



## **DOES SIZE MATTER, OR IS BIGGER BETTER?**

### **The Use of Head Circumference in Preadoption Medical Evaluations and Its Predictive Value for Cognitive Outcome in Institutionalized Children**

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#### **Introduction**

Reviewing referral documents to assess the well-being of a child is a challenging task for every health-care provider. While ultimate decision-making power resides with the family, frequently the information we provide determines whether a child is accepted or rejected. I view this as a grave and often a burdensome responsibility, primarily because there is so little objective data on which to base my opinion.

Much of the information I would like to have at my disposal is not present in the medical abstract. Frequently absent are maternal medical history; details on the pregnancy, labor and delivery; whether the mother used drugs or alcohol; and gestational age at delivery. Many children are referred in the first few months of life. While I support any initiative that reduces the length of time a child remains within an institutional care setting, young infants are exceptionally difficult to evaluate since developmental milestones are few and easily attained by all but the most neurologically damaged.

Most information contained in referral documents is subjective, dependent upon the interpretation of the physician collecting the information. In these situations, unless the videotape is particularly informative, I am totally dependent upon the ability of another health-care provider to identify conditions such as fetal alcohol syndrome, profound developmental delays, autism, etc. As I often cannot rely on subjective information, objective data (particularly body measurements) assume an important role in my evaluation.

I occasionally speak with adoptive families who seek children with whom to share unique gifts. Parents often desire children with their own specific disabilities, such as blindness or deafness. Other families who have parented a child with a specific medical condition feel able to face those specific challenges with another similarly affected child. Others are attached to their child's image as firmly as parents who cradle their newborn in the delivery room, and would never consider abandoning what is now their child—even facing the prospect of severe medical problems. However, most parents seek a child with a good chance of living a “normal life”—a desire no different from those who await birth children.

While many factors enter into a child's quality of life, no one would dispute that a healthy brain is important. The dilemma we face in adoption medicine is that we are not only tasked with determining the health status of a child, but are asked to judge whether a child's brain is healthy. We are requested to assist the family in choosing a child who has a good chance of being a happy and productive member of society, able to participate fully in life's joys and opportunities.

Head growth has been used by generations of health-care providers as a marker of brain well-being. Plotting head growth is a ritual in the offices of child health-care providers worldwide, and children whose heads measure too small or too large for their age are viewed with great concern. However, problems are encountered with obtaining and interpreting this measurement in the case of an individual child. These



problems are magnified when the child's head is being measured by another individual, and interpreted in the absence of complete medical and social information on the mother and child. Nevertheless, head circumference is one of the few pieces of objective information present within the referral document. The purpose of this presentation today is to discuss the positives and negatives of using measurement of head circumference (occipitofrontal circumference, or OFC) as a measure of brain health and, by inference, long-term developmental potential.

### **Measuring Head Circumference (OFC)**

As the name implies, occipitofrontal circumference is a measurement of the circumference of the head around the occiput, or posterior aspect, of the skull, to the most anterior portion of the frontal bone. The measurement should be taken with a device that cannot be stretched, such as a flexible metal tape measure. As everyone's head is slightly different, the tape should be moved around the circumference of the head in order to obtain the largest possible measurement.

It is impossible to inadvertently inflate the OFC unless a stretchable measuring device is used. Conversely, it is quite easy to obtain a measurement that is artifactually small if one does not move the tape around seeking the largest measurement. This is probably the most common reason why a child has a "small" head circumference. Remeasuring the head around the BIGGEST possible circumference may place the child within the normal range. In rare situations, such as premature closure (ossification) of the junctions (sutures) between specific skull bones, brain growth causes the skull to expand upward rather than from front to back. Children with this condition, termed craniosynostosis, may have a small measured OFC but a brain of normal size.

