BLOOD PRESSURE TRACKING AS AN INDICATOR OF HYPERTENSION RISK

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ABSTRACT

The significance of high blood pressure to cardio- and cerebrovascular disease is well recognized. The associated mortality and morbidity risks call for multiple approaches to control the development of high blood pressure. Recent studies have shown that precursors of cardiovascular disorders may be apparent from a young age, and that these can persist and contribute to disease in later life. With regard to blood pressure, the phenomenon of persisting at the same rank has been referred to as tracking. This allows for the possible identification of high-risk groups, for whom early intervention can be initiated. In this paper, some of the findings of studies on blood pressure tracking are reviewed.

Keywords: Blood pressure tracking, hypertension, children, adolescents, young adults.

SINGAPORE MED J 1992; Vol 33: 474-477

INTRODUCTION

The pervasiveness of hypertension in industrialized countries has drawn much attention to the identification of its precursors. For example, about 30% or 42.2 million of adults aged 18 to 74 years are estimated to have borderline or definite hypertension in the United States[1]. Hypertension is also becoming more apparent in developing countries of middle-income status. In fact, elevated blood pressure is now known to be the single most important risk factor for potentially life-threatening coronary and cerebrovascular ailments in humans[2,3]. It is this augmentation of mortality risk that lends urgency to hypertension prevention efforts[4]. Despite the fact that cardiovascular disorders, including hypertension, are largely confined to adults, the scope of research in this area has expanded to younger age-groups. This is based on the recognition that cardiovascular disorders may begin early in life[5,6]. Of particular interest is the period of adolescence, which is recognized as a critical stage of physical, mental and emotional growth, including habit-formation[7].

Indications of an early onset arose from prospective studies that documented the tendency for certain characteristics in adolescence to persist at older ages. Most notable were reports of a link between adolescent and adult blood pressure levels, a phenomenon referred to as 'tracking'[8-11]. Paffenberger et al[8] also showed that higher blood pressure in late adolescence was associated not only with higher pressures later in life, but also a higher incidence of coronary disease mortality. It may be argued that other risk factors, such as obesity and diet also exhibit 'tracking'; characterized by an early onset that continues through adult life and that contributes to disease. Evidence on blood pressure tracking will be reviewed in this paper.

TRACKING OF BLOOD PRESSURE

Longitudinal studies on children have revealed that blood pressure levels persist, to some extent, within the same range over time. The concept of tracking, defined as a serial record of blood pressure status[9], or a persistent peer rank order of blood pressure[12], may be useful as a new approach to classify hypertension risk among children and adolescents. Thus, children with blood pressure tracking in the high-normal range may merit further attention.

Prospective surveys of populations below 18 years have shown substantial proportions of subjects remaining at the same blood pressure ranks over time[10,13,14], and significant statistical correlations between measurements in subsequent years of up to 0.60 for SBP and 0.45 for DBP[12,15,16]. Some of these studies will be described below. Systolic and diastolic blood pressures are represented as SBP and DBP, respectively. Referring to the measurement of diastolic pressure, K4 and K5 represent the fourth and fifth Korotkoff phases, respectively. The letter 'N' denotes the sample size of the study.

Studies on children and adolescents

From a study on 900 children (7-11 years old), who were followed-up for up to five years, 42% of children (7-10 years) who were in the highest quintile of initial SBP remained in this category two years later[14]. Random-zero sphygmomanometers were used in this study, but other details were not reported. Furthermore, 43% were still in the highest quintile four to five years hence. Among 11-year-old children who were re-examined annually, 43% remained in the highest quintile one and two years later, 47% in the third year and 51% in the fourth to fifth years of follow-up. A similar pattern was observed for DBP, but at lower rates. Three percent or less crossed-over to the lowest quintile during the study period. For those in the highest decile, 37% persisted in the same blood pressure category at years four and five of follow-up.

A prospective research in the United States (Bogalusa, Louisiana), surveyed 93% of all eligible children in the target area consisting of 3,524 children aged 5 to 14 years (63% white; 37% black)[15]. Children who were 5, 8, 11 and 14 years at baseline were re-examined annually for four years (n=868). In each year, blood pressure (K4) was measured with a standard mercury sphygmomanometer three times each by two technicians, with a 15 minute resting interval between the first and second sets of measures.

