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Incidence of pre-, peri-, and post-natal birth and developmental problems of children with sensory processing disorder and children with autism spectrum disorder

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As the diagnosis of sensory processing disorder (SPD) is advanced, it is important to investigate potential contributing factors to this disorder as well as early diagnostic signs. An exploratory descriptive study, utilizing retrospective chart review, was conducted to investigate the incidence of pre-, peri- and post-natal, birth and developmental problems in a sample of 1000 children with SPD and of 467 children with autism spectrum disorder (ASD), who also had SPD. This study revealed that although no one factor was strongly associated with SPD or ASD, an average of seven events for children with SPD and eight events for children with ASD occurred across categories. These included: one pre-natal/pregnancy problem, delivery complication, assisted delivery, gestational or birth-related injury/illness; one or more early childhood illnesses or injuries; two or more infancy/early childhood developmental problems; and one or more delayed early childhood developmental milestones. When comparing results to national studies of the typical population, most remarkable was the incidence of jaundice, three to four times higher in both the SPD and ASD groups than in typical children. In addition, rates of breech position, cord wrap/ prolapse, assisted delivery methods (particularly forceps and suction deliveries), and high birth-weight were greater in both groups. Incidence of premature birth was higher in the ASD although not significantly different from the SPD group. Also of note was a high frequency of absent or brief crawling phase, and high percentages of problems with ear infections, allergies, and maternal stresses during pregnancy.

Keywords: allergies, assisted deliveries, birth weight, crawling, delivery complications, jaundice, maternal stress

INTRODUCTION

Sensory Processing Disorder (SPD) is a dysfunction in the way children process and use sensory information for regulation, motor performance and function. Initially identified by Ayres (1972a) as sensory integration dysfunction, but also referred to as difficulties in sensory processing, SPD is currently the diagnostic term submitted for possible inclusion in the next revision of the Diagnostic Statistical Manual and the International Classification of Diseases manual. Ayres (1972a, 1979) proposed that unknown pre-natal problems, such as a lack of oxygen at birth, may contribute to children's sensory integration problems. More recently it has been proposed that some children may have a hereditary or genetic predisposition to sensory integration problems and that they may be more vulnerable to environmental toxins, anoxia at birth, or other pregnancy, birth, and/or early childhood related problems (Ayres, 2005). Windle (1969) found that monkeys deprived of oxygen at birth demonstrated poor sensory processing and had damage to auditory and tactile processing areas of the brain. Kyllerman (1982) later found a relationship between asphyxia and intrauterine growth retardation in studies of neurodevelopmental disorders. Schneider et al. (2007) found strong evidence that pre-natal maternal stress in primates was related to sensory defensiveness, specifically tactile defensiveness. There has been no research to date that has examined the causality of SPD or the relationship of pre-natal, peri-natal, or early childhood problems to sensory integration deficits, however, some researchers have linked these early problems to aspects of sensory processing and motor performance in children with motor coordination problems and in children with autism.

In addition to disruptions in sensory processing, occupational therapists working with children with SPD consistently identify aspects of delayed or atypical early childhood developmental language and motor milestones or developmental problems as characteristic of these children (Cermak, 1985; Cermak and Larkin, 2002). Frequently children with SPD with motor coordination delays may also be referred to as having a Developmental Coordination Disorder (DCD). The prevalence and etiology of DCD has been examined by a number of researchers and is reported to be between 6% and 22% (American Psychiatric Association, 2000), a rate that is consistent with reported rates of 5–13% in SPD (Ahn et al., 2004). Children with DCD are believed to have "minimal brain damage" as identified through the presence of neurological soft signs (Walton et al., 1962; Gubbay et al., 1965; Henderson and Hall, 1982). Peri-natal abnormalities and complications have been identified in children with coordination problems and implicated as possible etiological factors with this group. Particular problems have been noted in areas such as jaundice, lower birth weight, and high rates of pre- and post-maturity (Johnston et al., 1987). More recently, Hoare and Kerley (1991) identified a high incidence of pregnancy complications,

breech birth, use of forceps, C-section, vacuum extraction, jaundice, and low birth-weight in children with motor coordination problems. Thus peri-natal factors have frequently been associated with motor coordination problems common in children with SPD.

Similar to SPD and DCD, sensory processing problems and motor delays are also characteristics of children with Autism Spectrum Disorder (ASD) (American Psychiatric Association, 2000) and a large percentage, most recently estimated at 92%, have specifically been found to have sensory processing disorder (Talay-Ongan and Wood, 2000; Tomchek and Dunn, 2007). In addition, the presence of sensory processing difficulties often occurs prior to the diagnosis of autism and may well be a key factor in the regulatory difficulties presented by this population (Dahlgren and Gillberg, 1989; Adrien et al., 1993; Lord, 1995; Baranek, 1999).

Events in early and developmental areas may be the first signs that a child is at risk and in need of a referral for assessment and possible intervention. Families of children with both SPD and ASD need to manage sensory issues and related behavioral, emotional and motoric concerns from very young ages, therefore, it is important for health professionals, in particular pediatricians and early intervention team members, to be aware of any trends in pre-, peri- and post-natal development that may be linked to these diagnoses. Thus, while there is evidence that pre-, peri-, and post-natal and early childhood problems may be related to sensory processing and motor coordination problems, to date, no one has empirically examined the type and incidence of these problems specifically in children with SPD.

In ASD, there have been studies examining pre-, peri- and post-natal developmental factors, and a range of problems have been noted. There have been reported deviations from normal conditions in the pre-natal and peri-natal periods among at-risk infants who later manifested ASD (Nelson, 1991; Burd et al., 1999). In children with ASD, Finnegan and Quarrington (1979) reported significantly more incidence of low birth weight, low Apgar scores, hemolytic disease, hyperbilirubinia (jaundice) and respiratory distress. Mason-Brothers et al. (1990) noted that jaundice occurred more frequently than other possible contributing factors. Gillberg and Gillberg (1983) reported significantly more incidences of prematurity and postmaturity at birth. More recently, Juul-Dam et al. (2001) reported significantly higher incidence of uterine bleeding and hyperbilirumbinia in children diagnosed with autism when compared to the general population. Hultman et al. (2002) found that mother's incidence of daily smoking in early pregnancy, Cesarean delivery, infant being small for gestational age, low Apgar scores, and congenital malformations were all associated with increased risk for autism.

Kolevzon et al. (2007) reviewed seven previously conducted studies involving pre- and peri-natal factors only and suggested that advanced maternal and paternal age, e.g. greater than 39 years of age, maternal birth outside of Europe and North America, birth-weight, duration of gestation and intra-partum hypoxia may all be conditions related to an increased risk of ASD and should be examined further. Beyond the factors examined in this current study, Persico and Bourgeron (2006) suggest that there may be complex pathenogenic pathways that lead to ASD through altered brain development and that some environmental factors, specifically viral agents, may contribute to dysfunction. Overall, most studies suggest there may not be one specific pre-, peri- or post-natal event contributing to autism, but that a number of subtle pathologic factors may occur in combination and may be influenced by genetics.

