RESEARCH ARTICLE

Developmental Risk Signals as a Screening Tool for Early Identification of Sensory Processing Disorders

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Abstract

The main purpose of this research was to determine if the indicators of risk included in the Indicators of Developmental Risk Signals (INDIPCD-R) could differentiate between children at risk of sensory processing disorders (SPDs) from those with normal development and if the SPD indicators correlated with a delay or altered development. A retrospective, descriptive, correlational design was used with a sample of 51 children, 36 referred because of clinical sensory processing indicators and 15 with non-clinical indicators. Participants were assessed with a developmental scale Revised Profile of Developmental Behaviors (PCD-R), the Sensory Profile, play and clinical observations. The INDIPCD-R showed a high correlation with developmental areas of PCD-R and a sensitivity and specificity of 100%, when compared with the Sensory Profile. *T*-test results for independent samples showed significant differences at $p \leq 0.01$ level between the children with SPD indicators and those with no clinical signs in the PCD-R. The Mann–Whitney *U*-test was conducted for unpaired samples, to verify if there were significant differences between children with apparent SPD indicators and children with no apparent difficulties. The Spearman's rho was used to identify the correlations between the INDIPCD-R, with different areas of development. This study supports the use of the INDIPCD-R as a screening instrument that could be used by occupational therapists to discriminate children with and without indicators of SPD. The limitation of this study was that it did not cover all the ages of the INDIPCD-R. Additional studies are required to determine the utility of this instrument for outcome studies and whether it is valid and reliable to identify children at risk of different pathologies. The INDIPCD-R is a low-cost instrument that allows the occupational therapist to make a quick review of the different components that could be involved in SPD and therefore guide the more in-depth evaluation if necessary.

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Keywords

screening; child development; developmental scale; sensory processing

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Introduction

Sensory processing disorder (SPD) is a complex developmental disorder in which people over-respond, under-respond, excessively crave/seek out intense sensory experiences, have difficulty discriminating sensation or respond to sensory input in an atypical manner, impacting their daily life activities (Parham and Mailloux, 2005; Miller and Schaaf, 2008; Eeles, 2013).

Studies in the USA show that 5% of kindergarten children meet screening criteria for SPDs (Ahn *et al.*, 2004) and according to James *et al.* (2011), between 5% and 16% of all children entering preschool have SPD. Through its altered responses to stimuli and behavioural patterns, SPD can interfere with children's development and growth (Reebye and Stalker, 2007). Children with SPD often fail to perform the skills expected at their age, with the quality and dexterity necessary for motor and school learning (Cermak, 1985) and display difficulties in play, showing significantly lower playfulness than those of peers who are typically developing (Bundy *et al.*, 2007). In more severe cases, they develop stereotyped, rigid and maladaptive behaviours that can even compromise their overall development (Kramer and Hinojosa, 2010).

The need for effective screening instruments to identify young children at risk for developmental delays is well documented (AAP, 2006; BID, 2011). Approximately 25% of children who attend primary care centres in the USA show risk signals during their developmental process (Filipek *et al.*, 2000). While early identification reduces costs and increases the benefits of early intervention (Karoly *et al.*, 2005; Center on the Developing Child at Harvard University, 2008, 2010) according to the AAP (2006), failure to monitor child development may delay early detection and intervention and thus diminish the cost–benefit it offers. In accordance with Sices (2007), developmental delays are predictive of later learning and behavioural difficulties.

Most of the children with different pathologies such as autism, developmental coordination disorders, hyperactivity or learning problems are diagnosed when the child becomes older (Reebye and Stalker, 2007). Research shows that it is possible to detect risk signals that may compromise the child's development during the first year (AAP, 2006; Belinchón *et al.*, 2008). Most screening tools available today are based on missing or delayed developmental milestones even though they are not the only predictors of developmental problems (Meisels, 1989).

Regarding SPD, screening instruments have been developed to start early identification of the problem. Eeles *et al.* (2013) reported in their systematic review that more than 30 instruments measure sensory processing. However, only eight can be used for 2-year olds and only three include more than 50% of items related to sensory processing are criterion or norm referenced and are commercially available. None of these tests are currently validated in Mexico; none are based on developmental risks signals, and very few are available in Spanish.

The Indicators of Developmental Risk Signals (INDIPCD-R for its initials in Spanish), described in detail later, is a screening test based not on developmental milestones but on risk indicators: behaviours or difficulties that might appear in different stages of development (Bolaños, 2012). INDIPCD-R can be used with infants over 6 months old, has more than 50% sensory processing items, is norm referenced and will be commercially available in the near future.

Thus, the purpose of the study was to analyse whether the INDIPCD-R could be used as a screening instrument for early identification of children at risk of SPD at different developmental ages. The INDIPCD-R would fill in the gap in the currently available instruments.