For the various ages, correlation coefficients between the first (baseline) and second years' readings ranged from 0.62 to 0.73 for SBP, and 0.42 to 0.55 for DBP[15]. No consistent decline in blood pressure correlations between year one and years three and four were apparent. Controlling for all other significant independent variables, the partial correlation between years one and four was 0.52 for SBP and 0.36 for DBP. Furthermore, 48 and 33% of children of all ages in the highest decile of SBP at baseline remained in this category in year two and four, respectively.

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Based on a five-year follow-up of 310 adolescents (14-15 years), Kotchen et al[17] reported statistically significant correlations for SBP (r = 0.48 for boys; r = 0.29 for girls) between measurements. Lower significant correlations were also evident for DBP (r = 0.30 for boys; r = 0.17 for girls). In this study, two technicians measured blood pressure with a mercury manometer under standardised conditions after five minutes seated rest. Measurements were taken repeatedly until SBP was reproducible within two mmHg. The average number of measurements to achieve this reproducibility was not reported.

At follow-up, statistically significant average increases in SBP (by about 5mmHg), DBP (17mmHg), height (7.6cm) and weight (14kg) in boys were reported. In girls, DBP (by about 5.6mmHg), height (2.4cm) and weight (6kg) also increased[17]. However, the SBP of girls did not change significantly. Grouped into the highest, lowest and pooled middle quartiles of their baseline SBP, it was found that 50% of those in the upper and 60% of those in the lowest quartiles remained in their respective baseline categories of SBP at five-year follow-up[17]. Few from either category crossed-over to the other extreme. In other words, blood pressure ranks were maintained over the five-year period. In addition, adolescents aged 16-19 years (n = 323) who were in the highest and lowest blood pressure ranks at baseline, and a random sample of those in the intermediate group, were followed-up five years later. These limits were defined as the 95th and 5th percentiles for whites and 90th and 10th percentiles for blacks. In this group, differences in SBP and DBP between groups were sustained at follow-up. Similar to the younger group, the ranks of the follow-up and initial SBP were significantly related among older adolescents[17]. Statistical correlations for blood pressure were not reported, however.

In the International Collaborative Study on Juvenile Hypertension, blood pressure and other data were gathered in 1977 on the 1964 birth-cohort of children (n=17,634)[18]. Children at the 95th percentiles in both SBP and DBP distributions, comprising up to 10% of the sample, were selected for annual re-examination in a four-year study. In addition, a 10% random sample of the remaining population were re-examined. In total, these children were studied from age 14 to 17 years.

From year one to four, correlations between initial and follow-up blood pressure ranged from 0.61-0.54 in SBP and 0.40-0.28 in DBP for boys, and 0.58-0.49 in SBP and 0.41-0.28 in DBP for girls[18]. Based on age-sex-specific distributions, 65% of boys in the upper 30th and 60% in the lower 30th percentiles were found to remain in the same ranks of SBP in the first year of follow-up. By year four (final follow-up), 56 and 49% remained in the upper and lower 30th percentiles of SBP, respectively. In terms of DBP over the four years, 56 to 52 % of boys persisted in the upper rank, and 44 to 42% in the lower rank, with no consistent pattern by year of follow-up. Furthermore, 33% of boys in the 95th percentile of SBP at baseline, and 22% in the 95th percentile of DBP, persisted at these ranks in year four. The corresponding figures for girls were comparable.

The authors demonstrated tracking in another way: 36% of boys and 19% of girls among those with high SBP (≥140mmHg) at baseline were shown to remain hypertensive four years later[18]. In contrast, among those with normal levels at baseline (SBP ≤ 129mmHg), only 5% of boys and 1% of girls shifted to high SBP four years later. Among those with high DBP at baseline (≥85mmHg), 4% of boys and 5% of girls persisted in this category in year four. On the other hand, only 2% of boys and 2% of girls with normal DBP at baseline (≤79mmHg) developed high DBP in year four. Thus, SBP and, to a lesser extent, DBP tended to track at high ranks over a four-year period.

However, rather poor correlations (r<0.3) between initial and follow-up blood pressure have also been reported[19,20].

