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ORIGINAL PAPER

Behavioral Development and Sociodemographics of Infants and Young Children at Higher and Lower Risk for Autism Spectrum Disorders

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Abstract Identification of early signs of Autism Spectrum Disorder (ASD) could lead to earlier diagnosis and intervention. This cross-sectional study used the Parent Observation of Early Markers Scale (POEMS, Feldman et al. in J Autism Dev Disord 42:13–12, 2012) to identify early signs of ASD in 69 ASD high-risk (older sibling diagnosed with ASD) and 69 sex and aged-matched ASD low-risk second-born or later infants (no family history of ASD) between 6 and 36 months of age. Family sociodemographic comparisons were also made between the risk groups. The high-risk children had significantly more elevated POEMS items than the low-risk children at 12, 18, 24, 30 and 36 months of age, even when the children subsequently diagnosed with ASD were removed from the analyses. Families of the high-risk group had older parents, lower family income and fewer mothers working out of the home than the low-risk group. These sociodemographic variables were not significantly correlated with POEMS scores. The results suggest that high-risk infants may show signs of the broader ASD phenotype as early as 12 months of age that may be unrelated to observed sociodemographic family differences.

Keywords Early identification · At-risk infants · Infant siblings

This paper is dedicated to the memory of Jeanette J. Holden.

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Introduction

Infant Siblings

Siblings of children with Autism Spectrum Disorder (ASD) are at greater risk of ASD than siblings who do not have a family history of ASD (Jones et al. 2014; Messinger et al. 2013; Schwichtenberg et al. 2010). Between 10 and 20 % of young children who have older siblings with ASD will be diagnosed with ASD compared to 1 % of the general population (Messinger et al. 2013; Ozonoff et al. 2011). Another 10–20 % of siblings of children with ASD, while not diagnosed, may express a broader autism phenotype (Bolton et al. 1994; Gould and Gottesman 2006; Jones et al. 2014; Messinger et al. 2013; Pickles et al. 2000). Emerging evidence suggests that, like children with ASD, high-risk infant male siblings tend to show more prediagnostic autistic characteristics than female siblings, although more studies are needed (Messinger et al. 2013; Schwichtenberg et al. 2010). Gender and functioning of the affected sibling were not found to be predictors of an ASD diagnosis in younger siblings (Ozonoff et al. 2011).

Early Signs

Cross-sectional and longitudinal research suggests that early signs of ASD can be detected as early as 9 months (Feldman

et al. 2012), but older than 12 months is the norm (Landa and Garrett-Mayer 2006; Mitchell et al. 2006; Ozonoff et al. 2010; Wan et al. 2012; Zwaigenbaum et al. 2005). More signs are identified the older the child gets (Feldman et al. 2012). So far, it has been difficult to detect behavioral and developmental signs in the first 6 months of life that are predictive of later ASD diagnosis (Bolton et al. 2012; Jones et al. 2014; Rozga et al. 2011). Early signs include core social-communication impairments seen in ASD—e.g., lack of eye contact and interest in faces; and deficits in joint attention, gestures, imitation and communication (Bolton et al. 2012; Feldman et al. 2012; Landa and Garrett-Mayer 2006; Landa et al. 2007; Ozonoff et al. 2010; Rozga et al. 2011; Zwaigenbaum et al. 2005) as well as in subsidiary development and behaviors—e.g., fine and gross motor coordination, temperamental or passive moods, tolerance to waiting and empathy (Clifford et al. 2013; Feldman et al. 2012; Garon et al. 2008; Goldberg et al. 2005; Landa and Garrett-Mayer 2006; Loh et al. 2007; McDonald and Messinger 2012; Wetherby et al. 2004). Perhaps due to the young age of the siblings in most studies, one of the key features of ASD—restricted and repetitive behaviors (American Psychiatric Association 2013)—is not consistently different in high-risk subsequently diagnosed young siblings versus undiagnosed siblings or low-risk children (Jones et al. 2014); atypical motor activity has been seen in at-risk infants (Landa and Garrett-Mayer 2006; Loh et al. 2007; Wetherby et al. 2004).

