sizes are Same as that for SBP)*

Age	Rural				Urban			
	Boys		Girls		Boys		Girls	
	m	SD	m	SD	m	SD	m	SD
10 +	76.1	8	78.4	8	66.0	8	66.5	9
11 +	76.3	8	78.4	8	66.3	9	66.6	9
12 +	76.4	8	80.5	8	66.7	10	68.2	9
13 +	77.0	8	78.7	9	67.7	9	69.3	9
14 +	77.0	9	77.1	9	71.6	9	74.2	9
15 +	77.8	9	77.1	8	74.3	9	75.5	9
16 +	77.9	9	77.6	8	76.3	8	76.4	9
17 +	77.9	8	78.6	8	79.7	8	78.4	9

Age	Centiles											
	5	50	95	5	50	95	5	50	95	5	50	95
10 +	64	77	90	68	80	92	56	64	80	50	66	80
11 +	64	77	90	66	78	90	52	64	80	50	66	82
12 +	62	78	90	67	80	92	49	64	84	58	68	85
13 +	62	78	90	60	80	92	57	66	84	56	70	86
14 +	60	76	88	62	78	90	60	70	86	60	72	88
15 +	62	76	88	62	78	88	60	74	88	62	76	90
16 +	60	76	88	62	78	89	62	78	90	61	78	90
17 +	64	80	88	65	80	90	66	80	92	62	80	93

levels, respectively. Though the mean SBP values were generally higher for urban girls than that for urban boys of comparative ages (except at ages 16 and 17) they were significantly different only at 11, 12 and 13 years of age. Similarly, the mean DBP is also in favour of girls (except at age 17) with a significantly higher values at ages 12 and 14 only.

Discussion

From the foregoing analysis it is evident that boys and girls of urban background show a proportional increment in systolic and diastolic blood pressure levels over the ages but not by their rural counterparts. The US children covered under National Health Examination Survey (14,15) registered a 27% increase from a SBP value of 105.9 mm Hg at age 6 and reached 134 mm Hg at age 12; and 112 mm Hg at age 15 displaying an increment of 47%. Contrary to these, rural children of the present study recorded a marginal increment whereas the urban children showed an increment of 18% from the initial SBP level of 93 mm Hg at age 10.

Roberts and Maurer(14) and Weiss

TABLE III—*Means (m) with Standard Deviations (SD) and Centiles of Systolic Blood Pressure (SBP) Levels in Adolescents by Gender and Area of Residence*

Age	Rural						Urban					
	Boys			Girls			Boys			Girls		
	n	m	SD	n	m	SD	n	m	SD	n	m	SD
10 +	176	103.2	9	202	106.1	8	139	92.1	9	134	92.5	11
11 +	300	103.8	9	259	106.3	9	179	92.1	10	224	94.3	11
12 +	288	103.9	9	235	106.7	9	211	92.8	10	203	96.8	10
13 +	314	104.4	10	214	106.9	10	174	96.7	10	174	98.3	11
14 +	345	104.4	9	328	106.8	9	170	100.6	9	199	102.1	9
15 +	353	104.5	10	337	106.9	9	191	104.1	10	225	105.1	8
16 +	329	105.0	10	266	107.9	9	193	107.8	9	186	106.3	10
17 +	186	107.6	9	127	108.0	8	123	109.7	8	102	108.9	10
	Centiles											
	5	50	95	5	50	95	5	50	95	5	50	95
10 +	90	104	120	90	108	120	80	90	110	70	92	110
11 +	90	104	118	90	108	120	78	90	110	79	92	112
12 +	90	104	120	90	110	124	79	90	110	80	98	114
13 +	90	104	120	90	110	121	80	98	117	80	99	116
14 +	90	104	120	90	106	124	84	100	118	90	102	118
15 +	90	104	122	92	106	120	90	102	120	90	104	119
16 +	90	104	122	96	108	122	92	108	122	90	106	120
17 +	94	107	123	98	108	120	98	110	122	92	108	129

et al.(15) reported that the SBP showed a steeper increase in girls of 6-11 years age and a slower rate thereafter, whereas it was vice versa for the boys. Shock(17) observed that the Californian girls showed no significant increase in SBP from 11.5 years onwards till 17.5 years, but the boys have displayed a mean increment of 2 mm Hg per year from a base value of 103 mm Hg at 11.5 years. Similarly, a higher mean SBP was reported for Chicago boys(18) from the age 13 onwards. All these lead to the conclusion that the mean SBP levels are higher in boys than in girls of similar ages from 13 years of age to at least 17. Contrary to this, in the present study, girls display a higher mean SBP and DBP levels till the age of 15 after which the boys overtake.

So far there have been only three reports on the ascultatory BP profiles of normal Indian children. A comparison of mean BP values among children of similar gender and age (between 10 and 15 years) reflects that both SBP and DBP were higher among the Allahabad children(19) followed by those of Udaipur(20,21) and Vellore urban children in that order. Though the mean SBP and DBP differ in all the four groups, the total increment achieved by them during the ages 10 and 15 was about the same resulting in a mean increment of 2.6 mm Hg/year for SBP and 1.6 mm Hg/year for DBP. The wide variation in mean BP levels in children of various populations is generally attributed to varying climatic, constitutional, emotional, socio-economic and dietary factors.

Gupta *et al's*.(22) investigation, based on a community study, points that the mean BP levels were comparatively lower in rural than in urban subjects of either sex at all ages considered (22 to 69 years) and that BP is independent of body weight. But they did not offer any explanation for the existing rural/urban differences. While working on non-pregnant women from the present study areas Rao *et al*.(23) also reported the persistence of rural/urban differences in the BP levels and observed that although life in rural areas is not necessarily peaceful or free from stress, the pace of life is more rhythmic and slower than that in urban societies and could perhaps explain the low BP levels among the rural women. Typically, low levels of BP among the rural poor are attributed to the minimal exposure to stress, a chronic state of malnutrition, and infectious diseases(24). All these do not explain adequately the elevated BP levels in rural adolescents as compared to their urban counterparts, at least upto 15 years of age. In this context, the observation that BP levels in a community depend on age, sex and race though these are also known to be influenced by socio-economic, cultural and occupational factors(25) gains credence.

Attempting a review and pooled analysis of the relevant world wide literature, Brotons *et al*.(26) arrived at the following conclusions–"The overall pattern of change in SBP with age indicates that a marked increase with age is nearly universal during childhood and adolescence and is especially steep in the early to middle years of the second decade of life. The rare exception demands further investigation and explanation. The data on DBP give rather different picture of BP change with age than data on SBP. The increases are modest by comparison, the difference between populations are some what greater". In the present study the BP levels among urban children are in conformity with the above observation and those in rural children provide exceptions by attaining asymptotes at an early age.

The unexpected behavior of rural children, *i.e.*, exhibiting higher mean BP values than their urban counterparts, may possibly be explained by stress factors. It is known that stress results in elevated BP levels and rural South Indian adolescents are generally engaged in activities such as casual labor, agricultural labor, firewood collection, fetching potable water, looking after the younger siblings and some times cooking for the whole family too, causing considerable physical as well as psychological stress. However, further analysis on the possible association of blood pressure levels with body weight, height and mid arm circumference is in progress and the results will be reported subsequently.

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