Growth monitoring: testing the new guidelines

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Abstract

***Objective*—To assess the impact of recent guidelines from the UK joint working party of child health surveillance recommending that all children be measured at age 5 and again between 7 and 9 years of age to determine how many normal school age children are likely to be referred for specialist assessment.**

***Methods*—The longitudinal data of 486 children measured by school nurses in a community setting were examined and compared with measurements made in a research setting by a single, skilled observer.**

***Main outcome measures*—Number of children identified as having abnormal stature (< 0.4th or > 99.6th centile) and abnormal growth rate height standard deviation score (HSDS) change > 0.67).**

***Results*—The community survey identified seven (1.4%) children as having abnormal stature (four short, three tall), 11 (2.3%) were identified as "slow growing", and nine (1.9%) increased their HSDS by more than 0.67. These results were comparable to data collected in ideal research conditions.**

***Conclusions*—Following the recommendations would not result in an excess number of inappropriate referrals. However, this study highlights several unresolved issues such as interobserver variablity and time interval between measurements. A large scale prospective study should be considered to establish realistic and cost-effective criteria before implementation of a national screening programme.**

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The new UK guidelines for growth monitoring in the community[1] have recognised the importance of the early identification of **all** children with growth related disorders. Delay in diagnosis and treatment can result in irretrievable height loss.[2 3] Even if treatment is not appropriate, counselling may be essential to both children and parents. The guidelines propose that all children are measured at least three times between the ages of 18 months and 5 years and again between 7 and 9 years old. It is recommended that extremely short (< 0.4th centile) or tall (> 99.6th centile) children should be referred for specialist opinion as should "slow growing" children.

Extreme short stature is more likely to have a pathological cause[4–6] and we have recommended that these children be investigated.[6] However, even if growth were to stop completely, it could take many years for a "tall" child to become short. If short stature was the *only* criterion to warrant investigation, an unacceptable delay in diagnosis and treatment would result; therefore, it is important to refer slow growing children.

There are as yet no empirical standards defining slow growth. The recommendations from the joint working party acknowledge the difficulties of using height velocity. Not only is it affected by measurement error[7 8] but normal velocity is conditional on the height of the child.[9] However, as normal, prepubertal children are expected to stay close to their particular centile lines,[10 11] the new guidelines propose using centile changes over time to identify abnormal growth. They suggest, with little scientific evidence, that preschool children crossing the equivalent of two centile channels (a change of 1.34 in height standard deviation score (SDS)), and school age children crossing one channel (a change of 0.67 SDS) should be referred for specialist opinion. These guidelines reflect the expectation that younger children are more likely to cross centile lines[9] but their appropriateness has yet to be tested in the community where children are measured in different settings and by different measurers.

This study aimed to (1) examine the longitudinal data of children measured in the community to determine how many school age children in the normal population are likely to be identified for referral according to the recommendations in the Hall report using the new UK growth charts[12]; and (2) compare the community results with those from the Wessex growth study where prepubertal children have been measured at six monthly intervals in a research setting by a single, skilled observer.

Subjects and methods

PREPUBERTAL GROWTH IN COMMUNITY SETTING

Community height data were collected for 486 children (247 boys, 239 girls) measured in 11 mainstream schools across the Southampton health district. The children had been routinely measured at school entry (mean age 4.91 years) and again three years later (mean age 7.87 years) by school nurses who had received routine training in the technique and relevance of height monitoring. Each school was serviced by a different nurse, some of whom changed during the study period as frequently occurs in practice. Only children without reported health problems were included. Height measurements were converted to height standard deviation scores (HSDS) using the new UK reference data[12] and the prepubertal change in height standard deviation score (ΔHSDS) was calculated by

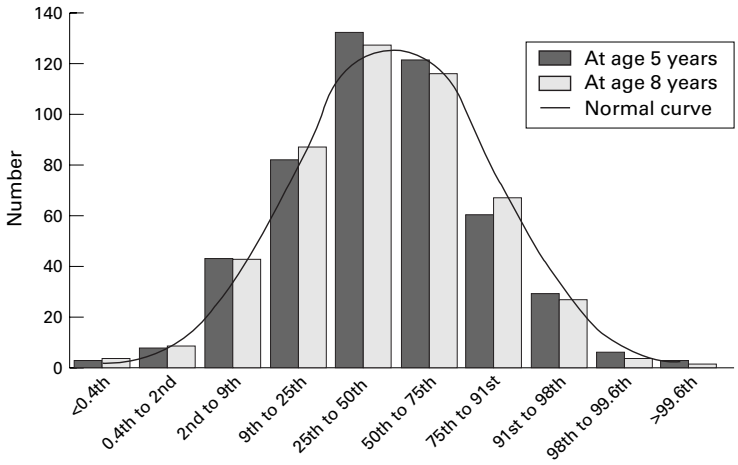

Figure 1 Height distribution of 486 children measured in the community at age 5 and 8 years.