Sociodemographic Factors in ASD

Family socioeconomic status (SES) and having a child with ASD may have bidirectional influences. SES may affect the likelihood of diagnosis and raising a child with ASD may affect SES. Having higher SES and living in a well-resourced neighborhood may increase the probability of a child receiving an ASD diagnosis compared to low SES families in low income neighborhoods (Thomas et al. 2012). This difference likely is due to differential reporting rates and access to health care and ASD services (Rai et al. 2012; Thomas et al. 2012). Several other studies, conducted in countries with universal health care, tend to find no or negative relationship between SES level and ASD prevalence (Dodds et al. 2011; Emerson 2012; Larsson et al. 2005; Rai et al. 2012). Once a family has a child diagnosed with ASD, indices related to SES may be negatively impacted. Using the 2002–2008 U.S. Medical Expenditure Panel Survey ($N = 67{,}531$), Cidav et al. (2012) found families that have children with ASD had 21 % lower income than families with no children with ASD, and mothers with children with ASD were less likely to be employed or work less hours. These findings highlight the impact of ASD on families, and points to the need to investigate sociodemographic variables in comparison studies of families with and without ASD. For the most part, high-risk infant sibling studies have not reported, let alone compared, sociodemographic characteristics such as SES, parental education and employment between families of high and low-risk children. In the current study, therefore, we compared sociodemographic variables between the two risk groups, and examined if there was a relationship between significantly different variables and scores on an early screener for ASD.

Parent Observation of Early Markers Scale (POEMS)

Recently, Feldman et al. (2012) described the preliminary validation of a new early screener for high-risk infants and young children (who have an older sibling). The POEMS is a 61-item measure that parents complete prospectively from child age 1–36 months, to track the child's development of possible early core signs of ASD (i.e., social-communication problems; repetitive behaviors). The POEMS also measures subsidiary behaviors (e.g., sleeping and eating problems; intolerance to noise, waiting and transitions) often seen in young children with ASD that may also be predictive of ASD. In a prospective study of infant siblings, the POEMS was able to differentiate the children who were diagnosed with ASD at 3 years as early as 9 months of age (Feldman et al. 2012). However, this first study did not include a low-risk comparison group of age and sex-matched children, so it was not known the extent to which the POEMS was sensitive to risk group status and possible early indicators of the broad ASD phenotype in at-risk children.

Purpose of Study

The purpose of this study was twofold. First, we cross-sectionally compared POEMS scores between matched male and female high and low-risk second-born or later children <36 months of age to determine to what extent the POEMS may be detecting risk of the ASD phenotype and which core and subsidiary behaviors differentiate the two groups at different ages. Second, we compared sociodemographic characteristics between the risk groups and examined possible relationships between significantly different characteristics and POEMS scores.

Methods

Recruitment

The 69 low-risk children were recruited within Ontario, Canada, through word of mouth, website and distribution of information flyers to physicians and daycares. Criteria for

inclusion in the low-risk group was no family history of ASD and having a second-born or later, typically developing child under 36 months of age (the target child). The target low-risk child had to be free of any condition that could impinge typical development (e.g., developmental delay, epilepsy, sensory impairment). Parents in the low-risk group reported on child age, birth order, health and family history of ASD to determine if the child met the entry criteria (three children were excluded from the low-risk group recruitment because of health and developmental problems). The 69 high-risk children represented a subsample of the 108 children who were originally recruited across North America through the Autism Spectrum Disorders-Canadian American Research Consortium (ASD-CARC) Prospective Study (Feldman et al. 2012). Participants were considered high-risk if they had an older sibling who had been diagnosed with ASD (confirmed in the original study). More details about the original ASD-CARC prospective group can be found in Feldman et al. (2012).

Participants

The 69 low-risk children were 35 females and 34 males between the ages of 4 and 36 months (mean = 19.01; *SD* = 9.02). From the pool of 108 high-risk children from the original prospective study, 69 were chosen who most closely matched the low-risk children for sex and age (±one month) on a one-to-one basis. When more than one high-risk child equally matched a low-risk child, the designated high-risk child was chosen at random. The researcher doing the matching was blind to the children's POEMS scores, diagnoses and sociodemographic characteristics. The 69 high-risk children were 35 females and 34 males between the ages of 3 and 36 months (mean = 18.60; *SD* = 8.98). In total, within each group there were 8 participants 6 months and younger, 17 participants 9 months and younger, 18 participants 12 months and younger, 34 participants 18 months and younger, 49 participants 24 months and younger, 61 participants 30 months and younger and 69 participants 36 months and younger. Table 1 presents key parent and family characteristics of each group. The range of family income of both groups overlaps the median Canadian family income ($76,600) reported by Statistics Canada (2013) in the *National Household Survey of 2011*. These families were virtually all two-parent families with highly educated mothers. The analyses of these sociodemographic variables will be presented in the Results section, below.

Table 1 Parent and family characteristics

Variable	High-risk (n = 69)	Low-risk (n = 69)
Mean (*SD*) mothers age in years	38.39 (4.36)	34.11 (4.30)
Percentage of mothers with college/university education	92 %	96 %
Percentage of mothers employed other than, or in addition to, homemaker	41 %	83 %
Mean (*SD*) fathers age in years	40.57 (4.73)	35.46 (4.69)
Percentage of fathers with college/university education	68 %	83 %
Percentage of fathers employed, other than or in addition to, homemaker	96 %	98 %
Mean (*SD*) annual family income	$61,154 (26,519)	$86,875 (17,093)
Percentage of two parent families	96 %	100 %

Measures

Family Information Questionnaire Sociodemographic information related to the child, each parent and the family was obtained via the Family Information Questionnaire (Feldman et al. 2000).