Methods

Participants

Between 2005 and 2011, 42 children were referred to the clinic of the Instituto de Terapia Ocupacional because of difficulties in following instructions, participating in school activities such as handwriting, hypersensitivity to touch, moving constantly and clumsiness (referred group). In this period of time, 15 children with the same age range and parental economic status volunteered for a developmental evaluation as part of certification courses for the developmental scale Revised Profile of Developmental Behaviors (Perfil de Conductas de Desarrollo in Spanish) (PCD-R) (Bolaños, 2003, 2005; Bolaños *et al.*, 2006) (non-referred group). Participants were included in the study if they were not sick, were willing to cooperate, had been assessed with the Sensory Profile and the PCD-R and had an observation of their playing. Fifty-one children ages 6 to 48 months old met the inclusion criteria to participate in this study. Parents had given informed consent. Only three of these children had previous diagnoses; two were diagnosed with tubular acidosis and one with autism. These three children were included as they also presented SPD indicators.

Table 1 shows socio-demographic data of the children and families that participated in the study.

Table 1. Socio-demographic data

	n	%	*n*	%
Sex			51	100
Boys	34	67		
Girls	17	33		
Range			51	100
18.1 to 24 months	1	2		
24.1 to 36 months	12	24		
36.1 to 48 months	38	74		
Reason for referral			51	100
Referred from schools	36	71		
Volunteer for certification (non-referred)	15	29		
Diagnosis			51	100
Without diagnosis	48	94		
With diagnosis	3	6		
Socioeconomic level**			51	100
High	23	38		
Medium	25	54		
Low	3	8		
Mother's education			45	100
Junior high school	4	9		
Senior high school	8	18		
Completed professional studies	33	73		

**The socioeconomic levels were defined in accordance with the Mexican Association of Research Agencies Market and Public Opinion (AMAI).

Design

This was a retrospective, descriptive, correlational study that aimed to determine if the risk indicators included in the INDIPCD-R could differentiate between children at risk of disorders associated with SPD from those with normal development and if the SPD indicators were associated with a delay or altered development.

Instruments

Indicators of Developmental Risk Signals

The INDIPCD-R is a list of behavioural items in which the child's responses to the sensory input indicate failure to properly organize the input in accordance with their developmental stage. The INDIPCD-R acquired its name in Spanish from the Indicators of Risk from the Revised Profile of Behavioral Profile (Indicadores de Riesgo del Perfil de Conductas de Desarrollo Revisado).

Risk indicators are marked with an X starting from the beginning of the instrument to the item that corresponds to the chronological age of the child, in a Likert scale as follows: frequently (present 100% to 75% of the time), sometimes (present less than 75% to 15% of the time) or never (less than 15% or not present). After completing all the items, the evaluator sums the items that are present. Cut-off points were established to define low risk with scores at 1 standard deviation (SD) below the mean, mild risk with scores within the 1–2 SD below the mean and significant risk with scores below +2 SD. Both moderate and severe risks require a more comprehensive evaluation. The INDIPCD-R is scored by both the parent and the therapist.

The INDIPCD-R items were developed by an expert panel including a physical therapist, a language therapist, a paediatrician and two occupational therapists, who are certified in early screening and intervention.

The INDIPCD-R items were selected after a thorough review of the literature (DeGangi, 1991; Guz and Aygun, 2004; May-Benson *et al.*, 2009) and a comprehensive review of developmental risk indicators that children with SPD often failed in a developmental test. The items are related to motor organization, emotional regulation, sensory stimulus responses and complex skills acquisition. They can be observed in the daily play, school activities and the child's social interaction at different cut-off ages from 6 to 48 months. In order to evaluate item effectiveness, a discrimination index analysis was conducted to identify items with a discrimination score of 0.40 or more and eliminate the items without it (Dorantes Rodriguez, 2010). Three items were deleted, with a final number of 42 behaviours assessed. The number of items to evaluate depends on the child's age.

In 2010, the INDIPCD-R risk signals were reviewed with the aim of using them as an independent screening instrument. Subsequent studies were carried out to validate its application in the community. Discriminative and convergent validity of the INDIPCD-R was examined by comparing it with the developmental scale, PCD-R, as the gold standard. The sensitivity and specificity of the INDIPCD-R was studied in a sample of 218 children attending nurseries for vulnerable children (CENDIS), children of preschools and children referred to the clinic. The INDIPCD-R showed significant differences in the frequencies of risk indicators $p < 0.01$ in the aforementioned groups. In the group of children from the clinic, Kappa index: 0.940; sensitivity: 100%; specificity: 69%; positive predictive value: 90% and negative predictive value: 100%.

