From infancy to young adulthood : the Leiden Longitudinal Adoption Study

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Cognitive and health-related outcomes after exposure to early malnutrition:

The Leiden Longitudinal Adoption Study

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Abstract

Background: We followed 190 early-adopted children from infancy to young adulthood to examine the long-term consequences of early malnutrition on cognitive and health-related outcomes. **Method:** We measured birth weight and physical condition in infancy, IQ and somatic problems in middle childhood, adolescence and young adulthood; in young adulthood, socioeconomic success was also assessed. **Results:** Early malnutrition negatively affected IQ in middle childhood and to a lesser extent IQ in young adulthood, but a negative effect on socioeconomic success was absent. Higher levels of early malnutrition predicted more somatic problems in middle childhood. **Conclusions:** Variation in early malnutrition explains differences in cognitive and health-related outcomes, with early malnutrition predicting lower IQs in middle childhood and in young adulthood. Early malnutrition did however not negatively affect the young adult's socioeconomic success, indicating that early malnutrition may be compensated by later experiences.

Keywords: adoption, longitudinal, early malnutrition, cognition, IQ

Introduction

International adoptees are often confronted with high risks at the beginning of their lives, such as malnutrition and deprivation in institutions (Van IJzendoorn et al., 2011). When placed with permanent adoptive parents, they experience a drastic change in environment (Palacios & Brodzinsky, 2010; Palacios, Román, & Camacho, 2010; Rutter et al., 1998). Indeed, after adoption children show remarkable catch-up in all domains of development, including cognitive competence (Van IJzendoorn & Juffer, 2005, 2006), which demonstrates the human brain's capability of adapting to (changed) environmental influences. However, malnutrition may restrict the extent of catch-up in adopted children and result in persisting developmental delays at least in some areas. Therefore, we examined the cognitive and health-related development of adoptees followed from infancy to young adulthood to examine possible consequences of early malnutrition.

The effects of early malnutrition

Brain development is most sensitive to early adverse experiences, such as the lack of sufficient and adequate nutrition, that can hinder normal organization of pathways in the brain (Johnson & Gunnar, 2011). As a consequence, cognitive processes such as executive control and memory may be negatively affected and result in lower levels of cognitive functioning. Duration of malnutrition seems to be crucial: the longer children are exposed to malnutrition, the more difficult it is to redirect their cognitive development to a normal trajectory (Nelson, Bos, Gunnar, & Sonuga-Barke, 2011). Rutter and colleagues (1998) examined the adjustment of Romanian children after adoption to the UK. At 11 years, cognitive deficits remained for children suffering from early deprivation for more than six months, whereas the children placed before 6 months showed cognitive outcomes comparable to non-deprived children (Beckett et al., 2006). Our study may shed light on the effects of relatively brief exposure to early malnutrition on cognitive outcomes extended to young adulthood. In adulthood, educational and occupational attainment become of major importance for young adults' integration into the labor market and into society (Dalen et al., 2008), and therefore socioeconomic success can be considered as an important adaptational outcome in this life stage.

Health-related outcomes may be associated with both early malnutrition and cognition. There is evidence that early adversities (including malnutrition) can negatively affect mental health outcomes such as psychiatric problems (Van der Vegt, Van der Ende, Ferdinand, Verhulst, & Tiemeier, 2009). In our study we included somatic problems, which are symptoms commonly reported in both children and adolescents, such as headache, stomach aches and fatigue (Campo, Jansen-McWilliams, Comer, & Kelleher, 1999). Multiple studies (e.g., Flaherty

et al., 2009) have shown that somatic problems adversely affect cognitive performance. However, vulnerability to adversities may be linked to child-related resilience, and some children might escape damage from early adverse influences (Van IJzendoorn et al., 2011).

The present study

In this longitudinal study, we examined long-term consequences of early malnutrition on cognitive and health-related outcomes in international adoptees. The adoption design provided an opportunity to investigate the development of children reared outside their biological family, and as a consequence possible associations are not confounded by the parents' and children's shared genetic make-up. First, we hypothesized that early malnutrition negatively affects IQ, somatic problems and socioeconomic success, but these effects may become less profound at later developmental stages. Our second hypothesis concerns the interdependence of intelligence and somatic problems; we expect higher levels of somatic problems to be associated with lower IQs. Third, we hypothesized that IQ and somatic problems would be direct and indirect predictors of socioeconomic success in young adulthood.