Parent Observation of Early Markers Scale (POEMS) (Feldman et al. 2012) The Parent Observation of Early Markers Scale has 61 items covering behaviors that are younger versions of core problems of ASD (e.g., social-communicative development; restricted interests; ritualistic, repetitive behaviors) tested by most ASD instruments such as the ADI-R (Lord et al. 1994), ADOS-Generic (Lord et al. 2000, 2002) and the Childhood Autism Rating Scale (CARS, Schopler et al. 1988). The POEMS also included subsidiary behaviors (e.g., sleeping, eating, temperament, sensory and tolerance problems) commonly seen in young children with ASD (but not necessarily in other childhood disorders like ADHD). In the validation study conducted by Feldman et al. (2012), the POEMS had acceptable internal consistency, test-retest reliability, construct and promising predictive validity of diagnosis by 36 months: sensitivity and specificity equaled .74 and .73, respectively, over 3–24 months of age.

On the POEMS, the parent rated their child's behaviors over the past week on a 4 point scale where a score of 1 is no problem (typical development—described), 2 is mild problem (child's behavior is not completely typical for his/her age), 3 is moderate problem (child behavior is concerning) and 4 is severe problem (described), with ½ ratings allowed. Elevated items are those with a rating of 3, 3.5 or 4. Items were organized by topic—e.g., sensory, language, social behaviors with no subscales. Descriptors were provided for the one and four anchor points. For instance, for the item Waiting, the description for a score of 1 is "tolerates brief wait before needs can be met; remains

calm but expectant while waiting," while a score of 4 read "cannot tolerate any wait to have needs met; easily frustrated; quick to cry or tantrum if needs are not met immediately." We instructed parents to score ''not applicable'' (NA) if an item was too developmentally advanced given the chronological age of the child. All NAs were converted to a score of 1 (no problem) so that every administered POEMS had the same potential range of scores (61–244). Parents were encouraged to test the child if they were unsure how the child would perform on a particular item (e.g., motor imitation, response to name). The breath and simplicity of the POEMS allow parents to explicitly track concerns (i.e., elevated items) on an ongoing basis up to 36 months and perhaps bringing any repeated elevated items to the attention of the child's pediatrician (Feldman et al. 2012).

Procedure

The parent (usually the mother) completed the POEMS by email or mail (a few opted for a telephone interview). In the study, we used the generic name, ''Parent Observation Checklist (POC)'' rather than the POEMS. Both groups were told that we were using the POC to monitor the development of second-born or later infants. Parents of the high-risk children could not be kept blind to the purpose of the study as they would have been aware why the researchers were interested in following the development of their subsequent child. We received ethics board clearance to withhold the purpose of study and nature of the POC to the low-risk group to reduce the likelihood of response bias (my child is not at-risk for ASD, so she would not have any of these problems) and emotional upset (my child has a problem with this behavior—does that mean he has ASD?).

Results

POEMS Total Score and Number of Elevated Items

Table 2 presents the mean POEMS total scores and elevated items for the low and high-risk groups, also separated into males and females. A 2 × 2 ANOVA (sex and group) revealed no significant differences in group, $F(1,134) = 1.68$, $\eta^2 = .012$ (η^2 is partial eta^2, effect size measure for ANOVA, provided in SPSS v20); sex, $F(1,134) = .52$, $\eta^2 = .004$; or group × sex interaction, $F(1, 134) = 1.65$, $\eta^2 = .012$, all p's $> .05$. The ANOVA on the POEMS number of elevated items (rating of 3, 3.5 or 4) revealed significant differences in group, $F(1, 134) = 6.03$, $\eta^2 = .043$, $p < .02$; but not sex, $F(1, 134) = 1.77$, $\eta^2 = .013$; or the group × sex interaction, $F(1, 134) = 1.71$, $\eta^2 = .013$, latter two p's $> .05$.