### **Does Head Circumference Really Measure Brain Growth?**

In infants between 18 and 43 weeks gestation dying during the first week of life, brain weight correlated directly with head circumference using log<sub>10</sub> transformations of the measurements (1). Postnatally, total brain DNA content (number of cells) is linearly related directly to changes in head circumference during the first six months of life, and brain weight and protein content are proportionate to cranial volume calculated from the OFC through the first year of life (2). For brain growth and head circumference beyond the first year of life, the relative rates of growth are fairly similar. Nearly all brain growth occurs in the first two years and virtually ceases by four years of age (3,4). Therefore, head circumference accurately reflects brain size and growth during gestation and the first years of life—the period of the majority of brain growth—except in unusual situations such as hydrocephalus, enlargement of the subdural space, significant scalp edema or a rickets-thickened skull.

### **Standards of Head Growth: What's Too Big or Too Small?**

Growth curves are designed to identify children whose head circumference measures smaller or larger than the majority of children at a given age. In general, curves are constructed by taking the head circumference measurements of a representative group of children—the larger the better—and statistically determining the range wherein the majority of measurements fall. Some commonly employed growth curves use as their cutoff points for "normal growth" the 5<sup>th</sup> and 95<sup>th</sup> percentile; in other words, heads that fall outside the range of "normal" are bigger or smaller than 95% of children measured at a given age.

Most authors and all papers referenced in this paper have chosen a criterion of two standard deviations above or below the average measurement (mean) for a given age as the cutoff points for normal growth. Standard deviation is a statistical term that is most applicable in situations where the distribution of measurements approximates a bell-shaped curve. Using two standard deviations above or below the mean encompasses a slightly larger population (3<sup>rd</sup> to 97<sup>th</sup> percentile). Therefore, more children will fall within the “normal range” when using this definition.

### **Does Head Circumference Vary Worldwide?**

Two growth curves are commonly used for assessing head size in the United States. Head growth curves most often used during the first three years of life are based on data gathered in the United States through a study performed by the National Center for Health Statistics (NCHS) (5). The World Health Organization has adopted height and weight data from this study as optimal growth standards for an ethnically diverse, well-nourished population. The implied limits of the normal range for these curves are the 5<sup>th</sup> and 95<sup>th</sup> percentile. Therefore, some children who fall slightly above or below this range will still be in the “normal range” if this is defined as being within two standard deviations from the mean.

The Nellhaus curves (6) for children 0-18 years of age are widely used, particularly for children three years of age and older. These curves define the normal range from  $\pm 2$  standard deviations from the mean. These were developed by merging data from 14 studies of head growth worldwide published between 1948 and 1965. Nellhaus concluded that composite head circumference growth curves developed from data in these reports demonstrated the applicability of these graphs “for children regardless of skin color or geographic location.” The United States medical community, solely on the basis of these data, has almost universally accepted this conclusion. However, the 15 groups of children from the 14 published articles included only two groups of African American children, from Washington, D.C., and Philadelphia, and only one group of Oriental children, from Tokyo. The remaining studies included only Caucasian children living in Scotland, Belgium, Sweden, Switzerland, England, Finland, Czechoslovakia and the United States.

With exception of the Czech Republic and Slovakia (two countries placing only a handful of children abroad), neither the Nellhaus charts nor the NCHS incorporates data from any country of the world placing children in the United States for adoption. Does this fact invalidate these curves for international adoptees? This is a difficult question to answer since specific head growth curves rarely exist from countries of interest; if they do, they may not represent the current population of children.

As a rule, both growth curves routinely employed by health-care providers in the United States represent head growth standards for a well-nourished and somewhat ethnically diverse population. They can be employed to evaluate international adoptees as long as the shortcomings of these curves are recognized. If a head growth curve is available from a child’s country of origin, it may be helpful in interpreting an individual’s head size in relationship to peers. Patterns of growth over time are much more informative than individual points.

