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Monitoring head size and growth using the new UK-World Health Organization growth standard

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Abstract

In order to assess the extent to which children in the United Kingdom (UK) will follow the UK-WHO head circumference standard, we used head circumference data from the Southampton Women's Survey (SWS; n=3159) and the Avon Longitudinal Study of Parents and Children (ALSPAC; n=15,208) in children age 0-36 months, converted into z-scores using both the UK-WHO or UK1990 references. Rapid head growth was defined as crossing upwards through 2 major centile bands (1.33 SD). The UK-WHO standard identified many more infants with heads above the 98th centile compared to the UK1990 reference (UK-WHO 6% to 16% of infants at various ages, UK1990 1% to 4%). Rapid head growth in the first 6 to 9 months was also much more common using the UK-WHO standard (UK-WHO: 14.6% to 15.3%; UK1990: 4.8% to 5.1%). Practitioners should be aware of these findings to avoid unnecessary referrals.

Keywords

ALSPAC; head circumference; growth charts; macrocephaly; microcephaly; hydrocephalus

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Conflict of interest

CW and AW are both member of the RCPCH growth chart design group and were closely involved in producing the new UK-WHO growth charts. CW also undertook a brief consultancy for WHO regarding the construction of their velocity standard. Otherwise none of the authors have anything to declare

Contributorship

CW did the analysis of the SWS data and KO analysed the ALSPAC data. CW drafted the paper and will act as guarantor. All the other authors contributed to the content and editing of the paper.

BACKGROUND

New UK-WHO growth charts were launched in 2009. They incorporate the new WHO 2006 Growth Standards from age 2 weeks to 4-years, combined with recalculated birth data from the British 1990 growth reference¹. The charts include UK-WHO head circumference standards published in April 2007 between 2-weeks and 2-years of age². The validity of the WHO 2006 weight and length standard for growth monitoring in the UK has already been explored³ but not the head circumference standard, due to its later publication date. We thus set out to assess the applicability of the new UK-WHO head circumference reference to British children, using data from two UK population-based studies.

METHODS

Populations

Southampton Women's Survey (SWS)—This study followed women aged 20-34 years through pregnancy and their infants are currently being followed through childhood⁴. Infants born before 37 completed weeks gestation were excluded. Maximal occipito-frontal circumference (OFC) was measured 3 times and averaged. After birth blank tapes were used, marked and read off against a fixed rule. Printed cloth tapes were used for infants and children. Inter-observer variation studies were conducted regularly to maintain consistency of measurements.

Avon Longitudinal Study of Parents and Children (ALSPAC)—The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective study (<http://www.alspac.bris.ac.uk>) that enrolled pregnant women living in the former County of Avon. Routinely collected OFC measures by health visitors were extracted from the local child health database.

Analysis

All head circumference data were converted into z-scores using both the earlier UK1990 growth references⁵ and the new UK-WHO reference using the LMS growth package⁶. The proportions in each cohort below the 2nd centile (equivalent to z-score < -2) and above the 98th centile (> +2) for each reference were identified. Changes in z-score in each child were calculated between birth and 6 months, and 6 to 12 months for SWS, and between 6 weeks and 9 months and 9 to 18 months for ALSPAC. Children crossing up or down through more than 2 major centile bands (equivalent to ± 1.33 z-scores) were identified. In SWS, mean head circumference was additionally compared to the WHO birth data, the Tanner and Whitehouse reference⁷ and the US standard (CDC)⁸ using the LMS growth program.

RESULTS

Head circumference data were available in up to 1,819 children in SWS, and in up to 14,091 children in ALSPAC (see web Table). For both cohorts, mean z-scores calculated compared to UK-WHO were markedly higher at all ages than compared to the UK1990 reference (table 1). Accordingly, compared to the UK-WHO standard a large proportion of children had heads above the 98th centile from age 6 months onwards and very few with heads below the 2nd centile. Compared to the UK1990 reference mean z-scores declined gradually from birth.

Using the UK-WHO standard, as many as 15% children crossed upwards through 2 major centile bands between birth and 6 months, while using the UK1990 reference, up to 14.5% crossed downwards through 2 centile spaces between 6 weeks and 9 months (Table 1). In

SWS there was little centile crossing in either direction after age 6 months, but in ALSPAC a substantial proportion showed either upward or downward centile crossing between 9 and 18 months.

In SWS the 3% infants (n=60) of South Asian origin had smaller head circumferences at birth (mean, 95% CI z-score: -0.28, -0.54 to 0.02) than White children (0.48, 0.43 to 0.53; $P<0.001$) and this difference persisted: e.g. South Asian z-score at age 12 months: 0.28 (0.02 to 0.54), White 0.96 (0.91 to 1.0) $P<0.001$.

The mean SWS head circumference z-scores according to UK1990, UK-WHO, WHO 2006 (i.e. using WHO 2006 birth data), Tanner and Whitehouse and CDC references all demonstrated markedly differing growth patterns over time (figure).