Table 2 Mean POEMS total scores and elevated items in the low and high-risk groups

	N	Mean POEMS total score (*SD*)	Mean POEMS elevated items (*SD*)[a]
Low-risk males	35	68.94 (8.85)	.54 (.89)
Low-risk females	34	67.49 (6.26)	.56 (1.28)
Total low-risk	69	68.22 (7.66)	.55 (1.09)
High-risk males	35	68.97 (12.17)	1.49 (3.88)
High-risk females	34	74.16 (25.74)	3.65 (8.74)
Total high-risk	69	71.53 (20.06)	2.55 (2.77)

[a] POEMS item rating of 3, 3.5 or 4 (maximum score = 4)

Six of the children in the high-risk group were eventually diagnosed with ASD, and had significantly higher POEMS total scores (mean = 110.17, $SD = 40.98$) than the remaining 63 high-risk children without a subsequent diagnosis (mean = 67.85, $SD = 12.16$), $t(67) = 6.12$, $p < .001$. The diagnosed high-risk children also had a greater number of elevated POEMS items (mean = 15.83, $SD = 15.64$) than the undiagnosed high-risk children (mean = 1.29, $SD = 3.43$), $t(67) = 6.31$, $p < .001$. To determine if the undiagnosed high-risk children still may have shown early signs of a broader ASD phenotype (Bolton et al. 1994), we removed the diagnosed children from the high-risk sample and repeated the high-risk versus low-risk group comparison on elevated POEMS items. Removing the subsequently diagnosed children from the high-risk children decreased the mean number of elevated items of the high-risk sample from 2.55 to 1.29, but the 63 undiagnosed high-risk children still had significantly more elevated items than the low-risk group, $t(130) = 1.69$, $p < .05$.

Between Group Comparisons Between 6 and 36 Months

Given no significant gender differences in the ANOVAs, we conducted independent t tests (one-tailed) combining males and females within each group and age. Figure 1 shows the mean, cumulative, cross-sectional POEMS total scores between 6 and 36 months. The only age showing a significant group difference on total score is 18 months, when the high-risk group had higher scores than the low-risk group, $t(65) = 2.14$, $p < .02$. Figure 2 shows the mean number of elevated POEMS scores cross-sectionally between 6 and 36 months. The high-risk group had significantly more elevated scores at every comparison age except 6 and 9 months: 12 months, $t(34) = 1.94$, $p < .05$; 18 months: $t(65) = 2.43$, $p < .01$; 24 months, $t(94) = 2.20$, $p < .02$; and 30 months, $t(120) = 2.28$, $p < .02$. The 2 × 2 ANOVA already showed that the high-risk group

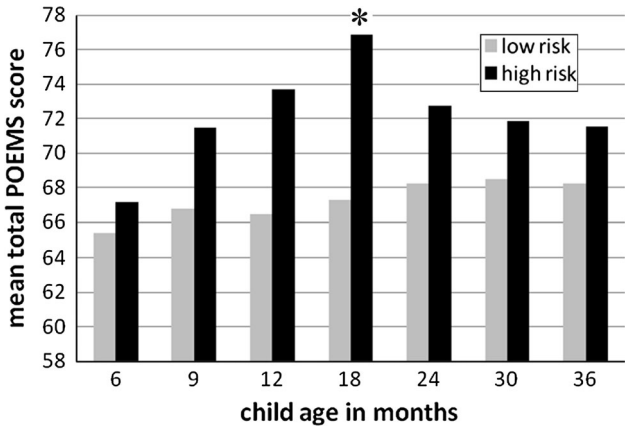

Fig. 1 Mean total POEMS score age comparisons of high and low-risk groups. POEMS minimum total score = 61; maximum total score = 244; total *N*'s (equal no. per group) at 6, 9, 12, 18, 24, 30 and 36 months are: 16, 34, 36, 68, 98, 122 and 138, respectively. *$p < .05$

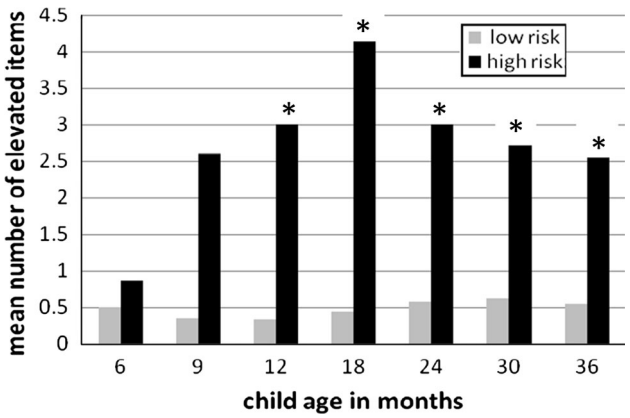

Fig. 2 Mean number of POEMS elevated items age comparisons of high and low-risk groups. POEMS minimum total score = 61; maximum total score = 244; total *N*'s (equal no. per group) at 6, 9, 12, 18, 24, 30 and 36 months are: 16, 34, 36, 68, 98, 122 and 138, respectively. *$p < .05$

had significantly more elevated items than the low-risk group up to 36 months.