Method

Participants

190 international adoptees (100 girls) were followed from infancy to 23 years (for details on earlier phases of the study, see Jaffari-Bimmel, Juffer, Van IJzendoorn, Bakermans-Kranenburg, & Mooijaart, 2006; Stams, Juffer, & Van IJzendoorn, 2002). Table 1 presents the demographics of the sample and the mean scores of the main variables. The children were adopted before the age of 6 months (M = 10.28 weeks, SD = 5.42) from Sri Lanka (n = 116), South Korea (n = 49), and South America (n = 25). Rearing conditions in birth countries were less than optimal for all adoptees (Juffer, 1993). The adoptive families were randomly recruited through adoption agencies. All parents were Caucasian and came from predominantly middle-class socioeconomic backgrounds.

In infancy, middle childhood and adolescence attrition was low (0% in infancy, 9% and 11% in middle childhood and adolescence, respectively; Jaffari-Bimmel et al., 2006; Stams et al., 2002). At 23 years, 69 percent of the eligible 190 adoptees participated in the study. Reasons for not participating were long traveling distances, lack of interest, or time constraints. Respondents who dropped out between adolescence and young adulthood did not differ on background and model variables at the 14-year assessment (p values ranging from .15 to .83), indicating that selective attrition did not play a role.

Procedure

Several assessments took place in infancy (5 to 30 months). In follow-up studies at 7, 14, and 23 years, major domains of development were investigated. In the current study we report on measures related to the children's early malnutrition, cognitive development and somatic problems over time. When the child was 5 months old, the adoptive parents were interviewed about the child's physical condition on arrival and adoption records were inspected. During home visits at 7 and 14 years, questionnaires were completed and children's IQ was measured. At 23 years the adoptees completed an IQ test and questionnaires in the laboratory. Throughout the study, ethical guidelines of the research institute were followed.

Measures

Weight-for-age z-scores. In infancy, adoption records were inspected for information regarding malnutrition. Birth weights (n = 139), or the earliest measured weights when birth weights were missing (M = 6.25 weeks, SD = 4.79 weeks), were used as an indicator of malnutrition. Weight-for-age z-scores were calculated with the program WHO Anthro (WHO Anthro, 2005), comparing the adoptees to a norm group of 8440 infants from diverse cultural backgrounds. Gender and preterm birth were taken into account. The continuous reversed z-scores were included in the analyses; higher scores indicated more profound malnutrition.

Physical condition on arrival. Information about the infant's physical condition at the time of arrival was reported by the adoptive parents in an interview when the child was 5 months of age. Physical condition (missings n = 6) was rated as normal (n = 143), moderate (n = 33), or poor (n = 8), and higher scores indicated worse physical condition. Children scoring in the moderate or poor category showed signs of malnutrition and physical delays.

Somatic problems at ages 7, 14, and 23 years. At age 7, mothers completed the Child Behavior CheckList (CBCL; Achenbach, 1991a). At ages 14 and 23 years, the adoptees completed the Youth Self Report (YSR; Achenbach, 1991b) and the Adult Self Report (ASR; Achenbach & Rescorla, 2003), respectively. The syndrome scale of somatic complaints derived from the CBCL, YSR, and ASR consists of items about various physical complaints without a clear medical cause. Only the overlapping items at each wave were selected, and further exclusions of items were based on minimal presence (e.g., skin problems) and ambiguity of the complaint (e.g., eye problems). The final 6 items represented two dimensions; general complaints (e.g., overtired) and more specific complaints (e.g., headache). Higher scores indicated more somatic problems.

Table 1. *Means and standard deviations of demographics, predictors, and outcome variables.*

Variable	*n*	*M*	*SD*	Range	
				Min	Max
Demographics					
Child's age at arrival in weeks	189	10.28	5.42	2	25
Age of the mother in years	176	39.98	3.69	30	52
Age of the father in years	176	41.99	3.70	33	51
Socioeconomic status of the adoptive parents[1]	181	9.98	2.75	2.86	14.73
Predictors					
0-5 months					
V1 Weight-for-age z-scores (reversed)	184	1.32	1.30	-3.38	4.94
V2 Physical condition on arrival	184	1.27	.53	1	3
Outcome variables					
Age 7 years					
V3 Somatic problems 1, mother report	175	.34	.68	0	4
V4 Somatic problems 2, mother report	175	.57	.91	0	6
V5 Verbal cognition	162	112.75	15.99	56	150
V6 Non-verbal intelligence	162	101.77	17.57	57	145
Age 14 years					
V7 Somatic problems 1, self-report	164	.91	1.17	0	6
V8 Somatic problems 2, self-report	165	1.19	1.37	0	6
V9 Intelligence	151	100.23	13.19	56	142
Age 23 years					
V10 Somatic problems 1, self-report	115	0.93	1.19	0	5
V11 Somatic problems 2, self-report	115	1.09	1.42	0	6
V12 Verbal intelligence	120	91.75	20.44	44	152
V13 Non-verbal intelligence	119	86.83	17.80	45	133
V14 Socioeconomic success	123	41.40	21.79	14.21	82.41

Note. [1]Mean scores of socioeconomic status correspond to socioeconomic strata in the following way: 3-9 lower class; 9-12 middle class; and 13-16 upper class.