Table 1 Comparison of height standard deviation shift of children measured in the community by one or two school nurses, and measured in the community and in a research setting

	*One v two nurses**		*Setting†*	
	Two	*One*	*Community*	*Research*
> 0.67 down	9 (3.1%)	2 (1.0%)	11 (2.3%)	1 (0.5%)
Within 0.67	280 (95.2%)	186 (96.9%)	466 (95.9%)	207 (97.6%)
> 0.67 up	5 (1.7%)	4 (2.1%)	9 (1.9%)	4 (1.9%)

*p = 0.330; χ^2 2.217. †p = 0.246; χ^2 2.804.

subtracting HSDS of the second measurement from HSDS of the first.

PREPUBERTAL GROWTH IN RESEARCH SETTING

The Wessex growth study[13] was set up in 1986 to identify and monitor the growth of short children in the community. A total of 140 short healthy children were identified at school entry as being < 3rd centile for height according to Tanner and Whitehouse standards.[14] They were matched for age, sex, and school class with children whose heights were between the 10th and 90th centiles. Children were measured every six months by the same auxologist (LDV) and heights recorded to the nearest millimetre. These were converted to HSDS using the new UK reference data.[12] The HSDS was calculated for 212 children (109 short, 103 controls) who had a height measurement recorded in the first year of school (mean age 6.05 years) and again three years later (mean age 9.00 years).

STATISTICS

The data were analysed using the SPSS statistical package. The Student's *t* test and one way analysis of variance were used to compare means, Bartlett's test to compare SD, and χ^2 to compare categorical data. Group results are presented as mean (SD).

Results

PREPUBERTAL GROWTH IN THE COMMUNITY

At school entry, the HSDS of the children was −0.12 (1.00) (46th centile), with no sex difference (boys, −0.14 (0.92); girls, −0.10 (1.07); p = 0.639). Seven (1.4%) children met the referral criterion for abnormal stature, four (three girls, one boy) for short stature (< 0.4th centile) and three (two girls, one boy) for tall stature (> 99.6th centile). At second measurement, the HSDS was −0.14 (0.99) (44th centile) and again no sex difference was found (boys, −0.09 (0.92); girls, −0.18 (1.06); p = 0.090). There were no new referrals for abnormal stature and the height of one initially very tall child then lay within normal limits. The height distributions at first and second measurement (fig 1) were approximately normal and corresponded with the new standards.[12]

The HSDS of 96% of the children did not alter by more than 0.67, the equivalent of one centile channel on the new charts, with 11 (one boy, 10 girls) decreasing and nine (five boys, four girls) increasing their height centile by more than this amount. One child's height data were excluded from further analysis as the height change was so extreme as to suggest that a recording or transcription error had been made.

The ΔHSDS was close to 0 (−0.01 (0.35)) and normally distributed although girls grew more slowly than boys (boys, +0.05 (0.31); girls, −0.07 (0.38); p < 0.001). Two hundred and ninety three (60%) children had been measured by different school nurses on the two occasions. As might be expected, the standard deviation of ΔHSDS was slightly larger, although not significantly different, for two observers than for one (two nurses, 0.36; one nurse, 0.32; p = 0.16) and nine (including the child excluded from analysis) of the 11 children whose HSDS had fallen by more than one centile channel had been measured by different observers (table 1). The correlation between the two height measurements was 0.948 for a single observer and 0.933 for two observers.

PREPUBERTAL GROWTH IN RESEARCH SETTING

The mean growth of both short and control children in the Wessex growth study stayed close to their initial mean height centile lines. Some grew at a slower rate than others but this was independent of both height and sex. For this population of very short and average controls (10th to 90th centiles[14]), ΔHSDS was a little above 0 (+0.15 (0.25)). However, the mean ΔHSDS for short and control children was similar (short, +0.18; control, +0.12; p = 0.073). A few children (one short, three controls) increased their HSDS more than 0.67 and one short boy fell by the same amount. For control children, the correlation between HSDS at the two measurements was 0.931, equivalent to a correlation of 0.966 for the whole population, rather than that truncated at the 10th and 90th centiles.