DISCUSSION

Our findings suggest that head circumferences of British children will be large relative to the UK-WHO standard. On the other hand the UK 1990 reference may in the past have led to the over-diagnosis of small head size and slow head growth. UK children show a good fit to the WHO 2006 standard for length³, but Norwegian and Belgian children have already been described as having relatively large heads compared to the WHO standard⁹. We found a substantial ethnic difference in head size, so it is feasible that, unlike length, occipito-frontal circumference does vary with ethnicity. In contrast to standard UK practice which is to record the largest head circumference, the WHO used a different measurement technique, where the tape was drawn tight rather than loosely applied and was anchored above the eyebrows, which is not always the fullest part of the head¹⁰. Whether these differences in measurement technique are sufficient to explain the difference observed, which are equivalent to more than one centimetre at age one year, is not clear. However, whether the basis of the difference between UK and WHO growth study children is biological or methodological, recognising such differences is still important.

It is centile crossing rather than head size alone that usually signals concern, particularly about possible hydrocephalus,¹¹ but the prevalence of centile crossing has been little studied previously. One US study found that 5-10% of infants crossed 2 major centile *lines* (roughly 1 SD) upwards or downwards up to 6 months, but rarely thereafter¹². The higher prevalence of early infancy head centile crossing could partly reflect the difficulties of obtaining a reliable measure of head circumference around birth. In the SWS, with measurements by research staff, there was little centile crossing after the age of 6 months, as in the study above¹². In the ALSPAC where data were collected by health visitors as part of routine care, a significant proportion also crossed centiles upwards or downwards after the age of 9 months. It is likely that these later infancy shifts in ALSPAC reflect higher levels of measurement error, as two imprecise measures in opposite directions can easily produce an artefactual centile shift. However these indicate the actual levels likely to be seen in routine clinical practise. Many clinicians assessing a child's head size also compare them to the parents' head circumferences, using the latest centiles on the children's chart as an adult reference. However the two references available for this purpose also differ markedly and it is not clear which best represents average adult head size¹³. In contrast to the UK-WHO reference, the UK1990 reference identified an excess of children with small heads. This finding is in keeping with a previous report that 60% of children referred with head circumferences crossing below the 2nd UK 1990 percentile had no identifiable pathology.¹⁴

CONCLUSIONS

With the change from UK1990 to UK-WHO charts it will become much more unusual to find infants with head circumferences below the 2nd centile and such infants should probably be investigated further, particularly if there is also downward centile crossing or slow neuro-developmental progress. In contrast head circumferences above the 98th centile and upward crossing through 2 centile spaces, will become substantially more common, so it will be important to look for other indicative signs or symptoms before deciding whether referral is required.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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WHAT IS ALREADY KNOWN

- New UK-WHO charts now include the WHO standard for head circumference.

WHAT THIS PAPER SHOWS

- Children from two population based UK studies have larger heads than the WHO standard and commonly cross centile spaces upwards, while their heads were slightly smaller than the previous UK 1990 reference.
- All of the available head circumference references show a variable fit to UK children over time, which could lead to children being spuriously labelled as having abnormal head growth.

Figure. Mean head circumference z-scores by age and sex, in the SWS birth cohort compared to British 1990, Tanner and Whitehouse, CDC, WHO and UK-WHO growth references.

Table
Prevalence of head circumferences <2nd centile or >98th centile and prevalence of extreme centile in the SWS and ALSPAC birth cohorts compared to the UK-WHO or UK1990 references.

SWS	<2nd centile				>98th centile			
	UK-WHO		UK1990		UK-WHO		UK1990	
Birth	0.8	(14)	1.4	(26)	6.0	(111)	2.0	(37)
6 months	0	(0)	2.3	(41)	11.3	(198)	2.2	(38)
12 months	0	(0)	4.1	(69)	11.9	(202)	1.8	(30)
24 months	0	(0)	5.6	(85)	14.7	(224)	1.3	(20)
36 months	0	(0)	5.4	(81)	12.1	(181)	1.1	(17)
ALSPAC								
6 weeks	1.8	(254)	3.1	(437)	8.1	(1141)	3.6	(507)
9 months	0.7	(84)	5.2	(625)	14.4	(1731)	3.1	(373)
18 months	0.5	(41)	6.9	(566)	16.4	(1345)	2.1	(172)
Downward crossing				Upward crossing				
SWS	(by >1.33 z-scores)				(by >1.33 z-scores)			
Birth to 6m	2.5	(44)	8.8	(153)	15.3	(265)	5.1	(89)
6m to 12m	0.2	(4)	1.1	(21)	0.5	(9)	0.2	(3)
ALSPAC								
6wk to 9m	3.3	(360)	14.5	(1583)	14.6	(1594)	4.8	(524)
9m to 18m	3.6	(252)	10.0	(701)	8.1	(567)	4	(280)

Values are percentage (n)