IQ at 7 years. At age 7, IQ was measured with the abbreviated Revised Amsterdam Child Intelligence Test (RACIT; Bleichrodt, Drenth, Zaal, & Resing, 1987). This abbreviation correlated r = .92 with the full RACIT; test-retest reliability and internal consistency of both versions are satisfactory. The following subtests were used: Vocabulary, Inductive reasoning, Ideational fluency, Flexibility of closure, Paired associates, and Perceptual reasoning. Scores were standardized and transformed into a verbal and a non-verbal dimension, consisting of the former three and the latter three subtests, respectively.

IQ at 14 years. At age 14, IQ was assessed with an abbreviated version of the Groningen Intelligence Test (GIT 1; Luteijn & Van der Ploeg, 1983), and the subtests of Cipher, Enumerate words 1 and 2, and Word matrices were included. A verbal and a non-verbal component of IQ could not be distinguished, and therefore the standardized scores were transformed into a total IQ score.

IQ at 23 years. At age 23, IQ was measured with the revised version of the Groningen Intelligence Test (GIT 2; Luteijn & Barelds, 2004). Test-retest reliability was above .80 for all subtests, and .99 for total IQ. The abbreviated version used in this study consisted of five subtests: Vocabulary, Matrices, Puzzles, Figures, and Numeracy. Scores were standardized and transformed into a verbal and a non-verbal dimension, consisting of the former two and the latter three subtests, respectively.

To control for socioeconomic status of the adoptive parents, we regressed all measures of intelligence on the continuous variable of parental socioeconomic status (SES; see Table 1 for details of parental SES) and the residual scores centered at the original mean were used in further analyses.

Socioeconomic success at 23 years. At age 23, the respondents completed a questionnaire in which they reported on their employment. The International Standard Classification of Occupations (ISCO; Ganzeboom & Treiman, 2008) was used to classify the occupations. The ISCO scores were converted into an ordinal scale with the International Socio-Economic Index of occupational status (ISEI; Ganzeboom & Treiman, 2008). This index represents the hierarchical positions in society. The ISEI scores were used in this study. Part of the participants were students (n = 54), and their ISEI scores were imputed based on the number of years of education they had completed since primary school, with exclusion of repeated school years. The imputation was conducted in SPSS, using predictive mean matching (Little & Rubin, 2002).

Statistical analyses

Weight-for-age z-scores and somatic problems showed skewed distributions, and therefore these measures were winsorized preserving the original order (Tabachnik & Fidell, 2001).

Table 2. *Correlations among indicators of early malnutrition, somatic problems, intelligence, and socioeconomic success in the original dataset.*

Measure	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
V1 Weight-for-age z-scores (WAZ)		.34**	.13	.11	-.04	-.16*	-.03	-.13	.00	-.26**	-.09	-.01	-.11	.06
V2 Physical condition on arrival			.17*	.12	-.16	-.16*	.11	.02	-.08	-.09	.07	-.09	-.13	.03
V3 Somatic problems 1 age 7				.38**	-.06	.00	.16*	.06	.09	-.01	-.08	.04	.02	.08
V4 Somatic problems 2 age 7					.10	.07	.07	.06	.07	.12	-.02	.10	-.04	.07
V5 Verbal cognition age 7						.41**	.01	- .03	.60**	.12	.03	.40**	.32**	.10
V6 Non-verbal cognition age 7							-.11	- .14	.46**	-.05	-.03	.51**	.56**	.28**
V7 Somatic problems 1 age 14								.56**	.12	.30**	.26**	-.11	-.12	- .04
V8 Somatic problems 2 age 14									.06	.34**	.33**	-.14	-.16	.12
V9 Cognition age 14										.23*	.09	.56**	.53**	.26**
V10 Somatic problems 1 age 23											.65**	.01	.16	.05
V11 Somatic problems 2 age 23												-.03	.05	.01
V12 Verbal cognition age 23													.59**	.11
V13 Non-verbal cognition age 23														.23*
V14 Socioeconomic success age 23														

Note. N ranges between 97 and 180; * $p < .05$ ** $p < .01$.