### **Does Head Size Correlate with Neurologic Outcome?**

A correlation between small head circumference, or microcephaly, and mental retardation has been recognized since the pioneering work of Kind in 1876 (7) and Tarbell in 1883 (8). This relationship was established primarily through studies that documented a high incidence of microcephaly in groups of

mentally retarded or neurologically at-risk individuals. For example, in 1960, measurements were recorded for 2,472 inmates of the California State Institution for the Mentally Deficient. Head circumference means for the total group were below normal for virtually the entire age range (9). Another study reviewed the clinical records of 247 children from 1 to 15 years of age seen between 1956 and 1961 at the Mayo Clinic with small head size, dwarfism, mental retardation, microcephaly or developmental retardation. The authors concluded that “children with a head circumference below minus 2 standard deviations from the mean are, probably with few exceptions, mentally subnormal”(10).

A review of 212 patients with microcephaly seen in either a birth defects or child development clinic documented a direct relationship between IQs and head size. Intelligence quotients decreased from 63 in children with head circumferences between 2.0 and 2.1 standard deviations below the mean to 20 for children whose OFCs were between 5.1 and 7 standard deviations below the mean (11). A study of 73 learning-disabled children revealed a significantly greater prevalence of abnormal head circumferences when compared with 71 controls (12). A review of 202 microcephalic children evaluated at a child development center between 1963 and 1967 demonstrated that only 27 children (13%) had normal intelligence. However, while these children had IQs in the normal range, more than half had evidence of brain damage or dysfunction (13). Finally, evaluation of 360 patients seen between 1976 and 1981 in a child development clinic established a significant direct correlation between head circumference and IQ. Of the children with an OFC  $\leq -2$  SD, 18/21 (86%) had a full scale IQ score  $< 80$  (14).

These studies imply that children with a head circumference more than 2 standard deviations below the mean are almost inevitably neurologically damaged. In terms of international adoptees, review of 268 children referred in early 1998 from Russian orphanages documented that, at the time of referral, 15% of children had a head circumference between 2 and 3 standard deviations below the mean and 7% had an OFC more than 3 standard deviations below the mean. Therefore, almost a quarter of referrals, an ominous number, appear to be at grave neurologic risk.

Conclusions reached to this point are based on data collected from small, very select, at-risk groups of children and not from the pediatric population as a whole. Therefore, it is not surprising that children with microcephaly who seek care in a developmental or genetics clinic have a high rate of neurologic dysfunction. The real question is whether there are children in the general population who are microcephalic but are functioning within the normal range. Such studies are difficult to do since they require a large number of children who have not only sequential head measurements, but data on their cognitive abilities as well.

Over thirty years ago, the National Institutes of Health funded a monumental study, the US National Collaborative Perinatal Project, which enrolled more than 54,000 pregnant women at 12 cooperating institutions across the country. Prenatal, perinatal and neonatal information was collected on the women and their infants, and the children were subsequently followed for up to seven years. Each child was examined at birth, four months, one year, four years and seven years, with physical measurements being taken at each of these ages. Full batteries of developmental tests, including the Wechsler Intelligence Scale, were administered at regular intervals. Using a sample of 35,704 children drawn from this study, Camp et al. (15) identified that microcephaly at birth was associated with a 2.35-fold increase in mental

retardation. However, this risk was only observed in African American infants in families with low socioeconomic status.

Persistent microcephaly was a much more ominous finding. Using data from 28,820 term infants with at least three head circumference measurements between birth and seven years and excluding infants with neural tube defects, hydranencephaly, craniosynostosis or Down syndrome, Dolk (16) studied the outcome of infants who had OFCs greater than 2 standard deviations below the mean. The children who fared worst were those with a head circumference consistently more than 3 standard deviations below the mean. Of these children, 51% were mentally retarded (IQ  $\leq$  70) and 17% had an IQ of 71-80. Within this group of children, of those with some further specification of pathology such as a syndrome, congenital infection, etc., 94% were mentally retarded. Among those with microcephaly as the only diagnosis, only 25% were mentally retarded. Head circumference consistently between 2 to 3 standard deviations below the mean was associated with retardation in 11% of cases and IQ of 71-80 in 28%. Only 2.6% of children with head circumferences within the normal range were mentally retarded and 7.4% had IQs of 71-80. Another study, relying on head growth of 9,379 children enrolled in the study, looked at the ability of head size at one year to predict IQ at four years (17). At four years, IQ varied directly with head circumference. Head size at one year, at less than 43 (-2.3 SD) for males and 42 (-2.4 SD) for females, was associated with an IQ  $<$  80 in approximately half the cases. None of these children achieved an IQ of 120 or greater at four years of age (17).