To date, although previous studies have examined these factors in children with ASD, no studies have been conducted on these birth and early childhood factors in children with ASD and SPD, nor with SPD alone. Therefore, it is important to examine these factors, along with research on other potentially causal factors in ASD and SPD, to illuminate the diagnosis and intervention for these disorders. Examination of differences in early factors between children with SPD and children with ASD may also assist with differential diagnosis of sensory processing problems. Therefore, the purpose of this study was to conduct an exploratory examination of the incidence of potential pregnancy, birth and early childhood risk factors in children with SPD and in children with ASD and SPD. Further we wished to examine differences between these groups to determine if these factors may contribute to the differential diagnosis of these problems.

The questions explored in this study were:

1. What, if any, pre-, peri- and post-natal and early childhood developmental factors are common in children with Sensory Processing Disorder (SPD) and in Autism Spectrum Disorder (ASD) with SPD?
2. Are there significant differences between the SPD and ASD groups on any pre-, peri- and post-natal as well as early childhood developmental factors?
3. What, if any, comparisons may be made with available data on typical populations?
4. What are the implications for any findings on future research and practice with children with SPD and those with ASD?

MATERIALS AND METHODS

PARTICIPANTS

This exploratory descriptive study involved a retrospective chart review of existing data collected as part of routine clinical practice completed on children with SPD and on children with ASD who also have SPD. At a large private practice specializing in assessment and treatment of sensory processing disorder. All children included in this study received a comprehensive occupational or physical therapy evaluation by a therapist certified in providing sensory integration assessment or supervised by a therapist who was certified who reviewed all evaluation reports for accuracy. The comprehensive evaluation included standardized assessment using the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989), Southern California Sensory Integration Tests (SCSIT) (Ayres, 1972b), or Miller Assessment for Pre-Schoolers (MAP) (Miller, 1982) when possible in conjunction with clinical observations of sensory processing, postural control, and motor performance. When use of these tests was not possible, other motor performance assessments and structured clinical observations were used as appropriate for the age and functioning of the child. All children had one or more difficulties in sensory integration functioning as identified by Ayres (1972a, 1979, 1989) and Bundy et al. (2002) including sensory over- and under-responsivity; sensory discrimination deficits of tactile, proprioceptive and vestibular functioning; and deficits with praxis. No attempt was made to select specific subgroups of sensory processing dysfunction for this study. The final group consisted of a representative clinical sample of children

identified with SPD or ASD. No new data were collected during this anonymous chart review. Specific data on socioeconomic status was not available, however, previous research studies at this practice have indicated that the clinic population generally has a moderate to high socio-economic status with over 90% of the parents of clients classified as married Caucasians, with post-graduate degrees obtained by 50% of mothers and approximately 60% of fathers (May-Benson, Cohn, Teasdale, 2009, unpublished data).

Sensory Processing Disorder (SPD) group

This sample consisted of 1000 participants between the ages of 3–17 years with a mean age of 6.7 (SD = 2.28) years, including 732 males, and 268 females. The sample consisted of three age groups: 0–3 years of age, 4–12 years of age, and 13–17 years of age. The largest percent of children were in the 4–12 year group. Two children were excluded after data collection as not meeting inclusion criteria. All eligible children with identified sensory processing problems were included in the study. Adopted children were not included in this study due to the likelihood of missing data points, most of which would have occurred prior to adoption. Children with known disorders such as autism spectrum disorder, Fragile X syndrome, Down's syndrome, cerebral palsy, etc. were also excluded.

Autism Spectrum Disorder (ASD) group

This sample consisted of 467 participants with ASD, all of whom also had SPD. Two participants were excluded prior to data analysis as not meeting criteria. The remaining 465 participants had a mean age of 5.9 (SD = 3.42) years including 384 males and 81 females in the same age groupings as the SPD group. Individuals who had additional medical diagnoses such as Down's Syndrome, Fragile X, etc. were excluded from the study. The diagnosis of ASD was obtained through parent report based on a diagnosis received from evaluations by pediatricians, pediatric neurologists, and/or neuropsychologists. Of the participants, 228 (49%) had a diagnosis of Autism, 288 (62%) had a diagnosis of Pervasive Developmental Disorder, and 51 (19%) reported both diagnoses.

Additional diagnoses including anxiety, cognitive delays, emotional disorders, attention deficit disorder, learning disabilities, non-verbal learning disability, and other diagnoses were reported as co-morbid for both the ASD and SPD groups. These diagnoses were retained for this study as they are commonly associated with SPD and in many cases, it is believed that poor sensory integration and praxis skills may underlie some of the problems associated with these other diagnoses, e.g. poor discrimination and praxis is thought to be associated with learning disabilities and anxiety is though to be a possible outcome of sensory hyper-sensitivity. A small age and gender matched subsample of 183 children with just SPD and those with ASD/SPD was examined to determine if inclusion of these additional diagnoses impacted the study findings. Results found no meaningful differences in the findings of this subgroup and the larger study group. Thus the findings of the larger group were retained as they are more representative of a typical clinical SPD population. Percentages were similar between groups with the exceptions that the ASD group had a significantly higher percentage of reported Anxiety ($p < 0.001$) and Cognitive Delays ($p < 0.001$) and the SPD group had a significantly higher percentage of Attention Deficit Disorder ($p = 0.015$). The Autism group had significantly more males ($p < 0.001$) and the SPD group had a significantly higher mean age ($p = 0.001$). In addition, the distribution of children across ages was different between the two groups. The majority of SPD children were school-aged while a large number of the ASD children were under 4 years of age. A MANOVA determined that there were no meaningful differences in findings when accounting for age with the exception of older children having more illnesses and injuries. See **Table 1** for detailed demographic information.

MEASURES

Three age-appropriate versions of the Developmental Sensory History (OTA-Watertown, 1996) were used to collect information on pre-, peri-, post-natal birth and early childhood developmental factors that are believed to be associated with sensory processing disorder. The Developmental Sensory History is a parent-report questionnaire consisting of questions on an individual's medical history, birth history (including maternal health) and early childhood health problems and development, as well as questions regarding the individual's sensory history. The questionnaire is completed at the time of the child's initial evaluation at the agency. Therefore, the age of children at time of completion varied. The developmental history information for the infant-toddlers (age 3 and under) and school-aged (4–12 years) children were exactly the same while there were some differences in wording and inclusion of questions on the adolescent/adults (age 13 and older) questionnaire. Only the developmental portion of the history was used in this study. In spite of this difference with the older child questionnaire, it was deemed important to include this group in as many factors as possible to obtain the most comprehensive information as this is the first study of its kind for SPD. All three versions of the Developmental Sensory History are available from the authors. See **Table 2** for the specific questions included in this study.

Table 1 | Gender, age, and diagnoses of SPD and ASD groups: percentage, valid *N*, and *T*-tests between groups.

