

University of Warwick institutional repository: <http://go.warwick.ac.uk/wrap>

This paper is made available online in accordance with publisher policies. Please scroll down to view the document itself. Please refer to the repository record for this item and our policy information available from the repository home page for further information.

To see the final version of this paper please visit the publisher's website. Access to the published version may require a subscription.

Author(s): Saverio Stranges

Article Title: Blood pressure centiles for Great Britain: perspective on their potential

impact

Year of publication: 2007

Link to published version: <http://adc.bmj.com/cgi/content/full/92/4/288>

**Blood pressure centiles for Great Britain: perspective on their potential  
impact**

**Saverio Stranges & Francesco P Cappuccio**

Clinical Sciences Research Institute  
Warwick Medical School, Coventry, UK

Word count: 1,320

Correspondence to:

FP Cappuccio

Cephalon Chair – Cardiovascular Medicine & Epidemiology

Clinical Sciences Research Institute

Warwick Medical School

CSB at UHCW Campus

Clifford Bridge Road

Coventry CV2 4DX

Tel: 02476 968662

Fax: 02476 968660

E-mail: [cvme@warwick.ac.uk](mailto:cvme@warwick.ac.uk)

The study by Jackson and colleagues represents a significant contribution to our knowledge in the area of hypertension research and related clinical practice (1). The definition of national blood pressure references for children and young adults, aged 4-23 years, living in Great Britain provides important, complementary information to the updated US guidelines on the management of high blood pressure in children and adolescents aged 1-17 years (2), as well as to earlier attempts to define normative blood pressure values from other countries (3-7). In addition, these centiles will integrate existing charts in the UK regarding other important parameters (e.g., BMI), thereby allowing a more comprehensive characterisation of the health of children. Some distinctive aspects of the study by Jackson and colleagues should be highlighted: the representative and large sample size of the seven surveys from which blood pressure data were drawn; the consistent methodology applied for blood pressure measurements; the use of a statistical technique such as the LMS method to construct blood pressure centiles, which accounts for the skewness (L), median (M), and coefficient of variation (S) of the blood pressure distribution (8). Indeed, this statistical tool had been previously used in a German study to derive normalised reference values for the 24-h ambulatory blood pressure in children and adolescents aged 5-20 years (7).

In addition to the statistical value of their contribution, the study by Jackson and colleagues is particularly relevant because it gives emphasis to a significant problem in the medical field: hypertension in childhood. In the past few decades, the definition of normative values for blood pressure in the paediatric age range has been increasingly recognised as an important issue in clinical practice and public health because of the changing patterns in the epidemiology and associated determinants of hypertension among children and young adults. Several reasons justify the increasing attention to this issue. First, essential hypertension, especially in school-age children and adolescents, has become a condition of clinical and epidemiological relevance at least comparable to that associated with secondary forms of childhood hypertension (9). Second, as

indicated by Jackson, there is substantial evidence demonstrating the tracking of blood pressure from childhood to adulthood at a population level (10). Third, hypertension in childhood may cause end-organ damage (e.g., left ventricular hypertrophy) and predispose children to the early development of atherosclerosis and the occurrence of cardiovascular sequelae in adulthood (11). Therefore, greater attention to blood pressure early in life has the potential to generate long-term benefits on cardiovascular health (12). Finally, common determinants of hypertension in adulthood have increasingly become important medical issues in children and adolescents. The most significant example is obesity-related hypertension, which is a condition that is acquiring epidemic dimensions in the UK as well as worldwide (13). The finding observed by Jackson and colleagues of a strong association between body weight/obesity and high blood pressure further corroborates this notion.

A further interesting result observed in the present study is the high percentage (23%) of young males with systolic blood pressure levels above the British Hypertension Society cut-off for hypertension (i.e., > 140 mm Hg) (14). This finding needs to be cautiously interpreted, however, as it is based on blood pressure measurements obtained on a single occasion, which may lead to some degrees of misclassification (over-diagnosis) because of the potential for a “white coat” effect (15) and regression to the mean on subsequent measurements (16). Further considerations refer to the age range of the study participants with a large proportion consisting of older teenagers and young adults (up to 24 years), and the use of an oscillometric device that may overestimate systolic blood pressures compared with values obtained by auscultation (17). Despite these methodological issues, it should be noted, however, that the apparently high prevalence of hypertension among young males found by Jackson and colleagues is comparable to figures reported in recent studies across different populations of children and adolescents (18-21). For example, using a similar approach to measure resting blood pressure (i.e., three consecutive measurements with an oscillometric device), a school-based survey of 3,589