School systems have also been exploited in trying to determine the functional level of children with microcephaly. In 1,006 Seattle school children ranging in age from 5 to 18 years, 1.9% were found to have OFCs 2 or more standard deviations below the mean. None were greater than 3 standard deviations below the mean. No significant difference was found between mean IQs of the microcephalic subjects and controls (99.5 vs. 105); however, mean academic achievement scores were significantly lower in the microcephalic subjects (49 vs. 70) (18). In 334 grade-school boys between 8 and 9.5 years of age from St. Louis public schools, head circumference was an excellent predictor of IQ. In subjects with the smallest head circumferences, only five were in the average IQ range and none were over 105 (19).

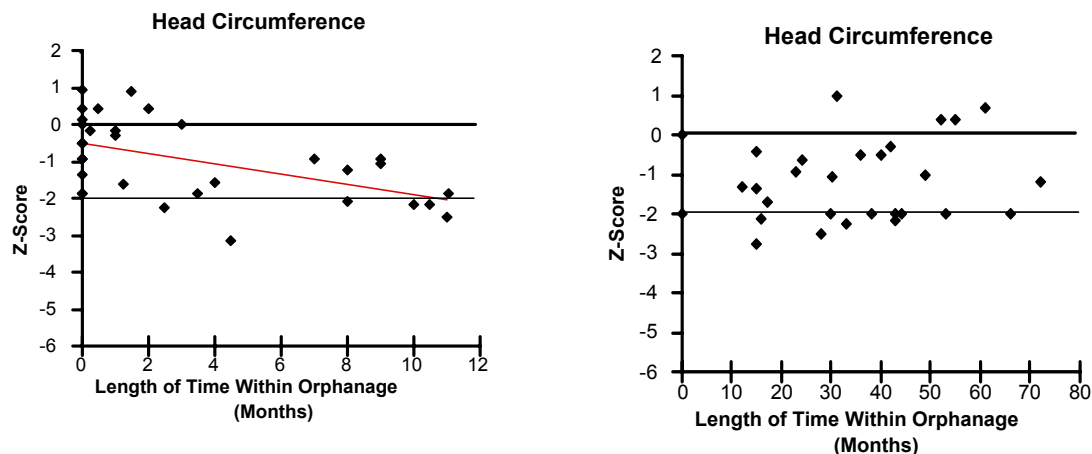
### **Proportionality**

Many physicians believe in the concept of proportionality of head size. In other words, one interprets head size in relationship to body size (e.g., a child with a small OFC who is also short is probably okay). There are some data to support this concept. The Seattle school study showed that in children whose head circumference was proportional, mean academic achievement scores were significantly higher than subjects whose head size was relatively small; IQ scores did not differ (18). Other studies contradict this opinion. O'Connell et al. (10) found that children who had normal intelligence but growth failure all had normal head circumferences. In the Nelson study (17), which involved the largest number of children, not only did IQ at four years of age vary with head circumference at one year, it also varied directly with body length at one year. At a given small head circumference, four-year IQ rose with increasing body length. Thus, for a child with a small head, it would seem that the less proportional the head is to body length, the better.

### Do These Data Apply to International Adoptees?

Certainly, children are referred for adoption who were born with a head circumference more than 2 standard deviations below the mean and whose head remains in the microcephalic range. In these situations, the data above predict a higher risk of mental retardation and a reduction in IQ scores in direct proportion to the degree of microcephaly. However, this situation is not commonly encountered when reviewing medical records of institutionalized children. A personal series of 427 children referred for adoption from Russia showed that of those whose head circumference was available at birth and at the time of referral ( $n = 199$ ), only 12% were in the microcephalic range at birth, and only 17% of these microcephalic children (2% of the total) remained so during their course of institutionalization.