The relations between early malnutrition, intelligence, somatic problems and socioeconomic success were investigated in a longitudinal structural model. Early malnutrition, intelligence and somatic problems were represented as latent variables with two indicators at each wave. Weight-for-age z-scores and physical condition on arrival were the indicators of early malnutrition. Verbal and non-verbal subscales of IQ tests were included as indicators of IQ. Due to the lack of multiple indicators, intelligence in adolescence was included as a manifest variable (see above), similar to socioeconomic success in young adulthood. Relations between latent and observed variables were investigated using EQS 6.1 for Windows (Bentler & Wu, 2006).

Because most variables representing somatic problems were non-normally distributed, the final model was tested with robust Maximum Likelihood estimation (Bentler, 2004). To control for method variance, error variances of identical measurements at different waves were allowed to correlate over time (Cole & Maxwell, 2003). Somatic problems and intelligence in young adulthood were also correlated because these constructs were assessed at a concurrent measurement wave. Multiple goodness-of-fit statistics were used to indicate model fit; the ratio between χ^2 and corresponding degrees of freedom, comparative fit index (CFI), and root mean square of approximation (RMSEA). Good fit is indicated by a ratio between χ^2 and degrees of freedom smaller than 2.0, CFI exceeding .95, and RMSEA lower than .05 (Byrne, 2006; Tabachnick & Fidell, 2001). Missing values were replaced with an expectation-maximization (EM) missing data procedure in EQS.

Results

Preliminary analyses

Table 2 shows a summary of the correlations among the main variables. Significant correlations were found among indicators of the same latent variable, among intelligence at consecutive waves, among intelligence and socioeconomic success, and among indicators of self-reported somatic problems.

Model testing

We estimated a structural model in which longitudinal pathways of IQ and somatic problems, and pathways from somatic problems to IQ at the consecutive wave were included. Furthermore, early malnutrition was added as a predictor of all other constructs, and socioeconomic success was predicted by all constructs. This (full) model showed an acceptable fit ($\chi^2/df = 0.96$, CFI = .94, RMSEA = .05). Wald test statistics were used to simplify the model by removing non-significant pathways. This final model also presented the data reasonably well, $\chi^2/df = 0.98$, CFI = .92, RMSEA = .06 (see Figure 1).

Model outcomes

Early malnutrition was a negative predictor of IQ in middle childhood, with more malnutrition predicting lower IQ. A similar predictive pathway was found from early malnutrition to IQ in young adulthood, although the standardized estimate of this pathway was lower. Further, we did not find a significant pathway from early malnutrition to socioeconomic success in young adulthood.

IQ showed strong stability over time, and higher IQ in middle childhood predicted higher IQ in young adulthood through IQ in adolescence ($p < .001$). All IQ measures contributed to the prediction of socioeconomic success indicating higher IQs predicting more socioeconomic success: there was a direct path from IQ at the concurrent wave to socioeconomic success, and IQ in middle childhood ($p = .048$) and adolescence ($p = .033$) were also indirect predictors of socioeconomic success in young adulthood.

Early malnutrition predicted somatic problems in middle childhood, and this positive predictive path was also found from somatic problems in adolescence to somatic problems in young adulthood. However, somatic problems in middle childhood did not significantly predict somatic problems in adolescence, which