Demographic	SPD % (*N* = 998)	ASD % (*N* = 465)	*t* (*p*)
GENDER			
Male	73.2	82.6	–4.147 (<0.001)
Female	26.8	17.4	4.147 (<0.001)
AGE			
0–3	1.1	26.8	–12.367 (<0.001)
4–12	97.8	67.7	13.541 (<0.001)
13–17	1.1	5.4	–4.951 (<0.001)
PARENT REPORTED DIAGNOSES			
ADD/ADHD	17	12	2.314 (0.015)
Tourettes	0	0.9	–2.939 (0.045)
Anxiety	3	8	–4.642 (<0.001)
Cognitive delay	0.3	4	–5.393 (<0.001)
Emotional problems	0.2	1	–1.842 (0.066)
Learning disability	2	3	–1.187 (0.235)
Non-verbal learning disability	3	5	–1.657 (0.098)
Other diagnoses	15	16	–0.718 (0.473)

Table 2 | Developmental Sensory History questions.

Question/category
MATERNAL HEALTH DURING PREGNANCY[1]
Did the mother:
Have any infections/illnesses during pregnancy? If yes, please describe[1]
Have any shocks or unusual stresses during pregnancy? If yes, please describe[1]
Receive any medication during pregnancy? If yes, what kind[1]
Have any complications during delivery/labor? If yes, please describe
CHILD'S BIRTH
Was the child full term?[1]
Was the child premature?
Weight at birth[1]
Number of weeks[1]
Was the child breech (feet first)?
Did the child require forceps for delivery?[1]
Did the child require suction for delivery?[1]
Did the child have any birth injuries?[1]
Did the child require intensive care hospitalization?
Was the child jaundiced?[1]
EARLY CHILDHOOD ILLNESSES AND INJURIES
Has your child had any of the following? If yes, please describe and give approximate dates.
Childhood disease or major illnesses
Serious injury
Ear infections
Tubes in ears[1]
Allergies
Seizures
Other
INFANCY AND CHILDHOOD
Does or did your child:
Have feeding problems? If yes, please describe
Have sleeping problems? If yes, please describe
Have colic? If yes, for how long?[1]
Prefer certain positions as an infant? If yes, please describe[1]
Dislike lying on stomach?[1]
Dislike lying on back?[1]
Enjoy bouncing?[1]
Become calmed by car rides or infant swings?[1]
Become nauseated by car rides or infant swings?[1]
Go through the "terrible two"? If no, please describe your child's toddler stage[1]
DEVELOPMENTAL MILESTONES
Please provide approximate ages if remembered, or comment on anything unusual:
Roll over
Walk
Say words
Sit alone
Say sentences
Crawl
Was crawling phase brief?[1]
Was crawling stage absent?[1]
Did child experience hesitancy or delays in learning to go down stairs?[1]

[1]*These questions were missing from the adult Developmental Sensory History.*

Information from the Developmental Sensory History was divided into five areas. Pre-natal/Pregnancy: included information on maternal health during pregnancy. Birth History: included information on labor and delivery complications, birth-weight, and immediate post-natal health issues. Early Childhood Illnesses and Injuries: included information on common childhood illnesses and health issues. Infancy/Early Childhood Issues: included information on eating, sleeping, sensory and behavioral issues seen in early childhood. Developmental Milestones: included information on early childhood motor and language milestones. Pregnancy and birth history data were reported for all ages. Early childhood illnesses, childhood problems and developmental milestones were reported only for the 4–12 year-old age group. Data on the younger children showed many of them were not old enough to have reached the developmental milestones and many of the illnesses/injuries reported also occurred after age 4 so the data was not comparable across age groups. In addition, the older group often did not report developmental milestones, illnesses, etc. in enough detail to allow comparable data. Variable *N*'s in the data analysis reflect these differences.

PROCEDURES

Anonymous chart review of records of all current and discharged individuals who had received a sensory integration-based occupational or physical therapy assessment at the practice and who met the selection criteria of having one or more types of sensory integration deficit identified above were located through manual review of the records. Only existing data was reviewed once the study was initiated and included charts from 1997 to 2008. Prior to 1997 a different version of the Developmental Sensory History was used in the clinic and obtainable data was not comparable. Chart review began with the most recently completed assessments and worked backwards until 1000 participants with SPD with completed developmental sensory histories were enrolled. Chart review for the ASD group continued until appropriate Developmental Sensory Histories were no longer available resulting in 467 participants. The chart reviews and data entry were completed by research assistants. Data analysis, entered into SPSS version 15.0 (SPSS, 2006), was conducted by the third author, a statistician. As this study only included retrospective anonymous chart review of existing data, no informed consent was required. This study conforms to the guidelines established by the Office for Human Research Protection (OHRP), United States Department of Health and Human Services.

DATA ANALYSIS

Due to differences in the developmental histories and the inconsistency in parent reporting, there were consistently some missing items on most histories. Data analysis, therefore, reflects variable *N*'s to account for missing data. Questions were answered with "Yes/No/Don't know" responses to the questions described above and additional comments were recorded for the following items: during pregnancy – infections/illnesses, unusual stresses, and medications; complications during labor/delivery; birth injuries; and childhood diseases/illnesses. Data was extracted from the histories and divided into the five areas of interest. Where specific questions were asked, e.g. Was the child breech?, the data was coded directly. In many

cases, the questions were general and parents wrote in responses. These responses were recorded and then compiled and coded into variables after data collection was completed, e.g. responses of umbilical cord prolapsed and cord wrap were combined into cord insult at birth. In recording the data several guidelines were established for coding responses. First, responses were recorded in the appropriate category regardless of where parents reported the problem. For instance, some parents indicated there was a labor/delivery problem but did not provide any details, whilst others reported there were no problems but noted difficulties elsewhere on the form. These other difficulties were usually C-sections, which, when found were included as labor/delivery problems. Second, in order to eliminate common medical problems, data for mother's illness/infection during pregnancy and childhood diseases/illnesses was examined and in those cases where the only illness reported was cold or common flu these were removed and did not enter into the analysis. Occasionally the mother was reported as only taking common medications such as aspirin, Tylenol, cold medicine or vitamins during pregnancy and these responses were coded as "No" for medications.

Next, comment responses to various questions were grouped together according to common problems. For instance, the Developmental Sensory History included a single question about any complications during labor/delivery, the responses to this question were used to create six commonly reported variables: C-Section delivery, umbilical insult, prolonged labor, fetal distress, low fetal heart rate and high fetal blood pressure. In most cases we suspect that the findings presented under-report the specific problem as many factors relied on parents writing in the response rather than checking off a stated problem. This appeared particularly likely for the labor/delivery problem factors as well as for asthma as this was a variable derived from the comments included in response to the "other" item in the early childhood illness and injuries section.

In keeping with the preliminary explorative nature of this study data analysis was limited and is intended to identify potential relationships which may be worthy of further investigation. Descriptive statistics including percentages of incidence for each item, based on reported data, were calculated separately for the SPD and ASD groups. To answer the first question of what, if any, pre-, peri- and post-natal and developmental factors are common in children with SPD and in ASD the percentage of children reporting a problem on a given variable was calculated based on the number of valid responses for that factor. Examination of the percentage of valid responses for any given item was deemed the most useful information given the variable *N*'s for each factor. To answer the second question of whether there were significant differences between the SPD and ASD groups on any of the pre-, peri- and post-natal developmental factors, differences between the groups were examined using a two sample independent *t*-test. Due to the exploratory nature of the study and the desire to examine all possible significant relationships, no correction for multiple tests was conducted at this time. To answer the third question, descriptive comparisons with normative data is reported for factors where comparable information was available as statistical analysis was not possible with this information. Lastly, implications for future study and practice are discussed in the "Discussion" section.