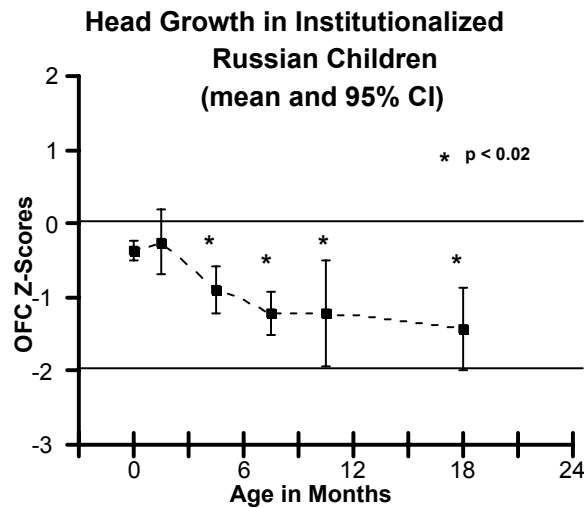
A more commonly encountered situation is birth OFC within the normal range but extremely poor head growth during the first year of life. In institutionalized children from Romania, head circumference decreased in direct relationship to the length of orphanage confinement during early infancy ( $r = -0.54$ ,  $p < 0.005$ ) (21) (figure below, left). This early effect on head growth persisted into early childhood. Only 7% of infants < 10 months of age ( $n = 27$ ) had head circumferences  $\geq 2$  SD below the mean vs. 41% of those  $\geq 10$  months of age ( $n = 37$ ) ( $p < 0.005$  by  $X^2$ ) (figure below, right).



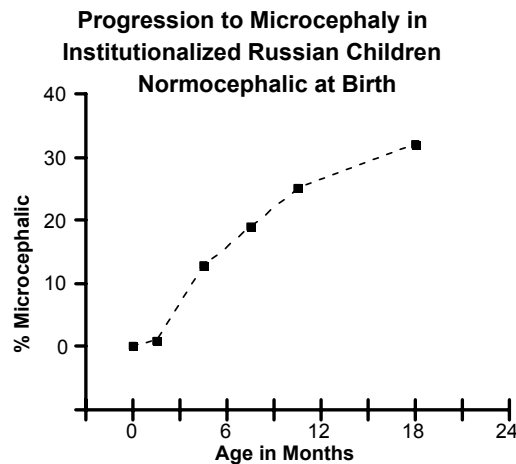
The data of Rutter et al. (22) confirm the profound effect of institutionalization on head growth. Average head circumference on entry to the United Kingdom in his cohort of Romanian adoptees was in the microcephalic range for infants under (-2.1 SD) and over (-2.3 SD) six months of age.

### Head Growth Pattern in Institutionalized Children

Segregating a lower risk group of children ( $n = 154$ ) referred from Russia (normal head circumference at birth and no obvious indication of prenatal alcohol exposure), average head circumference decreased progressively during the first months and remained low throughout the first two years of institutionalization (figure below).



The percentage of children in this group whose head was within the microcephalic range (> 2 standard deviations below the mean) progressively increased during the first two years. Of those referred at 0-3 months of age, only 4% were microcephalic, in contrast to almost one-third of children referred at 12-24 months of age (figure below).