POEMS Age by Item Comparisons

Table 3 shows the most common elevated items that differentiated the high- from low-risk groups at 9, 12, 18, 24, 30 and 36 months of age. For the high-risk group, sleep duration remained the most frequently reported problem across age groups, with milk/formula intolerance also appearing up to 24 months. Lack of interest in faces is one of the frequently reported problems starting at 12 months and imitation of sounds and words is a consistent issue from 18 months onwards in the high-risk group. By contrast, few problems are reported in the low-risk group, and there were no POEMS items that were more frequently elevated in the low-risk group than the high-risk group.

Multiple POEMS Administrations

The high-risk, but not the low-risk children, received multiple administrations of the POEMS (mean = 8.19; $SD = 5.19$), as the former group was involved in a longitudinal study (Feldman et al. 2012). As it is possible that parents completing the POEMS several times may rate differently as they become more experienced with the items than someone completing the POEMS just once, we tested whether there was a relationship between the number of times the parents in the high-risk group completed the measure and the POEMS administration number that was used in this study (mean = 3.96, $SD = 3.97$). For example, if a high-risk child was matched to a low-risk child at 12 months and the high-risk child's 12 month POEMS was the third POEMS that the parent completed, then that child's POEMS administration number would be 3. The Pearson correlation coefficients were small and insignificant between the POEMS administration number and the POEMS total score, $r(67) = 0.18$, $p > .05$, and the number of elevated items, $r(67) = 0.16$, $p > .05$, suggesting that the number of times the parent completed the POEMS did not influence the ratings.

Sociodemographic Variables

Of the variables presented in Table 1, mothers and fathers of high-risk infants were found to be significantly older than the low-risk mothers, $t(102) = 5.30$, and fathers, $t(101) = 5.50$; high-risk families reported lower incomes, $t(63) = 5.24$, all p's $< .001$, two-tailed. High-risk families had less maternal employment, $\chi^2 = 14.65$, $p < .001$, than low-risk families. No other variable in Table 1 was significantly different. Combining both groups' sociodemographic data, there were no significant relationships between the significant sociodemographic variables and POEMS total scores and number of elevated items: mothers age and the total POEMS score, Pearson $r(104) = 0.08$, and the number of elevated items $r(104) = 0.12$; fathers age and the total POEMS score, $r(103) = 0.15$, and the number of elevated items, $r(103) = 0.16$; family income and the total POEMS score, $r(87) = -0.09$, and the number of elevated items, $r(87) = 0.06$; and number of mothers employed and POEMS score, Spearman $rho(112) = 0.04$, and the number of elevated items, $rho(112) = -.11$; all p's $> .05$, two-tailed. No significant correlations emerged when each risk group was analyzed separately (results available from first author on request).

Table 3 Most frequently reported elevated POEMS items in the high-risk group by age (months) compared to the low-risk group

Age (months)	*N* per group	Elevated item on POEMS	% high-risk participants with elevated item	% low-risk participants with elevated item
9	17	Sleep duration at night	24	6
		Milk/formula intolerance	24	0
12	18	Sleep duration at night	28	6
		Milk/formula intolerance	22	0
		Acceptance of new foods, Mood, Interest in faces, Attention span	17	0
18	34	Sleep duration at night	27	3
		Imitates sounds or words	21	6
		Milk/formula intolerance,	18	0
		Appetite	18	3
		Interest in faces, Waiting, Coordinates gestures with communication	15	0
24	49	Sleep duration at night	19	2
		Imitates sounds or words	14	4
		Milk/formula intolerance	12	0
		Interest in faces, Coordinates gestures with communication	10	0
30	61	Sleep duration at night	15	3
		Imitates sounds or words	11	3
		Interest in faces, Coordinates gestures with communication	10	0
		Waiting	10	2
		Shifts attention to person	8	0
36	69	Sleep duration at night	13	1
		Waiting	12	1
		Interest in faces	10	0
		Coordinates gestures with communication	7	0

Discussion

High Versus Low-Risk POEMS Scores

In this cross-sectional study, the children at high-risk for ASD (because they had older siblings with ASD) had significantly more elevated POEMS items from 12 to 36 months of age; total POEMS scores were not significantly different except at 18 months of age. No significant differences on POEMS total score or elevated items were found between males and females in the high-risk (and low-risk) children. While this gender result is inconsistent with some previous high-risk infant studies (Constantino et al. 2010; Messinger et al. 2013) that show that males tend to have more severe ASD signs than females, there may not be differences in symptom severity between males and females already diagnosed with ASD (Rivet and Matson 2011).