RESULTS

PRE-NATAL/PREGNANCY FACTORS

Three pre-natal/pregnancy factors were examined: maternal stress, maternal illnesses, and maternal use of medications. Results found that both children with SPD and ASD have a relatively high incidence of mothers with health related problems or high maternal stress and there were no significant differences between the two groups. Maternal stresses were typically reported to be events such as job related stresses of the mother or father, early pregnancy bleeding and bedrest, marital or family stress, death or terminal illness of a loved one, and major moves or home renovations. Maternal illnesses were frequently reported to be gestational diabetes, hypertension or high blood pressure, diabetes, very severe flu, or pregnancy related illnesses such as pre-eclampsia or toxemia. Medications were not always specified but, when reported, were typically related to the above illnesses as well as mental health concerns such as depression or anxiety. Within the SPD group, 18% of mothers reported suffering shocks or stresses during pregnancy, 25.4% reported having a significant illness, and 26.1% reported being on medications for some significant health problem. Therefore, 44.7% of mothers reported having at least one or more of the above problems. Of those reporting problems, 26.3% had one problem, 13.6% had two of the above problems, and 4.8% had three. In the ASD group, 21.7% of mothers reported suffering shocks or stresses during pregnancy, 23.8% reported having a significant illness, and 28.4% reported being on medications. In this group, 44.7% had at least one or more problems, of these, 23.3% had only one problem, 15.9% had two, and 5.5% had three. See **Table 3**.

BIRTH/DELIVERY-RELATED FACTORS

Four birth and delivery factors were examined: delivery complications, assisted delivery methods, gestational age and birth weight of the infant, and birth-related injuries/illnesses. In the area of delivery complications parents reported on six delivery-related factors: prolonged labor, breech position, fetal distress, low fetal heart rate, and high fetal blood pressure. General report of delivery complications during delivery was an additional summary variable of all delivery complications. For both groups there was a high incidence in this factor, 42.1% for SPD and 37.8% for ASD, suggesting that it is quite common for children in both groups to have some type of delivery-related problem. There were no significant differences between the SPD and ASD groups on birth and delivery factors with the exception of fetal distress which was significantly higher ($p = 0.022$) in the SPD group at 4.4% compared to 1.9% in the ASD group. Our findings for the ASD group are in contrast to a previous study on children with ASD who found an incidence of 6.3% (Brimacombe et al., 2007). As

Table 3 | Percentage, valid *N*, and *T*-tests of pre-natal/pregnancy factors for SPD and ASD children.

Factor	SPD % (*N*)	ASD % (*N*)	*t* (*p*)
Maternal stress	17.8 (982)	20.7 (421)	0.656 (0.211)
Maternal illness	25.4 (988)	23.8 (421)	0.656 (0.512)
Maternal use of medications	26.1 (980)	28.4 (416)	–0.865 (0.387)

Note: No comparable normative data was available on these factors.

previously noted, it is possible our numbers were underreported. In regards to other specific types of problems reported, prolonged labor had the highest incidence, 8.0% for the SPD group and 10.1% for the ASD group which is similar to previous findings of 7.6% in children with ASD (Brimacombe et al., 2007). Breech position was found in 4.7% of the SPD group and 5.7% of the ASD group which is similar to reported norms of 4.7 (Martin et al., 2007). Low fetal heart rate was found in 3.0% of the SPD group and in 2.6% of the ASD group. High fetal blood pressure was seen in both groups at 0.9%.

The incidence of assisted deliveries of any kind (C-section, induced labor, forceps and/or suction) was moderately high and significantly different between groups ($p = 0.011$) with 36.1% for the SPD group and 43.5% for the ASD. There were no significant differences between groups on any individual assisted delivery factor. C-sections were moderate with 18.1% of the SPD and 21.6% of the ASD groups. This is slightly below the previously reported 29.9% incidence in children with ASD (Brimacombe et al., 2007). The reported incidence of C-section deliveries varies by year, however, national averages suggest an incidence of about 30% in the year 2005. The reported incidences of the SPD and Autism groups were within that level. The national average for use of forceps is reported to be 3.5% in 1995 after which the rate steadily declined to reach only 0.9% in 2005. Our SPD group had over double the early rate at 8.3% and the ASD group was also higher than average at 7.4%. Suction birth was 7.6% for SPD and 10.3% for ASD groups. Both groups were well above the national norm for suction/vacuum extraction of 5.9% in 1995, again the rate declined reaching only 3.9% in 2005 (Martin et al., 2007), with the ASD group's rate being double that rate. Levels of induced labor were low at 5.4% with SPD and 7.4% with ASD. This is well below the reported national average of 22.3% and a previously reported incidence of 25.7% in children with autism (Brimacombe et al., 2007). The results of this factor are very likely under-reported as this variable was recorded from information written in by parents and not a specifically asked question.

In the area of gestational age and birth weight, there were no significant differences between the ASD and SPD groups on any items. The SPD group had 12.4% born prematurely before 37 weeks of gestation and the ASD group had somewhat more at 16.0%. The SPD group was similar to the national average of 12.7% (Martin et al., 2007). The autism group was higher than the national average but commensurate with a previously reported incidence of 16.7% for children with autism (Brimacombe et al., 2007). The SPD group had 1.5% and the ASD group had 1.8% of births which were very low birth-weight (less than 3 lbs. 5 oz) which is similar to the national average of 1.5% (Martin et al., 2007). Incidence of low birth-weight (less than 5 lbs 8 oz) for the SPD group was lower than the 8.2% national average at 4.8% and average at 7.6% for the ASD group (Martin et al., 2007). Incidence of high birth-weight (above 8 lb 12 oz) was well above the 8.1% national average (Martin et al., 2007) for both the SPD (14.9%) and ASD (18.0%) groups. See **Table 4**.

Table 4 | Percentage, valid *N*, and *T*-test for birth and delivery-related factors.