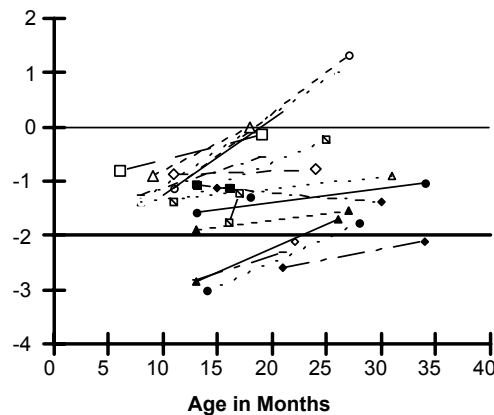


Among the studies cited above, the findings of Nelson (17) are most applicable, and argue that those children who are microcephalic at one year of age are at higher risk for mental retardation and lower IQ. However, perhaps most relevant to the situation we see in institutionalized children is the study by Avery et al. (23) of 100 children with severe illness in the first year of life. Twenty-eight percent of these children were microcephalic at one year of age—a figure quite comparable with the data shown above. Overall,

50% of these microcephalic children were developing normally or were only slightly delayed. However, within this microcephalic group, 12 had diagnoses implying possible injury to the central nervous system (e.g., birth trauma, seizures, multiple anomalies, microcephaly at birth, and bacterial and viral central nervous system infections). The incidence of moderate to severe mental retardation was significantly higher in this group of children compared to children whose primary diagnoses were usually not associated with mental retardation (75% vs. 31%). Three patterns of head growth were identified. Children whose head circumference followed closely at or just below two standard deviations below the mean were generally normal or mildly delayed. Children whose head circumferences were consistently less than two standard deviations below the mean were all moderately to severely retarded. Children whose head growth most closely approximated the growth patterns seen in institutionalized children were normal to mildly retarded in 33% of cases and moderately to severely retarded in 66% of cases.

### Head Growth after Adoption

Catch-up head growth was documented in 85% of Eastern European orphans ( $n = 34$ ) after arrival. Mean head circumference increased an average of  $0.67 \pm 0.82$  SD from arrival ( $-1.07 \pm 0.9$  SD, mean age  $13.2 \pm 5.2$  months, range 5.5-32 months) to follow-up ( $-0.40 \pm 1$  SD, mean age  $26 \pm 7$  months, range 5.5-32



months) ( $p < 0.01$  paired  $t$  test) (Aronson & Johnson, unpublished data).

The length of institutionalization appears to have a very strong effect on eventual head size. Benoit et al. (24) found that 13% of children institutionalized more than six months had a head circumference  $<$  5th percentile an average of 12 months after arrival, while all children adopted at six months or less were within the normal range. Rutter et al. (22) found significant differences in mean head circumference at four years of age in children adopted at six months of age or more ( $-1.5 \pm 1.0$ ), children adopted prior to six months ( $-1.1 \pm 1.0$ ) and their control group of children adopted to the United Kingdom ( $-0.5 \pm 0.8$ ).

### Effect of Early Brain Insults on Head Circumference

The pattern of brain growth seen in institutionalized children is consistent with the concept of an early brain insult; as such, the data on outcome of other conditions that cause early brain insults may be instructive. Poor brain growth in infancy is seen in a number of situations, including acquired intrauterine infections



such as rubella (20) and radiation exposure (25). While the cause of poor brain growth within institutionalized settings is unknown, nutritional impairment leading to intrauterine or postnatal brain growth failure perhaps parallels the plight of institutionalized children most closely. An extremely large body of information is available on the effects of early childhood malnutrition including several excellent reviews of animal (26, 27) and human data (28). I particularly recommend the short summary on the effects of malnutrition on young children by Galler and Ross (29).

Brain growth is clearly affected in severe protein-energy malnutrition (2). In studies conducted in young Jamaican children between 6 and 24 months, head circumference averaged only 91% of expected at the time the child was admitted to the hospital for treatment (30). Head growth failure persisted during follow up despite improved nutrition. While weight for height after recovery compared favorably with the control group within one month, 36 months later mean head circumference was still only 94% of expected (approximately 1.8 SD below the mean). Stoch and Smythe, studying 21 children in South Africa, documented severe, persistent impairment in head growth secondary to early malnutrition (31). Initial OFCs in the malnourished group were  $> 2$  SD below the mean. After 15 years of adequate nutrition, the mean head circumference of this group continued to be more than two standard deviations below the mean (32).