The number of elevated POEMS items was more sensitive than POEMS total score in detecting differences between the high- and low-risk children. Parents in the high-risk group rated most of the 61 items as <3, making their children look much like the low-risk sample. Indeed, as seen in Table 2, the mean total scores were not that different, but the *SD*s showed a large between group discrepancy. Thus, the POEMS scores may reveal diversity in developmental trajectories in the high-risk group (Landa et al. 2012) and may isolate key ASD core or related behaviors that may signify the infant sibling's biological risk for diagnosis or the broader ASD phenotype. This finding supports other studies that show that short ASD-specific screener predictive validity is improved with additional information from parents (Kleinman et al. 2008). As most of the high-risk children in this sample only had one affected sibling, it would be expected that most of them would not be distinguishable from the low-risk children in terms of ASD symptoms and subsidiary behaviors (Constantino et al. 2010). Yet, when parents of high-risk infants are asked to examine a range of possible ASD-related behaviors, they tended to report one to four problems out of 61 items (see Table 2).

Elevated Items

In this study, a developmental progression was noted in parental concerns about socio-communicative skills in the high-risk group as compared to the low-risk group on the POEMS. Interest in faces was a concern at 12 months and

then imitates sounds and words, and coordinates gestures with communication, emerged as concerns at 18 months; shifts attention to person was elevated at 30 months (see Table 3). These problems in infants at-risk for ASD have been noted in other studies (Garon et al. 2008; Landa et al. 2007; Landa and Garrett-Mayer 2006; Mitchell et al. 2006; Ozonoff et al. 2010; Saint-Georges et al. 2010; Werner et al. 2000; Zwaigenbaum et al. 2005). In addition to core ASD socio-communicative features, commonly noted concerns in young children with ASD such as sleep and feeding problems (Cotton and Richdale 2010; Emond et al. 2010) were elevated in the high-risk, but not the low-risk group across ages. Waiting intolerance, not typically measured in infant sib studies, showed up in this study as another behavioral "red flag" across several ages (18, 30 and 36 months), as it did in the enlarged sample including the children in this study (Feldman et al. 2012). However, as seen in Table 3, no one POEMS item was elevated in a majority of high-risk infants at any age point. POEMS items related to aberrant motor movements (e.g., arm waving, holding positions for long periods of time, repetitive behaviors) did not differentiate the two risk groups, unlike in other studies (Landa and Garrett-Mayer 2006; Loh et al. 2007; Wetherby et al. 2004). As the POEMS measures parents' concerns with, as opposed to presence of, a particular behavior, it is possible that the parents in this study were not worried about their young children's restrictive and repetitive behaviors, as they also occur in typically developing young children (Jones et al. 2014).

Sociodemographic Differences and Relationships

High-risk families (who were recruited across North America) had older parents, fewer mothers who worked and lower family income. These findings are consistent with epidemiological ASD studies in the U.S. (Cidav et al. 2012) and Sweden (Rai et al. 2012). Having a child with ASD likely deters the parents from having a second child soon after. Families may have to change their priorities when their first child is diagnosed with ASD. One parent (usually the mother) stays at home to take responsibility for finding services and providing child care because of the inability to afford or find specialized child care. Hence, family income drops as one parent devotes her/himself to caring for the child with ASD. These demographic differences are a relatively new finding as many prospective studies have not compared low-risk to the high-risk infants on demographic variables other than gender and age (Garon et al. 2008; Landa et al. 2007; Loh et al. 2007; Mitchell et al. 2006). While in this study, sociodemographic characteristics were not related to POEMS scores or number of elevated items, Messinger et al. (2013) did find that low-risk mothers were more likely to have college education than high-risk mothers and that this variable predicted the children's developmental quotient scores. Future studies should include and analyze the potential differences and relationships of sociodemographic characteristics of risk samples, and whether these variables influence ASD symptom development, diagnosis and intervention outcomes.

Limitations

Cross-sectional age comparisons should be considered preliminary given the small sample sizes for each of the age groups, especially for <12 months. As the small sample sizes increased the risk of Type II error, no correction for multiple testing was used (Nakagawa and Foster 2004). Nonetheless, there were significant differences between the high-risk and low-risk groups in the number of elevated POEMS items at each of five age groups, suggesting an effect of biological risk for ASD or the broader phenotype on the number of elevated items. Further cross-sectional and longitudinal research should include increasing the sample size to add to the statistical power, particularly at the younger ages, and involve more diverse families. While it is possible that parents with high-risk infants were biased to report higher scores because they were aware of the purpose of the study, their overall POEMS scores were similar to the low-risk group and only relatively few (but key) elevated items were reported.