Birth-related factors	SPD % (*N*)	ASD % (*N*)	*t* (*p*)
DELIVERY COMPLICATIONS			
General report of delivery complications	42.1 (987)	37.8 (426)	1.528 (0.127)
Prolonged labor	8.0 (982)	10.1 (424)	–1.282 (0.200)
Breech position	4.7 (948)	5.7 (406)	–0.708 (0.479)
Fetal distress	4.4 (982)	1.9 (424)	2.296 (0.022)
Low fetal heart rate	3.0 (982)	2.6 (424)	0.371 (0.711)
High fetal blood pressure	0.9 (982)	0.9 (424)	–0.048 (0.961)
ASSISTED DELIVERY METHODS			
Overall assisted delivery	36.1 (988)	43.5 (426)	–2.509 (0.012)
C-section	18.1 (983)	21.6 (426)	–1.528 (0.127)
Induced labor	5.4 (982)	7.5 (424)	–1.553 (0.121)
Forceps	8.3 (973)	7.4 (403)	0.546 (0.585)
Suction	7.6 (934)	10.3 (390)	–1.589 (0.112)
GESTATIONAL AGE AND BIRTH WEIGHT			
Born prematurely	12.4 (991)	16.0 (455)	–1.875 (0.061)
Very low birth weight	1.5 (584)	1.8 (395)	–0.279 (0.780)
Low birth weight	4.8 (584)	7.6 (395)	–1.822 (0.069)
High birth weight	14.9 (584)	18.0 (395)	–1.284 (0.200)

BIRTH-RELATED INJURIES AND ILLNESSES

In the area of birth-related injuries and illnesses parents reported on five factors: general birth injury, umbilical cord insult including cord wrap and cord prolapse, meconium present in amniotic fluid, jaundice (hyperbilirubinia) at birth, and need for intensive care. There were no significant differences between the SPD and ASD groups on any factors. Birth injuries were low with 4.7% of the SPD group and 6.0% of the ASD. This included a variety of problems from trauma to the head including severe bruising or cuts and scratches on the head from forceps to broken or dislocated bones. Umbilical cord insult which involved primarily umbilical cord prolapse and cord wrapped around the baby's neck, was found for 5.1% of SPD and 5.4% of ASD children. This finding is higher than a previous study on children with ASD which found an incidence of less than 1% for cord wrap at birth for children with pervasive developmental disorder and 1.2% for children with autism (Glasson et al., 2004). It is also significantly higher than the less than 1% found in a normative sample for cord prolapse (Koonings et al., 1990). Meconium staining was found for 3.1% of SPD and 2.4% of ASD children which was lower than the 5.5% national average (Martin et al., 2007). Intensive care following birth was required for 11.3% of children with SPD and 13.3% with ASD. Most notable, 25.5% of children with SPD and 30.2% of ASD children reported jaundice at birth. There were no significant differences between the groups on any variables although jaundice approached significance at $p = 0.077$. Incidence of jaundice was very high for both the SPD (25.5%) and ASD (30.2%) groups in comparison with reported norms of 7% (Setia et al., 2002) and a previous study which found an incidence of 18.1% of jaundice in children with ASD (Brimacombe et al., 2007). See **Table 5**.

EARLY CHILDHOOD ILLNESSES AND INJURIES

In the area of early childhood illnesses and injuries, seven factors were examined: report of significant childhood illness, report of serious injuries, repeated ear infections, insertion of tubes

in ears, presence of allergies, seizures, and asthma. Significantly more children with SPD (31.9%) reported significant childhood illnesses compared to children with ASD (26.4%) at $p = 0.010$. The most common illnesses reported were chicken pox, severe pneumonia, croup, and a variety of step-related viruses. A significantly higher percentage of children with ASD (68.5%) reported ear infections compared to children with SPD (61.6%) with $p = 0.010$. This result is below the reported incidence of 91.1% in one study in a large mid-Atlantic metropolitan city where children had one ear infection by 24 months of age (Paradise et al., 1997). However, the ear infection variable for this study may not be comparable to this finding. In the current study parents were simply asked if the child had ear infections. Review of the data indicated that most parents indicated "multiple" or "many" infections and tended not to indicate single occurrences and thus may better reflect an incidence of multiple ear infections. There was also a statistically significant difference on incidence of allergies with the ASD group reporting 37.7% and the SPD group reporting 23.6% with $p < 0.001$. There were no significant differences between groups for the other variables. The SPD group had ear tubes at a frequency of 13.9% and the ASD group at 11.8%. This finding is well above reported findings of 4.2% by age two (Paradise et al., 1997). Serious injuries were reported for 12.7% and 11.8% of the SPD and ASD groups respectively. Incidence of seizures was 7.9% in the ASD group compared to 5.4% in the SPD group. Asthma was reported in 8.0% of the SPD group and in 7.4% of the ASD group both of which are below the national average of 12.5% (Child and Adolescent Health Measurement Initiative, 2003). See **Table 6**.

Table 5 | Percentage, valid *N* and *T*-test of birth-related injuries and illnesses factors.

Birth illness or injury factors	SPD % (*N*)	ASD % (*N*)	*t* (*p*)
General birth injury	4.7 (976)	6.6 (407)	–1.456 (0.146)
Umbilical insult	5.1 (982)	5.4 (424)	–0.258 (0.796)
Meconium	3.1 (982)	2.4 (424)	0.721 (0.471)
Jaundice at birth	25.5 (950)	30.2 (398)	–1.768 (0.077)
Intensive care	11.3 (961)	13.3 (428)	–0.444 (0.657)

Table 6 | Percentage, valid *N*, and *T*-tests for early childhood illnesses and injuries factors.

Early childhood illness or injury factors	SPD % (*N*)	ASD % (*N*)	*t* (*p*)
Significant childhood illness	31.9 (988)	26.4 (459)	2.508 (0.012)
Serious injury	12.7 (992)	11.8 (458)	0.489 (0.625)
Ear infections	61.6 (991)	68.5 (457)	–2.556 (0.011)
Insertion of tubes in ears	13.9 (823)	11.8 (458)	1.047 (0.295)
Allergies	23.6 (990)	37.7 (459)	–5.593 (<0.001)
Seizures	5.4 (992)	7.9 (458)	–1.774 (0.076)
Asthma	8.0 (993)	7.4 (457)	0.340 (0.734)

INFANCY AND EARLY CHILDHOOD DEVELOPMENTAL PROBLEMS

In the area of infancy and early childhood developmental problems, 10 factors were examined: reported sleeping problems, feeding problems, colic, child preferring certain positions, child dislike of lying on back, child dislike of lying on stomach, child dislike of bouncing, child not calmed by swings or cars, child nauseated by swings or cars, and child not experiencing Terrible Two's. In general, both the SPD and ASD groups demonstrated moderately high incidences of these developmental problems with many factors over 20–30%. There were significant differences between the SPD and ASD groups in the factors of sleeping problems, feeding problems and child not calmed by swings or car rides. There were few national norms available for these problems. Both groups demonstrated a high incidence of sleeping problems. The Autism group had significantly more (43.7%) than the SPD group (32.4%) at $p < 0.001$. Feeding problems in both groups were also high with the ASD group significantly higher at 37.9% and compared to the SPD 31.5% at $p = 0.027$. Feeding problems had a reported incidence of 25–40% in national norms (Reau et al., 1996) with both the SPD and ASD groups falling in that range. The SPD group had a significantly larger percentage of children who were not calmed by swings or car rides at 18.7% compared to13.5% with the ASD group at $p = 0.028$. The ASD group had somewhat more colic than the SPD group (23.7% versus 19.7%). Incidence of colic varies greatly and has been reported between 5–28% (Lucassen et al., 2001). Both SPD and ASD fell in that range but at the high. Both groups reported similar high levels of preferred sleeping positions with 33.2% for SPD and 35.0% for ASD. They both disliked lying on the stomach at similar levels (SPD = 16.2%, ASD = 20.5%) and both disliked lying on back similarly (SPD = 10.1%, ASD = 12.5%). Both groups showed similar percentages of disliked bouncing with the SPD group at 13.4% and the ASD group at 10.3%. Both groups had no significant difference in being nauseated by swings or car rides with SPD = 6.3% and ASD = 5.4%. Both groups had a very large incidence of children who did not experience the terrible two's with SPD = 45.4% and ASD = 50.8%. See **Table 7**.