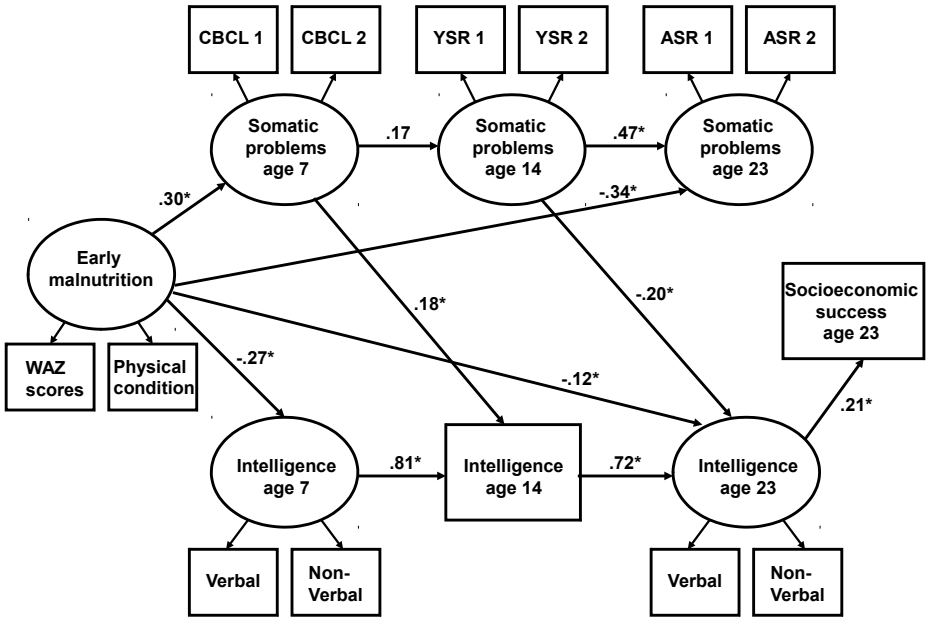

Figure 1. Longitudinal structural model of multiple traits across four measurement waves; 0-5 months, 7, 14, and 23 years. The coefficients are standardized maximum likelihood parameter estimates. The estimate of the non-significant pathway between somatic problems at age 7 and age 14 is also presented for the sake of clarity of the model. * $p < .05$.

indicated no longitudinal stability of somatic problems. In addition, the path from early malnutrition to somatic problems in young adulthood was negative. Significant pathways were found between somatic problems and IQ at the consecutive waves: somatic problems in middle childhood positively predicted IQ in adolescence, whereas somatic problems in adolescence negatively predicted IQ in young adulthood. Pathways leading from somatic problems to socioeconomic success were absent.

Discussion

In a prospective, longitudinal study on 190 international adoptees followed from infancy to young adulthood we investigated the long-term consequences of early malnutrition on adoptees' cognitive and health-related outcomes. The predictive pathways included in our model bridge a period of at least 6 years, while the longitudinal study spans a period of more than 20 years. We found that early malnutrition negatively affected IQ in middle childhood and to a lesser extent IQ in young adulthood, but a negative effect on socioeconomic success was absent. It should be mentioned that we measured the adoptees' socioeconomic success at an age at which careers may not yet be stable, and as a consequence some upward mobility may be expected.

Early malnutrition also predicted more somatic problems in middle childhood. Health and cognition were associated, as indicated by the predictions from somatic problems to IQ at the consecutive waves. Finally, higher IQs at all waves contributed to the prediction of more socioeconomic success in young adulthood.

Health-related and cognitive outcomes after early malnutrition

Somatic problems did not show longitudinal stability, which may be partly explained by the inclusion of mother report in middle childhood, while self-reports were included as the most reliable measures of somatic problems at later ages. Higher levels of early malnutrition predicting lower levels of somatic problems in young adulthood might be another indicator of this instability. An explanation for the latter finding may be that children with the poorest physical condition on arrival showed the strongest catch-up in self-reported health condition over time due to child-related resilience mechanisms (Van IJzendoorn et al., 2011). Compared to their earlier poor health condition, these young adults may have rated their own health condition as more optimal. Future studies may profit from more objective measures of health to complement the current subjective evaluation of somatic problems.

Furthermore, we found that more somatic problems in middle childhood resulted in higher IQs in adolescence, which was in contrast to our expectations.

An explanation may be linked to our previous finding that poorer physical condition on arrival predicted higher levels of maternal sensitivity in middle childhood (Stams et al., 2002). The poor physical state of the child may have evoked more optimal parenting behavior while in turn, higher levels of maternal sensitivity did predict better cognitive outcomes (Stams et al., 2002).

The significant variation in IQ explained by early malnutrition provides support for the idea that early malnutrition negatively affects brain development. On the other hand, early malnutrition did not negatively affect socioeconomic success. Converging with these outcomes, Tieman, Van der Ende, and Verhulst (2006) found that early-deprived adopted young adults (aged 24 to 30 years) did not differ from their non-adopted comparisons on occupational attainment. When selecting a job, additional factors such as social skills may become more important and adoptees may profit from the social skills acquired in their adoptive families (Sharma, McGue, & Benson, 1996; Stams, Juffer, Rispens, & Hoksbergen, 2000).

Conclusion

- Early malnutrition negatively affected IQ in middle childhood and to a lesser extent IQ in young adulthood
- A negative effect of early malnutrition on socioeconomic success in young adulthood was absent
- Early malnutrition may be compensated by later experiences, and its consequences may not extend to socioeconomic success later in life

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