children and adolescents conducted in Quebec, Canada, revealed prevalence percentages of high-normal or elevated systolic blood pressure to be 12%, 22%, and 30% among 9-, 13-, and 16-year-old males, respectively, with lower figures among females, based on the US cut-off values (18). This is consistent with the British data. Similar figures were observed in a sample of minority schools from three US locations; however only eight-grade adolescents were included (21). Together, these data support the existence of an evolving epidemic of hypertension in youth, which is closely associated with a parallel epidemic of obesity (13). In addition, these data indicate the potential for future increases in adult blood pressure levels and in the prevalence of hypertension in the next generations, which could determine a rise in cardiovascular morbidity and mortality. Open questions in this area pertain to the observed gender differences among children in hypertension prevalence, which tend to be magnified with increasing age; the predominance of systolic hypertension, which could be partially related to excess body weight and fat distribution; the role of other determinants in the development of high blood pressure in youth (e.g., diet, decreased physical activity, social factors, ethnicity, heritability, sleep disorders)(22-23) beyond body weight, which does not explain the overall variability in blood pressure levels and accounts only in part for the observed increase in the mean levels of blood pressure (24). For example, findings on the role of ethnicity in childhood hypertension have been inconsistent, with the observed ethnic differences often explained by differences in body size and fat distribution (19-21, 25). However, more data are needed to understand the interaction between ethnicity and environmental stimuli over the life course, which may result in ethnic differences in blood pressure levels in adulthood.

The information provided by Jackson and colleagues highlights the importance of performing routine blood pressure screenings in childhood for the early detection of high blood pressure levels, thus allowing the implementation of timely preventive and therapeutic measures. Nevertheless, some unresolved issues deserve further consideration. First, there is still concern about the accuracy of

blood pressure measurements in large epidemiological studies because of the aforementioned misclassification issues, which are particularly critical in the paediatric age range (26). In addition, the comparability across studies is often hampered by the use of different measurement methodologies. Moreover, the use of oscillometric devices is still a controversial issue despite the efforts made to validate this tool. Therefore, as recommended by Jackson and colleagues, the proposed centiles need to be applied with caution when blood pressures are measured by auscultation. Second, the difficulty in defining normative blood pressure levels in children has been due to the paucity of data associating childhood hypertension with cardiovascular risk in adulthood. However, ongoing longitudinal investigations should provide new insights into the long-term significance of high blood pressure in childhood, and of its interaction with other cardiovascular risk factors (27-29). Finally, although well-documented in adults, there is still uncertainty about the role of environmental determinants of hypertension in children. Indeed, while the evidence on the importance of excess body weight in the development of high blood pressure in children is substantial, findings on the effects of other determinants such as dietary factors are less persuasive (30). In particular, there is a paucity of data regarding the efficacy of dietary and other lifestyle modifications in the prevention and management of high blood pressure among children. Recent findings from small-scale studies suggest that short-term lifestyle interventions including dietary changes may produce beneficial effects on blood pressure and other components of the metabolic syndrome in overweight children (31-32). For instance, compelling evidence has become available for a reduction in salt intake in infants and children to reduce the rise in blood pressure with age and the ensuing risk of hypertension (33). Long-term and larger intervention trials are needed to evaluate whether the observed benefits are sustainable and clinically relevant within the paediatric age range.

## References

1. Jackson LV, Thalange NK, Cole TJ. Blood pressure centiles for Great Britain. *Arch Dis Child* 2006; in press
2. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004; 114:555-576.
3. De Man SA, André JL, Bachmann H, Grobbee DE, Ibsen KK, Laaser U, Lippert P, Hofman A. Blood pressure in childhood: pooled findings of six European studies. *J Hypertens* 1991; 9:109-114.
4. Sharma BK, Sagar S, Wahi PL, Talwar KK, Singh S, Kumar L. Blood Pressure in Schoolchildren in Northwest India. *Am J Epidemiol* 1991; 134:1417-1426.
5. Menghetti E, Viridis R, Strambi M, Patriarca V, Riccioni MA, Fossali E, Spagnolo A, on behalf of the Study Group on Hypertension of the Italian Society of Pediatrics. Blood pressure in childhood and adolescence: the Italian normal standards. *J Hypertens* 1999; 17:1363–1372.
6. Blake KV, Gurrin LC, Evans SF, Newnham JP, Landau LI, Stanley FJ, Beilin LJ. Reference ranges for blood pressure in preschool Australians, obtained by oscillometry. *J Paediatr Child Health* 2000; 36:41-46.
7. Wühl E, Witte K, Soergel M, Mehls O, Schaefer F, German Working Group on Pediatric Hypertension. Distribution of 24-h ambulatory blood pressure in children: normalized reference values and role of body dimensions. *J Hypertens* 2002; 20:1995–2007.
8. Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med* 1992; 11: 1305–1319.
9. Sinaiko AR. Hypertension in children. *N Engl J Med* 1996; 335:1968–1973.
10. Whincup PH, Cook DG, Geleijnse JM. A life course approach to blood pressure. In: Kuh D, Ben-Shlomo Y, eds. *A Life Course Approach to*