During the acute period of malnutrition, children are apathetic, demonstrate delays in all developmental scales (especially language), and demonstrate abnormal crying patterns and altered mother-infant interactions. During recovery from malnutrition, children have reversal of apathy and improved motor and exploratory skills, but continue to have delays in language and mental development and a reduced developmental quotient. Long-term sequelae through adolescence include decreased IQ scores, delayed cognitive development, impaired sensory integration, impaired school performance, a fourfold increase in attention deficit disorder compared to the control group (60% vs. 15%) and low self-esteem. While head growth failure in institutionalized children may not be due exclusively to malnutrition, these data on the short- and long-term cognitive and behavioral effects of early malnutrition are startlingly similar to behavioral and cognitive findings in post-institutionalized adoptees (29).

### **The Affect of Home Placement on Children with Early Brain Insult**

The above data imply that children with early brain insult are irreversibly affected and may be profoundly impaired on follow up. Indeed, the prognosis for children who continue to experience ongoing deprivation is not good (29,33,34). However, the positive effects of an enriched environment have been repeatedly demonstrated in children experiencing adverse conditions during early life. In the case of malnourished children, those who participated in a home-visiting program of psychosocial stimulation showed a marked advantage over the nonintervention group that persisted for at least six years (33,34). Children placed in single foster homes after an episode of early malnutrition had significantly higher IQ scores than similarly malnourished children subjected to multiple foster placements (35). Improvement in outcome within the enriched environments of adoptive homes or single placement foster homes has been demonstrated in malnourished children from Vietnam (36), Korea (37,38), Chile (39) and Peru (40), in intrauterine cocaine-exposed children in Canada (41), and in children adopted into higher socioeconomic groups in the United Kingdom (42).

Adoption of normal children prior to one year of life also appears to confer an advantage in terms of IQ at four years, though not at seven years of age (43). Scarr and Weinberg (44) showed that IQ scores in young

adopted children (mean age of 7 years) were similar to their unrelated siblings; however, by adolescence, they were similar to their biological parents and siblings. Other studies utilizing adopted children have clearly demonstrated that under normal circumstances, while early experience may confer a temporary advantage, ultimately IQ is strongly determined by genetic factors (45).

In summary, there is no better review of the effect of a child's environment on cognitive development than that authored by Michael Rutter (46). He concluded that:

- Environmental effects on IQ are relatively modest within the normal range of environments, but that the effects in markedly disadvantageous circumstances are very substantial.
- Cognitive development is influenced by direct effects on cognition and by indirect effects through alterations in self-concept, aspirations, attitudes to learning and styles of interaction with other people.

### **Is There a Correlation Between OFC and Outcome in International Adoptees?**

The study of Romanian children by Rutter et al. (22) is the only investigation to date that attempted to correlate outcome with head circumference. The authors demonstrated a statistically significant correlation between head circumference and the Denver Quotient at the time of entry into the adoptive home. However, they failed to demonstrate a clear relationship between head circumference at arrival or at four years with cognitive outcome at four years of age (Denver Quotient or McCarthy scores). McCarthy scores at four years of age did not differ between children who were normocephalic and microcephalic at entry into their adoptive homes [ $104.0 \pm 16.7$  (SD) vs.  $99.6 \pm 20.3$ , respectively]. This finding provides additional support for the benefits of the enriched environment of an adoptive home for at-risk children.

### **Is Bigger Better?**

Several of the studies referenced above examined the outcome of children who had large heads. Nelson and Deutschberger (17) documented that the 1% of children who had the largest head circumferences at one year of age [ $> 49$  cm in girls ( $+2.5$  SD) and  $> 50$  cm in boys ( $+2.1$  SD)] had the highest mean IQ at four years of the groups examined, and a higher proportion of these children had IQs of 120 or greater. Using a cohort of children enrolled in the Collaborative, Fisch et al. expanded the observations of Nelson et al. by confirming that children with superior intelligence (IQ  $\geq 120$ ) at seven years of age had significantly higher mean head circumferences at one, four and seven years of age than children with average and low intelligence (47). In the St. Louis school study, 50% of children with the largest heads ( $\geq 55$  cm) had IQs of 120 or above and none were below 90 (19).