In a survey of 14-year-old adolescents in Milan, Lattuada et al[16] reported significant correlations in DBP ranging from 0.10 to 0.35 between baseline and year four in four groups characterized by sex and maturation level. The corresponding results for SBP were higher (0.41-0.48). Blood pressure was measured three times using standard sphygmomanometers after 10 minutes rest.

Measurements of blood pressure at year five follow-up showed low correlations with baseline levels in a study of 2,777 boys and girls (4-18 years)[20]. Overall, statistical correlations of 0.33 in SBP and 0.21 in DBP were reported for boys, and 0.23 and 0.16 for girls, respectively. Expressed as a standardized score adjusted for height and sex, correlations were even lower - 0.19 (SBP) and 0.07 (DBP) for boys, and 0.15 (SBP) and 0.05 (DBP) for girls[20]. Furthermore, only 14% of boys and 8% of girls who were above the 95th percentiles for age and sex remained in this category five years hence.

The authors attributed part of the poor blood pressure correlations to the single measurement at baseline and follow-up, in view of the variability of blood pressure. Other details on blood pressure measurements were not reported in this paper. These could also have contributed to the study findings. Finally, no mention was made of possible differences in the findings for specific age-groups within the wide age-range covered, namely, pre-pubertal, early and late adolescence.

Be that as it may, both Lattuada et al[16] and Andre et al[20] concluded that there was evidence of blood pressure tracking in this age group. However, it was said to be insufficient for use as a screening device for predicting future hypertension. Overall, the need for anti-hypertensive medication for those in the high blood pressure rank has been rejected, except for counselling on diet and lifestyle[21].

A different method of measuring tracking was undertaken in the Muscatine (Iowa) study. Six biennial surveys were conducted on all schoolchildren from 1970-71 through to the 1980-81 academic years (about 6500 per year; 95% White)[12]. A participation rate exceeding 70% as achieved for each survey. From these surveys, a longitudinal sample was compiled, totalling 4,313 students who had been examined 3 to 6 times. This cohort was reported to be representative of the total study population in terms of blood pressure, height, weight, relative weight and triceps skinfolds. Blood pressure for each subject was expressed as an age-sex-specific percentile rank averaged over six surveys during the ten-year period[12]. Rather than classifying on a single reading, this method takes into account the variability of blood pressure measurements in children.

Based on this average, the cohort was divided into quintiles of blood pressure rank. Over the study period, it was noted that those in the lowest two quintiles experienced a negative trend or decreased rank over time. The middle quintile exhibited a stable trend, and the highest quintile an upward trend or increased rank[12]. Moreover, the degree of variability increased progressively from the lowest to the highest quintiles of pressure[12]. Utilizing these measures of overall (1) rank, (2) trend and (3) variability in blood pressure over time, distinct characteristics of tracking were identified in this study. This included groups with either high or low blood pressure, low variability, and either a stable or continuing trend in the extreme ranges. These were considered likely to remain in their respective blood pressure ranks over time. There was also a group who did not have high blood pressure, but showed a rising trend and low variability. Blood pressure may become high in the future for this group. Finally, the authors identified a group with high

blood pressure rank, as well as high variability, who were noted to resemble adults with labile hypertension. The variability component may provide an indication of the likelihood of shifting to different blood pressure ranks[12]. Thus, it was surmised that 11.9 % of students seemed to be tracking in the direction of future hypertension; 4.3 % of whom had a consistently high blood pressure rank and low variability, 1.1% had high rank, high trend and low variability, and 6.5% had lower pressure, high trend and low variability.

Studies on adolescents and your adults

In addition to studies linking blood pressure from childhood to adolescence, a few studies have investigated blood pressure tracking from adolescence to young adulthood.

As part of the Tecumseh Community Health Study (Michigan) initiated in 1959 to identify precursors of several chronic diseases, 2,415 white residents who were under 20 years old when examined in 1962-65 were re-examined in 1977 at ages 12-34 years[10]. Data were also collected from one or both parents of the respondents, including blood pressure, body mass index and sociodemographic background. Participation in 1977 was 77% among those still residing in the area (55% of original). Baseline measures of blood pressure, obesity or parental blood pressures between participants and non-participants were reported to be comparable. This paper focused on blood pressure (average of three readings) and body mass indices of the subjects and their parents.