Conclusion

In conclusion, the POEMS may not only predict ASD diagnosis in high-risk infants (Feldman et al. 2012), but also may reveal phenotypic differences in possible ASD signs and ASD-related subsidiary behaviors between infants with and without a family history of ASD. The potential strength of the POEMS to describe individual and diverse trajectories of high-risk children may be as or more important than the POEMS predictive power. The POEMS can be used by parents to track the behavioral development of their high-risk child with respect to possible early signs of ASD. Repeated elevated POEMS items could be used to guide focused intervention. While the POEMS has been initially tested with infants at-risk for ASD because they have diagnosed older siblings, future research will determine the utility of the POEMS as an ASD screener for all children.

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References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)* (5th ed.). Arlington: American Psychiatric Publishing.

Bolton, P. F., Golding, J., Emond, A., & Steer, C. D. (2012). Autism spectrum disorder and autistic traits in the Avon longitudinal study of parents and children: Precursors and early signs. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*, 249–260.

Bolton, P., Macdonald, H., Pickles, A., Rios, P., Goode, S., Crowson, M., et al. (1994). A case-control family history study of autism. *Journal of Child Psychology and Psychiatry, 35*, 877–900.

Cidav, Z., Marcus, S. C., & Mandell, D. S. (2012). Implications of childhood autism for parental employment and earnings. *Pediatrics, 129*(4), 617–623. doi:10.1542/peds.2011-2700.

Clifford, S. M., Hudry, K., Elsabbagh, M., Charman, T., Johnson, M. H., & The BASIS Team. (2013). Temperament in the first 2 years of life in infants at high-risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders, 43*, 673–686. doi:10.1007/s10803-012-1612-y.

Constantino, J. N., Zhang, Y., Frazier, T., Abbacchi, A. M., & Law, P. (2010). Sibling recurrence and the genetic epidemiology of autism. *American Journal of Psychiatry, 167*, 1349–1356.

Cotton, S. M., & Richdale, A. L. (2010). Sleep patterns and behaviour in typically developing children and children with autism, down syndrome, prader-willi syndrome and intellectual disability. *Research in Autism Spectrum Disorders, 4*, 490–500.

Dodds, L., Fell, D. B., Shea, S., Armson, B. A., Allen, A. C., & Bryson, S. (2011). The role of prenatal, obstetric and neonatal factors in the development of autism. *Journal of Autism and Developmental Disorders, 41*, 891–902.

Emerson, E. (2012). Deprivation, ethnicity and the prevalence of intellectual and developmental disabilities. *Journal of Epidemiology and Community Health, 66*, 218–224.

Emond, A., Emmett, P., Steer, C., & Golding, J. (2010). Feeding symptoms, dietary patterns, and growth in young children with autism spectrum disorders. *Pediatrics, 126*(2), 337–342.

Feldman, M. A., Hancock, C. L., Rielly, N., Minnes, P., & Cairns, C. (2000). Behavior problems in young children with or at risk for developmental delay. *Journal of Child and Family Studies, 9*, 247–261.

Feldman, M. A., Ward, R. A., Savona, D., Regehr, K., Parker, K., Hudson, M., et al. (2012). Development and initial validation of a parent report measure of the behavioral development of infants at risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders, 42*, 13–22.

Garon, N., Bryson, S. E., Zwaigenbaum, L., Smith, I. M., Brian, J., Roberts, W., et al. (2008). Temperament and its relationship to autistic symptoms in a high-risk infant sib cohort. *Journal of Abnormal Child Psychology, 37*, 59–78.

Goldberg, W., Jarvis, K., Osann, K., Laulhere, T., Straub, C., Thomas, E., et al. (2005). Brief report: Early social communication behaviors in the younger siblings of children with autism. *Journal of Autism and Developmental Disorders, 35*(5), 657–664.

Gould, T., & Gottesman, I. (2006). Psychiatric endophenotypes and the development of valid animal models. *Genes, Brain and Behavior, 5*(2), 113–119.

Jones, E. J. H., Gliga, T., Bedford, R., Charman, T., & Johnson, M. H. (2014). Developmental pathways to autism: A review of prospective studies of infants at risk. *Neuroscience and Biobehavioral Reviews, 39*, 1–33.

Kleinman, J. M., Robins, D. L., Ventola, P. E., Pandey, J., Boorstein, H. C., Esser, E. L., et al. (2008). The modified checklist for autism in toddlers: A follow-up study investigating the early detection of autism spectrum disorders. *Journal of Autism and Developmental Disorders, 38*, 827–839.

Landa, R., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry, 47*(6), 629–638.

Landa, R. J., Gross, A. L., Stuart, E. A., & Bauman, M. (2012). Latent class analysis of early developmental trajectory in baby siblings of children with autism. *Journal of Child Psychology and Psychiatry, 53*, 986–996.