EARLY CHILDHOOD DEVELOPMENTAL MILESTONES

In the area of early childhood developmental milestones nine factors were reported: not rolling over by 6 months, not walking by 18 months, not saying words by 12 months, not sitting alone by 10 months, not saying sentences by 24 months, not crawling by 12 months, having a brief crawling phase, having an absent crawling phase, and demonstrating hesitancy on stairs. As would be expected, there were a number of significant differences between the SPD and ASD groups. The ASD group had more problems with delayed language with higher incidence of not saying words by 12 months (ASD = 55.4%, SPD = 33.3%, $p < 0.001$) and not saying sentences by 24 months (ASD = 55.8%, SPD = 20.8%, $p < 0.001$). The ASD group also demonstrated significantly more difficulties with the motor skills of having an absent crawling phase (ASD = 10.0%, SPD = 8.0%, $p = 0.016$), and demonstrating hesitancy on stairs (SPD = 28.3%, ASD = 40.1%, $p < 0.001$). Similarly, both groups demonstrated a high incidence of having a brief crawling phase (SPD = 29.1%, ASD = 36.9%). Both groups demonstrated similar low incidence on not rolling over by 6 months (SPD = 11.4%, ASD = 13.6%), not walking by 18 months (SPD = 6.1%,

ASD = 7.7%), and not crawling by 12 months (SPD = 6.0%, ASD = 9.3%). The ASD group had a significantly greater number of children who did not sit by 10 months of age with ASD = 6.5% and SPD = 2.9%, $p = 0.010$. The SPD group had double and the ASD group had triple the number of children who did not crawl by 12 months than the 3% national average. Both groups had similar high incidence of an absent crawling phase that was double the rate of 4.3% found in a large multicenter study (WHO Multicentre Growth Reference Study Group, 2006) with the SPD group at 8.0% and the ASD group at 10.0%. See **Table 8**.

Table 7 | Percentage, valid *N*, and *T*-tests of infancy and early childhood developmental problems.

Early childhood developmental problem	SPD % (*N*)	ASD % (*N*)	*t* (*p*)
Sleeping problems	32.4 (612)	43.7 (451)	–3.799 (<0.001)
Feeding problems	31.5 (626)	37.9 (448)	–2.210 (0.027)
Colic	19.7 (604)	23.7 (405)	–1.522 (0.128)
Child preferring certain positions	33.2 (512)	35.0 (363)	–0.548 (0.584)
Child dislike of lying on back	10.1 (555)	12.5 (383)	–1.711 (0.242)
Child dislike of lying on stomach	16.2 (568)	20.5 (395)	–1.714 (0.087)
Child dislike of bouncing	13.4 (551)	10.3 (390)	1.470 (0.142)
Child not calmed by swings or cars	18.7 (588)	13.5 (416)	2.207 (0.028)
Child nauseated by swings or cars	6.3 (576)	5.4 (408)	0.562 (0.574)
Child not experiencing terrible two's	45.4 (568)	50.8 (384)	–1.625 (0.105)

Table 8 | Percentage, valid *N*, and *T*-tests of early childhood developmental milestones.

Developmental milestone	SPD % (*N*)	ASD (%) (*N*)	*t* (*p*)
Not rolling over by 6 months	11.4 (429)	13.6 (337)	–0.928 (0.354)
Not walking by 18 months	6.1 (590)	7.7 (415)	–1.000 (0.318)
Not saying words by 12 months	33.3 (519)	55.4 (345)	–6.574 (<0.001)
Not sitting alone by 10 months	2.9 (509)	6.5 (369)	–2.573 (0.010)
Not saying sentences by 24 months	20.8 (452)	55.8 (251)	–10.075 (<0.001)
Not crawling by 12 months	6.0 (453)	9.3 (333)	–1.776 (0.076)
Brief crawling phase	29.1 (560)	36.9 (347)	–2.445 (0.015)
Absent crawling phase	8.0 (552)	10.0 (411)	–2.410 (0.016)
Demonstrating hesitancy on stairs	28.3 (573)	40.1 (399)	–3.880 (<0.001)

INCIDENCE OF MULTIPLE ISSUES

In an attempt to determine if there was any pattern of dysfunction in either the SPD or ASD groups the number of multiple problems identified in each area and overall were examined. **Table 9** presents the mean number of problems reported for the SPD and Autism groups. The mean is based on a simple frequency count of problems for each factor. Any missing data was assumed to indicate no problem in this analysis. Children with SPD reported an average of $M = 7.5$, SD = 3.63 problems while children with ASD reported an average of $M = 8.1$, SD = 3.90. This was a significant difference which was attributed to significant differences on gestational age, birth weight and delays in early developmental milestones.

This finding suggests that there is not one specific problem that is characteristic of either children with SPD or ASD, but each child is likely to demonstrate a number of problems with the ASD group exhibiting a greater number of problems. The number of infancy and early childhood developmental problems was highest with an average of 2 of 10 possible problems for both the SPD and ASD groups. Early childhood illnesses were next with an average of 1.5 for SPD and 1.7 for ASD of 7 problems and early childhood developmental milestones problems were similar with 1.2 for SPD and 1.7 for ASD of 9 common milestones. In general, these results suggest a child with SPD or ASD is likely to have one pre-natal/pregnancy problem, delivery complication, assisted delivery, gestational or birth-related injury/illness; one or more early childhood illnesses or injuries; two or more infancy/early childhood developmental problems; and one or more delayed early childhood developmental milestones. Because of missing values in the data we were unable to complete meaningful factor or cluster analyses to determine if there are patterns of problems.

DISCUSSION

Results of this study examined three major areas: pre-natal and birth-related factors; developmental signs; and infancy and early childhood health factors. Notably, no one problem was common to all children with SPD or ASD, as has been noted in earlier studies with both children with ASD and those with DCD (Mason-Brothers et al., 1990; Cermak et al., 2002). This finding likely points to the diverse nature of the possible etiologies of SPD and ASD, as well as the various subtypes within both diagnoses. What was clear, however, is that there appears to be a pattern of risk factors and any individual child will typically demonstrate one or more of the most prevalent problems, therefore, one does not want to dismiss the possible importance of examining for and attending to pre-, peri- and post-natal factors. Children with SPD had, on average, seven problems across five or more domains while those with ASD had an average of eight problems. In both groups these were likely to consist of one pre-natal/pregnancy problem, delivery complication, assisted delivery, gestational or birth-related injury/illness; one or more early childhood illnesses or injuries; two or more infancy/early childhood developmental problems; and one or more delayed early childhood developmental milestones, with the ASD group being more likely to have delayed developmental milestones other than an absent or brief crawling phase which was common in both groups.

Table 9 | Means, standard deviations, valid *N*, and *T*-tests of multiple problems by category.

