Early Life Stress, Physical Growth, and Structural Brain Development in Internationally Adopted Adolescents

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Introduction
How does early life stress impact relationships between physical growth, pubertal timing, and prefrontal cortex development at adolescence?

Animal studies have documented neuroanatomical and behavioral effects of early life deprivation. Studies of children adopted from institutional care (post-institutionalized; PI children) suggest that this discrete time period of early life adversity is associated with long-term:

- differences in cognitive and socioemotional development
- changes in the volume of the brain’s limbic system
- alterations in gray and white matter development of the brain’s prefrontal cortex
- interplay of physical growth, pubertal development, and prefrontal cortex development.

Poor growth in currently institutionalized children has been long recognized.

- PI children show catch-up growth following adoption, although growth rate may fall off at adolescence resulting in PI children reaching shorter final height in comparison to their non-adopted peers (e.g., Daro et al., 2010; Martin & Bateson, 2009).

Variations in early life experiences after pubertal timing and development.

- PI children are at risk for earlier puberty (van Oortmerssen & Kruithof, 2009), especially PI children with increased growth stunting at adoption followed by rapid catch-up growth (Juffer, 2010).

This study characterizes the lasting impacts of early life stress on the intersection of physical growth, pubertal development, and prefrontal cortex volume in youth adopted internationally from orphanage care.

Participants
12-14 year old children either adopted internationally from institutional care or reared in Minnesota with their biological family

Non-Adopted Control Children
N = 132
(65 females)

Adopted Children
Early Adopted (PI-EA)
N = 69
(52 females)

Late Adopted (PI-LA)
N = 63
(35 females)

Not adopted
- No developmental, neurological, or psychiatric disorders
- Adopted before 12 months
- At least 50% of pre-adoption care spent in an institution
- Diverse countries of origin

Excluded Participants: The final data set does not include research participants from a larger project who provided growth measures and segmented structural MRI data of adequate quality.

Methods

Early Growth Measures in PI Children:
- Z-scored height, weight, head circumference, and weight for age from repeat measures of infant adoption visit (Baun, 1984).

Adolescent Growth Measures:
- Z-scored height and weight for age from laboratory measurements (CDC, 2000).

Puberty Measure: Petersen Self-Rating Scale for Pubertal Development (Petersen et al., 1996)
- Self-report measure completed by the adolescents, containing growth in height, growth of body hair, changes in skin, changes in voice and growth of facial hair (smiling), and sexual development (breasts along a breast-town scale and presence of menstruation (breast)).

- Reflects changes in adrenalin, gonadals, and growth hormones
- Used to create both continuous and categorical measures of pubertal development

Structural MRI Scan: T1-weighted 3D MPAGE anatomical series acquired on a Siemens 3T Trio Scanner
- TR = 2530 ms, TE = 3.56 ms, FOV = 256 mm, flip angle = 7 degrees
- 1 mm iso-voxel, 240 sagittal slices

MRI Analysis: FreeSurfer Image Analysis Suite was used to obtain automated, volumetric segmentation data
- Segmentation quality was hand-checked
- Analyzes included age and sex as covariates

Previous Results

Both earlier- and late-adopted PI children have reduced prefrontal cortex gray matter volume in comparison to non-adopted controls, even after adjusting for head size

Are prefrontal volume differences in PI adolescents related to broad alterations in physical growth?

Results: Growth Following Early Life Stress

PI children showed evidence of growth restriction at adoption. Long-term institutionalization predicted greater height stunting at adoption (p < .05).

Results: Growth & Pubertal Development

Adolescent heights were shorter and lighter at adolescence than non-adopted peers. Height, weight, and head circumference at adoption predicted height and weight at adolescence (driven by later-adoptees).

Results: Growth Restriction at Adoption Predicts Smaller Prefrontal Volume at Adolescence

Conclusion

Growth measures in adoption in post-institutionalized children provide a marker of developmental risk across intertwined biological systems.

Growth restriction at adoption is related to both pubertal timing and prefrontal cortex volume during early adolescence.

- Both earlier- and late-adopted PI children showed evidence of growth restriction at adoption and remained shorter than their non-adopted peers at adolescence.
- More advanced pubertal development was reported by earlier-adopted children and by children who were less height-stunted at adoption (driven by earlier-adopted females).
- PI children who were more growth restricted at adoption showed the greatest decreases in prefrontal cortex volume at adolescence.

A better understanding of catch-up growth, ethnicity effects, and longitudinal change will help explain how early life stress, growth, pubertal timing, and brain development interact, and how these factors may relate to the heightened risk of behavioral and emotional problems in PI adolescents.