- Chronic Disease Epidemiology. Oxford: Oxford University Press; 2004: 218–239.
11. Celermajer DS, Ayer JGJ. Childhood risk factors for adult cardiovascular disease and primary prevention in childhood. *Heart* 2006; 92:1701-1706.
  12. McGill HC Jr, McMahan CA. Starting earlier to prevent heart disease. *JAMA* 2003; 290:2320-2322.
  13. Sorof J, Daniels S. Obesity hypertension in children: a problem of epidemic proportions. *Hypertension* 2002; 40: 441–447.
  14. Williams B, Poulter NR, Brown MJ, Davis M, McInnes GT, Potter JF, et al. British Hypertension Society guidelines for hypertension management 2004 (BHS-IV): summary. *Br Med J* 2004; 328:634-640.
  15. Sorof JM, Poffenbarger T, Franco T, Portman R. Evaluation of white coat hypertension in children: importance of the definitions of normal ambulatory blood pressure and the severity of casual hypertension. *Am J Hypertens* 2001; 14:855–886.
  16. Davis CE. The effect of regression to the mean in epidemiologic and clinical studies. *Am J Epidemiol* 1976; 104:493-498.
  17. Park MK, Menard SW, Yuan C. Comparison of auscultatory and oscillometric blood pressures. *Arch Pediatr Adolesc Med* 2001; 155:50–53.
  18. Paradis G, Lambert M, O’Loughlin J, Lavallée C, Aubin J, Delvin E, Lévy E, Hanley JÁ. Blood pressure and adiposity in children and adolescents. *Circulation* 2004; 110:1832-1838.
  19. Sorof JM, Lai D, Turner J, Poffenbarger T, Portman RJ. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics* 2004; 113:475-482.
  20. Jafar TH, Islam M, Poulter N, et al. Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the United States: a comparative study. *Circulation* 2005; 111:1291-1297.
  21. Jago R, Harrell JS, McMurray RG, Edelstein S, El Ghormli L, Bassin S. Prevalence of abnormal lipid and blood pressure values among an



- ethnically diverse population of eighth-grade adolescents and screening implications. *Pediatrics* 2006; 117:2065-2073.
22. Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, Steer C, Sherriff A for the Avon Longitudinal Study of Parents and Children Study Team *et al.* Early life risk factors for obesity in childhood: cohort study. *Br Med J.* 2005; **330**: 1357-63
  23. Currie A & Cappuccio FP. Sleep in children and adolescents: a worrying scenario. *Nutr Metab Cardiovasc Dis* 2007; in press.
  24. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. *JAMA* 2004; 291:2107–2113.
  25. Rosner B, Prineas RJ, Daniels SR, Loggie JMH. Blood pressure differences between blacks and whites in relation to body size among US children and adolescents. *Am J Epidemiol* 2000; 151:1007–1019.
  26. Gillman MW, Cook NR. Blood pressure measurement in childhood epidemiological studies. *Circulation* 1995; 92:1049–1057.
  27. Davis PH, Dawson JD, Riley WA, Lauer RM. Carotid intimal-medial thickness is related to cardiovascular risk factors measured from childhood through middle age: the Muscatine Study. *Circulation* 2001; 104: 2815–2819.
  28. Li S, Chen W, Srinivasan SR, Bond MG, Tang R, Urbina EM, Berenson GS. Childhood cardiovascular risk factors and carotid vascular changes in adulthood: the Bogalusa Heart Study. *JAMA* 2003; 290: 2271–2276.
  29. Raitakari OT, Juonala M, Kähönen M, Taittonen L, Laitinen T, Mäki-Torkko N, Jarvisalo MJ, Uhari M, Jokinen E, Rönnemaa T, Åkerblom HK, Viikari JSA. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. *JAMA* 2003; 290: 2277–2283.
  30. Simons-Morton DG, Obarzanek E. Diet and blood pressure in children and adolescents. *Pediatr Nephrol* 1997; 11:244-249.
  31. Monzavi R, Dreimane D, Geffner M, Braun S, Conrad B, Klier M, Kaufman FR. Improvement in risk factors for metabolic syndrome and insulin

- resistance in overweight children who are treated with lifestyle intervention. *Pediatrics* 2006; 117:e1111–e1118.
32. Chen AK, Roberts CK, Barnard RJ. Effect of a short-term diet and exercise intervention on metabolic syndrome in overweight children. *Metabolism* 2006; 55:871-878.
33. He FJ & MacGregor GA. Importance of salt in blood pressure regulation in children: a meta-analysis of controlled trials. *J Hum Hypertens* 2006; 20: 813