Problem area	SPD *M* (SD) (*N*)	ASD *M* (SD) (*N*)	*t* (*p*)
Pre-natal/pregnancy problems	0.68 (0.882) (997)	0.66 (0.910) (462)	0.476 (0.634)
Delivery complications	0.37 (0.613) (992)	0.36 (0.597) (449)	0.171 (0.864)
Assisted delivery methods	0.39 (0.567) (993)	0.43 (0.571) (449)	–1.366 (0.172)
Gestational age and birth weight	0.25 (0.508) (992)	0.40 (0.620) (457)	–4.768 (<0.001)
Birth-related injuries and illnesses	0.50 (0.697) (993)	0.52 (0.728) (458)	–0.954 (0.340)
Early childhood illnesses and injuries	1.5 (1.15) (998)	1.7 (1.14) (464)	–2.269 (0.023)
Infancy and early childhood developmental problems	2.0 (1.61) (645)	2.2 (1.74) (465)	–1.876 (0.061)
Early childhood developmental milestones	1.2 (1.37) (629)	1.7 (1.40) (459)	–6.091 (<0.001)
All problems	7.5 (3.63) (622)	8.1 (3.90) (445)	–2.440 (0.015)

The findings of this study indicate that the mothers of nearly half of the children with SPD and ASD had some type of significant health-related issue or stress during pregnancy. There were no comparable norms available but the high incidence of this finding suggests that it may be an area of future investigation. While no studies have examined the relationship of maternal stress specifically to children with SPD or ASD, most studies indicate that maternal stress may be associated with negative outcomes during infancy so the high levels in these groups is of concern. During pregnancy maternal stress is associated with reduced blood flow to the fetus (Sjostrom et al., 1997) and fetal stress hormones levels (Gitau et al., 1998). Positive associations have been found between maternal anxiety, in the first half of pregnancy and behavioral disorders or negative emotionality in children at preschool age (Martin et al., 2000; O'Connor et al., 2002). Huizink et al. (2002) found that the ability of 8-month olds to pay attention during a developmental assessment was negatively correlated with the amount of anxiety their mothers' reported during pregnancy. Only one study has suggested that maternal anxiety during the middle trimester may be associated with better motor and mental development scores, DiPietro (2004).

The rates of assisted delivery methods, including forceps and suction deliveries, and high birth-weight were greater in both groups than national averages and consistent with a previous study on children with DCD which reported increased rates of breech birth, vacuum extraction, forceps use and C-section. (Hoare, 1991, unpublished). Suction use with ASD and forceps use with SPD were double national averages, while incidence of premature birth was higher only in the ASD group. These findings suggest that some assisted delivery methods are performed more frequently with SPD and ASD children than in the typical population which was also found in one study with ASD (Hultman et al., 2002). In addition, while incidence of individual delivery-related problems is generally low, breech position during delivery, like the DCD study, was a significant factor, although this was not the case for prior ASD studies. It may be that no one problem is unique to children with SPD and ASD but that the presence of any delivery complication regardless of nature is quite common. This is consistent with a previous study of children with DCD who found that 50% of mothers of children with motor coordination problems had pregnancy complications compared to 17% of a group of typical children (Hoare, 1991, unpublished).

In gestational age and birth weight, children with ASD were higher than average for low birth weight births. Both ASD and SPD were much higher for high birth weight births. These findings were consistent with a previous study on ASD that found problems with both high and low birth weight (Finnegan and Quarrington, 1979; Gillberg and Gillberg, 1983; Hultman et al., 2002) and on studies which have found positive relations between low birthweight and prematurity and motor coordination delays (Johnston et al., 1987; Fox and Lent, 1996; Hultman et al., 2002). Thus atypical birthweight, either low or high, may be a risk factor worth examining in more detail.

These findings suggest that SPD and ASD children do not generally have more frequent birth injuries or illnesses than expected for typical peers. However, umbilical cord insults and jaundice are areas that may reflect particular concern and should be examined further. In addition, incidence of colic varies greatly and has been reported between 5–28% (Lucassen et al., 2001). Both the SPD and ASD/SPD groups fell in that range but at the high end of normal and although within the range of normal, research indicates that there is a high incidence of SPD associated with colic and fussiness (DeSantis et al., 2007), thus this may be another area that warrants further investigation. Given the high incidence of SPD and ASD suspected in the population, the incidence of some of these events may not need to be significantly higher for these groups than in the typical population to cause trauma to the developing nervous system. Of the birth-related injuries and illnesses, incidence of jaundice was the most remarkably different statistic in comparison with a normative sample. Jaundice has been previously reported to be a potential causal factor in motor coordination problems in numerous studies (Johnston et al., 1987; Hoare, 1991, unpublished; Michelsson and Lindahl, 1993). In a study examining the effects of jaundice in 12 US medical centers, Newman and Klebanoff (1993) indicated that only minor motor abnormalities resulted. However, these minor motor problems are consistent with the soft neurological signs seen in children with DCD and are consistent with the types of coordination and praxis problems commonly found with SPD and ASD. Although jaundice may not result in cerebral palsy or other signs of hard neurological damage, the resultant dyspraxia that is common to both groups may have significant functional implications (Cermak and Larkin, 2002). In addition, a recent study has proposed that motor planning and praxis problems may be a defining feature of ASD (Dziuk et al., 2007).

These findings suggest that there are some differences between children with SPD and children with ASD on early childhood illness and injuries. Children with SPD had more illnesses, but children with ASD had more ear infections and allergies. Allergies and food intolerances of many types have been a suspected factor in autism (Bidet et al., 1993). Although reports of ear infections vary by area and demographic groups, children with SPD and ASD demonstrate a large number which may suggest that this area is worth looking at in more depth as clinically we observe that both groups have vestibular problems which have been previously associated with incidence of ear infections (Schaaf, 1985) and that children with ASD are often observed to have the most significant vestibular processing problems. Reports of many of the illness and injury factors in this area were moderate to high suggesting these factors may be an area of future study, in particular incidence of severe viral illnesses such as strep, may be pathogenic factors in autism (Persico and Bourgeron, 2006). Lack of comparable national norms for most items, however, makes it difficult to know at this time how these findings compare with typical peers.

The findings related to difficulties with developmental milestones were consistent with observations made during clinical practice and on previous studies on children with DCD. Feeding and sleeping problems are frequently reported by parents with both SPD and ASD. In areas related to sensory processing, both children with SPD and ASD had a subgroup of children not calmed by swings, although children with SPD had more difficulties. Difficulties in this area suggests problems processing vestibular information. Similarly, both children with SPD and ASD experienced a high incidence of hesitancy on stairs which may be an important characteristic of these groups. The significantly higher incidence in the ASD/SPD group may be due to the increased difficulty these children have with integrating vestibular, ocular and proprioceptive inputs relative to the SPD group. In addition, this behavior is characteristic of gravitational insecurity, a vestibular processing-based sensory integration condition. Both groups of children sometimes preferred certain positions which may be due to low muscle tone which in turn may be related to poor vestibular or proprioceptive processing, however the significance of a desire for certain positioning needs further study. These findings reflect a range of functional difficulties related to processing and integration of vestibular/ocular/proprioceptive inputs.