COMPARISON OF COMMUNITY AND RESEARCH RESULTS

Table 2 shows the mean, SD, and SE for ΔHSDS of measurements made in a research setting and in the community by both a single and two different school nurses. Equipment, setting, and observer are prone to variability in the community and the variance of the ΔHSDS was less when measurements were made in

Table 2 Change in HSDS of children measured in a research setting and in the community by one or two school nurses

	Community			
	2 nurses	*1 nurse*	*Researcher*	*p value*
Mean	−0.06	0.06	0.15	<0.001
SD	0.36	0.32	0.25	<0.001
SEM	0.02	0.02	0.02	

Means were compared using the one way analysis of variance and SDs using Barlett's test.

ideal research conditions than for community measurements. However, the number of children whose HSDS changed by more than 0.67 was not significantly different (table 1).

Discussion

Our data confirm that the 1990 growth reference charts are appropriate for school children today[15] and can be used effectively with the recommendations to screen for abnormal stature. The mean height of the children measured in our community was close to the 50th centile, the distribution normal, and the number falling above and below ±2 SDs was as expected. Whether the cut off for abnormally short stature should be the 0.4th centile, as recommended, or be raised to the second centile[15] is open to debate, but must depend to a large extent on the resources available.

Our data show that 2.3% of children (one boy, 10 girls) measured in the community would have been identified and referred as "slow growing" and a similar number of children (five boys, four girls) have increased their height centile by more than one centile channel. We do not know why so many girls should be identified as "slow growing" and we consider this needs further investigation. It may simply be chance, recording errors, or the effect of the earlier occurrence of puberty in girls, causing some to transiently fall from their centile before the growth spurt. Nine of the slow growing children had been measured by different observers on each occasion highlighting the problem of interobserver error. Differences between observers, apparently using the same technique, have been demonstrated.[16 17] Nevertheless, our findings are compatible with the theoretical model that would have predicted that 1–2% of the reference population would fall and the same number increase by the equivalent of more than one centile channel[9 18] between 5 and 8 years old. The joint working party recommendations therefore would not result in an excessive number of referrals for abnormal growth rate, even in a community setting.

There are, however, several areas within the guidelines that need clarification. First, the one child measured in a research setting who was identified as slow growing illustrates the importance of not relying on single estimates of growth rate. He had been measured at six monthly intervals since the age of 5 years and the measurements taken at age 6 and 9 years happen to represent his largest and smallest HSDS. Assessing all his prepubertal height measurements showed that his growth rate was similar to all other short and control children.

Key messages

- Height data collected by **trained** community personnel will not result in an excessive number of inappropriate referrals for specialist opinion
- Interobserver error will always be a problem, and consistency of measuring techniques between different observers should be a training goal
- It is difficult to identify abnormal growth rate as this depends on many variables including age, height, and measurement interval
- It is unusual for the height of a prepubertal school age child to change by as much as a centile channel, **but** such a referral criterion is unlikely to identify all growth related pathology

Second, the proposal for the identification of slow growth is ambiguous. Growth rate requires both change in height **and** the time interval between measurements to be considered. While the guidelines stipulate the change in height required, they do not clearly define the time interval. They simply recommend that children are measured at 5 and again between 7 and 9 years of age, an interval of between 2 and 4 years. However, it has been shown that the variability in the change of height increases as the measurement interval increases.[18 19] Therefore, if 3% of school age children drop one centile channel in a 3 year period, *fewer* could be expected do so in a 2 year period and *more* in 4 years. A child whose height falls one centile channel in 3 years has grown better than a child falling as much in 2 years but worse if the drop was over a 4 year period.

Third, the guidelines do not specify a method for identifying height centile shift. Visual inspection of the height chart is clearly subjective and open to error. The new UK reference charts can be used to estimate HSDS as outlined by Cole,[18] and ΔHSDS calculated by subtraction. However, this would require further training of primary care workers, an additional calculation, and even more instructions on the already overcrowded reference charts. Ideally data should be computerised and children meeting the referral criteria automatically recalled.