Landa, R. J., Holman, K. C., & Garrett-Mayer, E. (2007). Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Archives of General Psychiatry, 64*(7), 853–864.

Larsson, H. J., Eaton, W. W., Madsen, K. M., Vestergaard, M., Olesen, A. V., Agerbo, E., et al. (2005). Risk factors for autism: Perinatal factors, parental psychiatric history, and socioeconomic status. *American Journal of Epidemiology, 161*, 916–925.

Loh, A., Soman, T., Brian, J., Bryson, S. E., Roberts, W., Szatmari, P., et al. (2007). Stereotyped motor behaviors associated with autism in high-risk infants: A pilot videotape analysis of a sibling sample. *Journal of Autism and Developmental Disorders, 37*, 25–36.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H, Jr, Leventhal, B. L., DiLavore, P. C., et al. (2000). The Autism diagnostic observation schedule—generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*, 205–223.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (2002). *Autism diagnostic observation schedule—generic*. Los Angeles: Western Psychological Services.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism diagnostic interview-revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*, 659–685.

McDonald, N. M., & Messinger, D. S. (2012). Empathic responding in toddlers at risk for an autism spectrum disorder. *Journal of Autism and Developmental Disorders, 42*, 1566–1573. doi:10.1007/s10803-011-1390-y.

Messinger, D., Young, G. S., Ozonoff, S., Dobkins, K., Carter, A., Zwaigenbaum, L., et al. (2013). Beyond autism: A baby siblings research consortium study of high-risk children at three years of age. *Journal American Academy of Child and Adolescent Psychiatry, 52*, 300–308.

Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., et al. (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics, 27*, 69–78.

Nakagawa, S., & Foster, T. M. (2004). The case against retrospective statistical power analyses with an introduction to power analysis. *Acta Ethologica, 7*, 103–108.

Ozonoff, S., Iosif, A. M., Baguio, F., Cook, I. C., Hill, M. M., Hutman, T., et al. (2010). A prospective study of the emergence of early behavioral signs of autism. *Journal of the American Academy of Child and Adolescent Psychiatry, 49*, 256–266.

Ozonoff, S., Young, G. S., Carter, A., Messinger, D., Yirmiya, N., Zwaigenbaum, L., et al. (2011). Recurrence risk for autism spectrum disorders: A baby siblings research consortium study. *Pediatrics, 128*(3), e488–e495.

Pickles, A., Starr, E., Kazak, S., Bolton, P., Papanikolaou, K., Bailey, A., et al. (2000). Variable expression of the autism broader phenotype: Findings from extended pedigrees. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*, 491–502.

Rai, D., Lewis, G., Lundberg, M., Araya, R., Svensson, A., Dalman, C., et al. (2012). Offspring autism spectrum disorders in a Swedish population-based study. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*, 467–476.

Rivet, T., & Matson, J. (2011). Review of gender differences in core symptomatology in autism spectrum disorders. *Research in Autism Spectrum Disorders, 5*(3), 957–976.

Rozga, A., Hutman, T., Young, G. S., Rogers, S. J., Ozonoff, S., Dapretto, M., et al. (2011). Behavioral profiles of affected and unaffected siblings of children with autism: Contribution of measures of mother–infant interaction and nonverbal communication. *Journal of Autism and Developmental Disorders, 41*, 287–301. doi:10.1007/s10803-010-1051-6.

Saint-Georges, C., Cassel, R., Cohen, D., Chetouani, M., Laznik, M., Maestro, S., et al. (2010). What studies of family home movies can teach us about autistic infants: A literature review. *Research in Autism Spectrum Disorders, 4*(3), 355–366.

Schopler, E., Reichler, R. J., & Renner, B. R. (1988). *The childhood autism rating scale*. Los Angeles: Western Psychological Services.

Schwichtenberg, A. J., Young, G. S., Sigman, M., Hutman, T., & Ozonoff, S. (2010). Can family affectedness inform infant sibling outcomes of autism spectrum disorders? *Journal of Child Psychology and Psychiatry, 51*, 1021–1030.

Statistics Canada (2013). Income composition in Canada. *National Household Survey of 2011*. Retrieved on Aug. 7, 2014, from http://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-014-x/99-014-x2011001-eng.pdf.

Thomas, P., Zahorodny, W., Peng, B., Kim, S., Jani, N., Halperin, W., et al. (2012). The association of autism diagnosis with socioeconomic status. *Autism, 16*, 201–213.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012). Parent–infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities, 33*, 924–932.

Werner, E., Dawson, G., Osterling, J., & Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: A retrospective study based on home videotapes. *Journal of Autism and Developmental Disorders, 30*, 157–162.

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorders in the second year of life. *Journal of Autism and Developmental Disorders, 34*, 473–493.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23*, 143–152.