Correlations in SBP between baseline and follow-up were statistically significant for all age groups[10]. Correlations were also slightly greater among girls than boys and appeared to increase with age; 0.20 (boys) and 0.30 (girls) among children under six years at baseline, 0.32 (boys) and 0.39 (girls) among children six to nine years, 0.45 (boys) and 0.48 (girls) among the 10-15 years group, and 0.34 (boys) and 0.51 (girls) among the 15-19 years group[10]. In fact, follow-up SBP had higher correlations with baseline SBP than with follow-up body mass index[10]. As predictors of high blood pressure (top 20th percentile of age-sex-specific distributions), the contributions of baseline blood pressure, body mass index, change in body mass and parental blood pressure were assessed. Furthermore, baseline blood pressure was found to be the most important predictor[10].

In Pittsburgh, 1,212 white middle-class respondents (mean age 34 years) who were examined between 1957-63 at ages 15-19 years in a previous study were recontacted in 1977[11]. Of those that could be located and still living in the area, 71% (n=373) completed the clinical examination (31% of the original). Information was collected on personal and health history data from the (local resident) refusals and a random sample of those who were no longer resident in the area. The baseline profiles of the participants, refusals and nonresidents were reported to be similar in mean age, pulse, blood pressure, height and weight. More non-residents, however, had completed more years of education and were in professional occupations, especially among the males.

In this study, statistically significant correlations between initial and follow-up SBP and DBP were reported (SBP 0.44 and DBP 0.31 for males; SBP 0.39 and DBP 0.24 for females)[11]. Based on linear regression analysis, high-school blood pressure and, to a smaller extent, weight change explained 21% of the variance in adult blood pressure. The addition of baseline height, weight and weight/height indices did not improve this result appreciably.

In terms of methodology, three readings each were taken by two observers, at the beginning and end of the clinical examination in the follow-up session. Since the first readings were about 1mmHg higher than the rest, the last two readings of both sets were averaged as a final measure. Inter-observer differences in measurements were not significant. In the school examination, however, only one reading was taken by a school physician. Inspite of this, the correlations obtained were reported to be similar to other long-term studies, at least for SBP. Furthermore, nearly 17% of boys in the top decile of SBP were still in this decile after 17 years, while 44% remained in the top two deciles[11]. The corresponding values for girls were not reported.

CONCLUSIONS

Based on several studies, there is evidence of tracking in blood pressure through childhood and adolescence, and thereon, to young adulthood. This supports the data on blood pressure tracking from follow-up studies on adults. Longitudinal studies on youth, ranging from one year to 17 years of follow-up, have demonstrated significant statistical correlations between baseline and follow-up blood pressure levels. Relatively high rates of persistence over time within selected percentiles of blood pressure rank have also been reported. Correlations appear to be consistently better for SBP than DBP, possibly due to the difficulty in detecting DBP in children; greater measurement error can weaken observed associations. The degree of tracking also appears to be higher for older than for younger children.

However, the evidence for blood pressure tracking is thought to be too weak for its use as a screening tool for the early detection of, or to predict, hypertension. Clearly, a protracted follow-up period is needed to measure the incidence of hypertension in later adulthood. Although a higher risk for adult-onset hypertension may be present for children in the upper blood pressure range, there is consensus that it does not justify anti-hypertensive drug therapy, nor undue medical attention that may raise anxiety. Nevertheless, close monitoring, weight control and dietary counselling have been advocated for children and adolescents with high-normal blood pressure. Further studies on this group and its associated factors could be useful in understanding the aetiology of hypertension.

ACKNOWLEDGEMENT

The author gratefully acknowledges the support for the preparation of this manuscript from the University of Malaya, Kuala Lumpur, and the Johns Hopkins University School of Hygiene and Public Health, Baltimore USA. Specific mention of thanks is given to Professor Dato Dr Khairuddin Yusof (Social Obstetrics and Gynaecology, University of Malaya), Craig Ewart, PhD (Department of Health Policy and Management, Johns Hopkins University) and Jon Rolf, PhD (Department of Maternal and Child Health, Johns Hopkins University).

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