The issue of sensitivity must also be addressed before the introduction of a national screening programme. It is generally considered that growth monitoring is good clinical practice that will lead to the early detection of growth related disorders such as Turner's syndrome, coeliac disease, and acquired hypothyroidism. Our findings suggest that, given reliable height data and a suitable measurement interval, the criterion for the referral of slow growing school age children may well be specific and identify few normal children, but they tell us nothing about its sensitivity. Unfortunately there is little longitudinal data on growth related disease. It is unknown how many children with untreated disease cross centile

bands. Disease specific growth charts are available for Turner's syndrome[20] and these show that tall girls with Turner's syndrome—those above the 0.4th centile on normal height charts—are unlikely to fall by as much as one centile band between 5 and 8 years of age.[21] Noonan's syndrome is also associated with short stature; however, Ranke *et al* reported that the mean height of prepubertal children with Noonan's syndrome followed Tanner's third centile and only transiently decreased owing to delayed puberty.[22] It is unlikely therefore that growth monitoring alone would detect significant numbers of prepubertal children with undiagnosed Turner's or Noonan's syndrome.

Slow growth rate can be a symptom of endocrine and metabolic disorders. While these may severely compromise growth, they rarely stop it completely. The time taken to fall one centile band clearly depends on rate of growth. A school age child would need to grow at half his or her normal rate for over a year before such a fall could be detected. Further studies are necessary to determine which, if any, disorders are likely to be identified through growth monitoring alone.

Finally, in today's economic climate the need for cost efficiency and effectiveness is paramount. To be successful, a screening programme must be specific and sensitive, but it should also be simple and relatively cheap to administer. The benefit of preschool growth monitoring has yet to be assessed but, even if growth monitoring is proved worthwhile, we should not minimise the planning, training, and cost involved in a national programme.[23] Growth monitoring of all children from the age of 2 to 8 years is clearly a multidisciplinary exercise involving the cooperation and commitment of health visitors, school nurses, growth specialists, and administration personnel.

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1 Hall DMB. Growth monitoring. In: Hall DMB, ed. *Health for all children.* 1996:109–29.
2 Herber SM, Milner RDG. When are we diagnosing growth hormone deficiency? *Arch Dis Child* 1986;**61**:110–12.
3 Tanner JM. Towards complete success in the treatment of growth hormone deficiency: a plea for earlier ascertainment. *Health Trends* 1975;7:61–5.
4 Lacey KA, Parkin JM. The normal short child. Community study of children in Newcastle upon Tyne. *Arch Dis Child* 1974;**49**:417–24.
5 Vimpani GV, Vimpani AF, Pocock SJ, Farquhar JW. Differences in physical characteristics, perinatal histories, and social backgrounds between children with growth hormone deficiency and constitutional short stature. *Arch Dis Child* 1981;**56**:922–8.
6 Voss LD, Mulligan J, Betts PR, Wilkin TJ. Poor growth in school entrants as an index of organic disease: the Wessex growth study. *BMJ* 1992;**305**:1400–2.
7 Voss LD, Wilkin TJ, Bailey BJR, Betts PR. The reliability of height and height velocity in the assessment of growth (the Wessex growth study). *Arch Dis Child* 1991;**66**:833–7.
8 Cameron N. The methods of auxological anthropometry. In Falkner F, Tanner JM, eds. *Human growth* Vol 3. New York: Plenum, 1986:3–46.
9 Bailey BJR. Monitoring the heights of prepubertal children. *Ann Hum Biol* 1994;**21**:1–11.
10 Tanner JM. The regulation of human growth. *Child Develop* 1963:**34**:817–47.
11 Hindmarsh PC, Brook CGD. Normal growth and its endocrine control. In: Brook CGD, ed. *Clinical paediatrics* 1989: 57–73.
12 Freeman JV, Cole TJ, Chinn S, Jones PRM, White EM, Preece MA. Cross sectional stature and weight reference curves for the UK, 1990. *Arch Dis Child* 1995;**73**:17–24.
13 Voss L, Walker J, Lunt H, Wilkin T, Betts P. The Wessex growth study: first report. *Acta Paediatr Scand (Suppl)* 1989;**349**:65–72.
14 Tanner JM, Whitehouse RH, Takaishi M. Standards from birth to maturity for height, weight, height velocity and weight velocity. British children 1965. *Arch Dis Child* 1966; **41**:613–35.
15 Cotterill AM, Majrowski WH, Hearn S, Jenkins S, Preece MA, Savage MO. The potential effect of the UK 1990 height centile charts on community growth surveillance. *Arch Dis Child* 1996;**74**:452–4.
16 Voss LD, Bailey BJR. Equipping the community to measure children's height: the reliability of portable instruments. *Arch Dis Child* 1994;**70**:469–71.
17 Voss LD, Bailey BJR, Cumming K, Wilkin TJ, Betts PR. The reliability of height measurement (the Wessex growth study). *Arch Dis Child* 1990;**65**:1340–4.
18 Cole TJ. Growth monitoring with the British 1990 growth reference. *Arch Dis Child* 1997;**76**:47–9
19 Sorva R, Lankinen S, Tolppanen EM, Perheentupa J. Variation of growth in height and weight of children. 11. after infancy. *Acta Paediatr Scand* 1990;**79**:498–506.
20 Lyon AJ, Preece MA, Grant DB. Growth curve for girls with Turner syndrome. *Arch Dis Child* 1985;**60**:932–5.
21 Cole TJ, Hall DMB. Screening for growth: towards 2000. *Arch Dis Child* 1996;**74**:183.
22 Ranke MB, Heidemann P, Knupfer C, Enders H, Schmaltz AA, Bierich JR. Noonan syndrome: growth and clinical manifestations in 144 cases. *Eur J Pediatr* 1988;**148**:220–7.
23 Hearn S, Majrowski W, Jenkins S, Savage M, Cotterill AM. Setting up a height surveillance programme: recommendations based on the Hackney growth initiative. *J Med Screening* 1995;**2**:157–9.