Large heads are also associated with hydrocephalus and rare neurologic conditions, grouped under the descriptive term megalencephaly, which are associated with poor neurologic outcome. Perhaps this is why Nelson and Deutschberger (17) also found a higher number of children within the lowest IQ groups in their group with the largest head circumference and Desch et al. (14) found minor differences in IQ and mathematical achievement tests.

### **Summary**

Dogmatic statements on the use of head circumference in evaluating institutionalized children cannot be developed by analysis of the data presented above. In lieu of doctrine, I offer the guidelines on which I rely

when counseling prospective adoptive families on the meaning of head circumference measurements in the referral document.

- Cognitive abilities are determined primarily by genetic factors. A child's innate intelligence is unlikely to be improved by enhancement strategies under normal circumstances. Early brain insults can decrease cognitive potential, but enriched environments can mitigate their effects.
- While valuable as one of the few object measures of brain health in a referral document, head circumference should not be interpreted in isolation if at all possible. Probable gestational age of the child, the presence of additional risk factors and the growth pattern of the head over time strengthen the predictive value of head circumference.
- For a given head circumference, genetic, biologic and environmental risk factors as well as the presence of a specific medical diagnosis will worsen the prognosis for any given head circumference (e.g., retardation in the family, congenital rubella, syphilis or prenatal alcohol exposure, prematurity, early childhood institutionalization, cerebral palsy or severe developmental delay).
- A consistently small head circumference ( $> 2$  SD below the mean) markedly increases the risk for mental retardation. The smaller the head, the more profound the deficit.
- Early brain insults are associated with short- and long-term deficits. The longer the insult, the more profound the deficit.
- The environment in which a child is raised after such an insult has profound effects on short- and long-term outcome. Adoptive and single-placement foster families have consistently been shown to have a powerful positive effect on the outcome of at-risk children.
- Relying on head circumference alone rather than proportionality for prognosis is probably more reliable.
- Big heads probably are better, though in rare circumstances can be a sign of a disorder with neurologic sequelae.

While data to support the following statements are limited, I offer the following for consideration:

Average risk group: Full- or near-term infants with head sizes anywhere in the normal range at birth and at the time of referral ( $\pm 2$  SD) without genetic, environmental or biologic risk factors aside from early institutionalization.

Parents who are considering adopting these children should be counseled that no child arrives unscathed from an institution, but that these children have as good a chance as any institutionalized child for a healthy brain.

Higher risk group: Children who are within the normal range at birth but who become microcephalic over time (greater than 2 standard deviations below the mean).

Parents should be counseled that function within the normal range is possible and may even be probable, but that these children are at risk for long-term neurologic dysfunction, including lower IQ scores and

hyperactivity with accompanying learning disabilities. Of these children, those with a head circumference at the time of referral close to the lower limits of normal probably have a level of risk close to the average risk group. Those who have profound head growth failure and additional risk factors, the most common being prolonged institutionalization ( $\geq 2$  years), probably have a prognosis closer to the highest risk group

Highest risk group: Children with consistently small head circumferences (greater than 2 standard deviations below the mean).

Parents considering these children should be counseled that their outcome will be positively affected by the environment of an adoptive home, but they still have a high probability of long-term neurologic problems, including significant mental deficits, learning disabilities, hyperactivity and a variety of behavioral problems. The smaller the head, the higher the likelihood of retardation and the greater the deficit. The addition of any risk factor increases the probability of long-term neurologic dysfunction. In children with profound microcephaly ( $\geq 3$  SD below the mean) coupled with additional risk factors, the possibility of life-long supervisory or custodial care should be discussed.

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