In the area of motor milestones, children with SPD and ASD did not differ from typical peers on incidence of delays in motor development such as sitting or walking, although Hoare (1991, unpublished) found children with poor coordination to walk later than typical children and Ahern (1995, unpublished) found 39% and Knuckey et al. (1983) found 83% of children with motor coordination problems were delayed in walking. Further, Johnston et al. (1987) found 13% of children to have delayed motor milestones while Gubbay (1978) found 18%. Atypical crawling was a characteristic for both groups with a total of 37% of the children with SPD and 47% of the children with ASD. This incidence was comparable to the 40% who had difficulty with crawling in a study on children with motor problems (Ahern, 1995, unpublished). In the current study, an absent crawling phase was approximately double for both groups in comparison to nationally reported numbers. Delays in sitting alone by 10 months were significantly higher for the ASD group. Language delays were found in both ASD and SPD, but more frequently in ASD as would be expected. Overall, delays in achieving both motor and language developmental milestones may be indicative of possible problems in both children with SPD and ASD but these findings suggest that these delays may not be an important distinguishing characteristics of SPD and ASD/SPD, with the exception of an absent or brief crawling phase; hesitancy on stairs; and lack of resistive behaviors at age two when most children begin to gain mastery and seek greater independence in motor exploration; and delayed sitting for the ASD/SPD group only.

Overall, this study has shown that there are many similarities between children with SPD and ASD on a number of items, but there were also a number where there were statistically significant differences between the two groups which may eventually be helpful in differential diagnosis. Children with SPD were found to have significantly higher incidences of fetal distress, incidence of childhood illnesses, and not being calmed by swings or car rides. Children with ASD were found to have significantly higher incidences of assisted deliveries, both higher and lower gestational ages and birth weights, allergies, ear infections, sleeping and feeding problems, not sitting alone at 10 months, language delay, and hesitancy on stairs. Therefore, this research provides a profile of a child with ASD having a greater degree of problems than a child with SPD, although similar trends on many variables were seen for both groups and in comparison to normative data.

Although ASD is diagnosed currently by behaviors primarily related to social and communicative skills, current research is increasingly focusing on difficulties in sensory processing (Baranek and Berkson, 1994; Tomchek and Dunn, 2007) and motor coordination/praxis (Dziuk, 2007) and how these difficulties may influence behavior in this group. It is possible that one day ASD may be recognized as having moderate to severe SPD as a primary component of the disorder and diagnostic criteria may be developed for ASD which includes both problems related to sensory processing and motor coordination as well as some salient peri-, pre- and post-natal factors. Interestingly, in both groups, approximately half of each group was reported to not experience the period of mastery and separation from parents referred to frequently as the "terrible two's". This may be evidence that many of the children have problems with praxis, the ability to plan and sequence the steps of a new or non-habitual task which is a frequent outcome of poor sensory integration of information from tactile, proprioceptive and vestibular senses. Further studies will be needed to illuminate this possible relationship.

CONCLUSIONS

The results of this study provide us with the first report on a large group of children with SPD showing the consistent association of unfavorable events in pregnancy, delivery, neonatal and infant phases and SPD. It also supports the previous findings of these associations with ASD and with DCD. As has been true for earlier studies on ASD and DCD, there is presently no specific unifying features. This study points to the likelihood of a variety of features being present with each of these diagnoses. Perhaps future studies will confirm that certain pre-, peri- and post-natal factors can be used to generate a high-risk historical and infant profile to use in conjunction with diagnostic tools. This may help to identify children at risk for these disorders earlier and lead to more effective interventions to enhance the quality of life for individuals with these diagnoses and their families.

At this time, it seems prudent to consider watching for possible signs of SPD in a young child when there is a history of major maternal stresses during pregnancy, fetal distress, jaundice, significant

childhood illnesses including chronic ear infections, sleeping and eating problems, and an absent or brief crawling phase, language delays, and a lack of separation from parents and mastery of motor skills by age three. Those who may be at risk for ASD may exhibit all of the above, perhaps to a greater degree or with higher frequency than those with only SPD, and may also have a greater likelihood of assisted deliveries, allergies, delays in sitting, and hesitancy to descend stairs.

LIMITATIONS OF STUDY

As an exploratory retrospective study there are many limitations to this study. The questions on the developmental history used for data collection were initially designed for clinical use rather than research and would have benefited from being more specific. Due to the fact that much of the data presented was gathered from additional comments parents made electively, it is likely that the results are under-reported on many items and would benefit from further investigation. The compilation and coding of such diverse data was somewhat subjective within guidelines established at the time of data collection but makes comparisons with normative data in other studies difficult as each study has collected somewhat different information. In addition, this information is gathered from parent recall rather than review of medical records and the length of time since birth and delivery varied due to the varying ages of children upon referral to the practice for evaluation or treatment. There were also a number of missing values in the data limiting the analyses. A major limitation was a lack of control group and non-matched groups of children in the two groups which would have been ideal due to demonstrated differences between groups. Because many of the factors studied vary in incidence by local, population, race and socio-economic status, a comparable control group would be considered important for future studies.

SUGGESTIONS FOR ADDITIONAL STUDY

It is suggested that further study of pre-peri natal and developmental factors be conducted to confirm and expand these results. It is suggested that future studies of pre-, peri- and post-natal development all include the items that have most commonly been found in previous studies to show problems for ASD and now SPD such as maternal and paternal age, birthplace of the mother, lack of oxygen at birth, incidence of jaundice, incidence of crawling and hesitancy to descend stairs, and incidence and frequency of ear infections, allergies, and asthma. It is important to detail these questions so that as much data can be collected as possible.

It is important to also examine the relationship of pregnancy/birth/childhood problems to specific sensory processing problems, e.g. hesitancy on stairs and incidence of vestibular/proprioceptive processing problems, and to determine if there are differences between the SPD and ASD populations. Future studies may also help to determine if there are inter-relationships between specific pregnancy/birth/childhood factors and later developmental outcomes, assisting in developing more precise diagnostic patterns for clinical use. Prospective examination of the incidence and relation of individual factors to specific subtypes of SPD is also recommended to determine if particular maternal, prenatal or peri-natal problems predict specific types of sensory processing problems.

Although this study did not examine any genetic factors, there is suspicion that genetics may play a strong role in the etiology of both SPD and ASD as well as DCD. Ayres (1979) hypothesized that genetic factors may make the brain more vulnerable than usual. On the Developmental Sensory histories used in this study, the questionnaire also contains a question asking if the person completing the history form, most commonly the mother, or any other relative has or does have similar problems. It is common for the parent completing the questionnaire to indicate that one or more relatives have similar issues, therefore, potentially reflecting a genetic component. Studies on children with motor coordination problems have supported this theory and found similar motor problems in close family members at an incidence of 20–30% (Gubbay, 1978; Johnston et al., 1987; Hoare, 1991, unpublished). For many individuals the potential interplay of genetic factors with pre-, peri- and post-natal events may create the conditions necessary to produce SPD and ASD. And it also may color our interpretation of the events found to be prevalent in this study. For instance, a higher incidence of forceps deliveries could be related to difficulty the fetus was experiencing due to genetically caused difficulties, and there are countless ways genetics could interplay with any of the noted pre-, peri- or post-natal events that occurred.

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