Commentary

Why measure children? Parents like to know that their children are growing normally; growth data are of public health interest; school nurses use measuring, like vision testing, as an excuse to extract children from the classroom. But the main justification is to identify occult disease. This apparently innocuous activity is, therefore, a screening test and must meet the criteria of Wilson and Jungner.[1]

Mulligan *et al* examine a proposal of the Joint Working Party on Child Health Surveillance that the benefits should be assessed of identifying children who cross centile channels (that is, those who shift 0.67 SDS or more). The proposal was not invented by the working party, but was based on consultation with paediatric endocrinologists.

The results support the prediction that 2–4% of all children would be referred for specialist opinion. If most of the disease were within that 2–4% of children this would be a good investment—but it seems that this is not so; therefore, this referral rate represents much work for little return. It seems unlikely that height monitoring for slow growers can ever meet the Wilson and Jungner criteria, in spite of improved training and quality control. We can estimate from published data roughly how many cases would be found and at what cost. A case could be defined as "identification by growth monitoring of new, significant pathology before there is any other evidence of ill health". The yield of such cases will be small and, for the reasons set out in the paper, the amount of disease missed will probably exceed it severalfold.

Measuring and plotting height are cheap and acceptable but they are not simple, and the process lacks both sensitivity and specificity. There is no simple reference test by which abnormality can be diagnosed. The financial cost is probably acceptable, but the cost in professional resources and parental anxiety may not be.

Does this mean that measuring children is not important? Quite the contrary. Growth is an excellent index of health and children should be measured whenever opportunity allows. In health care systems where children receive primary care from a paediatrician, consultation would include measuring, plotting, and interpreting the growth parameters[2]—just as one would routinely measure an adult's blood pressure. Surely the standard should be the same in countries where general practitioners are the main providers of primary health care for children. The responsibility for detecting growth disorders and ill health belongs to the primary care team and it is there that children must be measured and growth charts completed. With adequate training and support, primary care teams should be able to provide this service. School based growth monitoring programmes detached from the primary care team are unwieldy, result in diffusion of responsibility, and are unlikely to offer value for money.

The recent proposals for development of primary care groups[3] may be the stimulus needed to accelerate the integration of school nurses into primary care, providing a long overdue link between two systems of care that currently compete more often than they collaborate, and producing benefits for child health in general.

Addendum

A meeting was held in Coventry, UK on 19–20 June 1998 to review growth monitoring and a consensus statement is in preparation.

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1 Wilson JMG, Junger G. *Principles and practice of screening for disease*. Public health papers No 34. Geneva: World Health Organisation, 1968.
2 Green M, ed. *Bright futures–guidelines for health supervision of infants, children and adolescents*. Arlington: National Center for Education in Maternal and Child Health, 1994. (http://www.brightfutures.org)
3 Department of Health. *The new NHS*. London: HMSO, 1997.