In the group from the CENDIS, Kappa index: 0.648; sensitivity: 94%; specificity: 84%; positive predictive value: 90% and negative predictive value: 91%. The results of the reliability analysis of the INDIPCD-R using the Cronbach's alpha analysis was $\alpha = 0.93$ indicating that INDIPCD-R is a tool that has internal consistency. The inter-rater reliability between therapists and parents and between parents and teachers was strong to moderate ($r = 0.94$ and $r = 0.62$, respectively). Both results were with 95% confidence interval of $p < 0.05$ (Bolaños *et al.*, 2015).

Profile of developmental behaviours revised

The Perfil de Conductas de Desarrollo (PCD-R) (Bolaños, 2005) is a developmental scale that assesses the development level of children aged between 0 and 4 years in different development areas. The PCD-R scoring is performed online, reducing the examiner margin of error. SDs, developmental coefficient and graphics are given by the programme (Bolaños, 2005).

The PCD-R is made up of 306 items and 11 development areas: sitting, crawling, standing, gait, expressive language, receptive language, emotional/social, fine motor, cognition and praxis, from 0 to 4 years. It uses a 0 to 3 ordinal grading scale. Several statistical analyses were conducted to establish its validity and reliability with a stratified sample of 579 children (Bolaños, 2003, 2005; Bolaños *et al.*, 2006). Content validity was carried out by external judges, and a theoretical revision was also conducted (De la Riva, 2007). Concurrent validity was examined with Bayley Scales of Infant Development II (EDIB II) (1993), which included an analysis of sensitivity and specificity (Bolaños *et al.*, 2006). In order to do the statistical analysis, the developmental areas of PCD-R corresponding to sitting, crawling, standing and gait were grouped as motor areas. Fine skills, cognition, praxis, expressive language and receptive language were grouped as mental areas. Emotional/social was kept as emotional area. Results showed 88% agreement between PCD-R and EDIB II in the motor area and 90% agreement in the mental area. In the emotional area, the percentage of agreement was 37.5%. A later qualitative analysis found that this low percent agreement was because at age 2 years, behaviours considered normal by the PCD-R, such as temper tantrums, are considered unacceptable by the EDIB II. The Specificity was high in all areas (90% in the motor area and 93% in the cognitive and emotional areas).

Construct validity was conducted with *Z*-test, in order to find the coefficient of development within the normal curve for the seven cut ages (Bolaños, 2005). The standard error of the PCD-R had a variability of 0.41 and 1.05, in accordance with what was expected for a developmental scale (Parker *et al.*, 1990). A reliability study to determine the internal consistency of the test was conducted using Cronbach's alpha. The results ranged from 0.8474 to 0.9719, depending on age range. Such studies confirmed that the PCD-R is a valid and reliable instrument for early detection of developmental delays and disorders in the metropolitan area of Mexico City.

The PCD-R was applied by health professionals who did not know that their scores were going to be part of the study.

Instruments used to identify sensory processing disorder

Sensory profile

The Sensory Profile (Dunn and Westman, 1997; McIntosh *et al.*, 1999) offers several instruments based on the child's age, which are answered by parents indicating the frequency of specific behaviours displayed by their child, in a Likert scale format. These scales analyse tactile, visual, auditory, gustatory/olfactory processing and sensitivity to motion, auditory filter, low/weak energy as well as sensory seeking. The two versions of the Sensory Profile used for this study measure functional behaviour associated with responses to sensory stimuli, are norm referenced and translated in Spanish.

Because of the age range of the participants in this study, two versions of the Sensory Profile were used:

(a) The infant and toddler sensory profile (ITSP) (Dunn, 2002), corresponding to 7 to 36 months of age and
(b) The brief/short sensory profile (BPS/SSP), for ages 36 months to adulthood. The reduced BPS/SSP has 38 items.

The ITSP's scoring uses quadrant categories in accordance with Dunn's model, while the BPS/SSP uses sensory channels. The BPS/SSP scores tactile, oral, olfactory, visual/auditory and movement sensitivity, sensation seeking, auditory filter and low energy. The ITSP was validated in the USA with a sample of 589 children aged 0 to 3 years, classified by age and sex.

Content validity was examined by an expert panel, and convergent validity was examined with the infant/toddler symptom. No construct validity is reported. Reliability with the Cronbach's alpha for the 7–36 months section scores were as follows: general: 0.6310, auditory: 0.6961, visual: 0.5453, tactile: 0.7149, vestibular: 0.4234 and oral sensory: 0.5518. Cronbach's alphas for quadrant scores were as follows: low registration: 0.6997, sensation seeking: 0.8580, sensory sensitivity: 0.7165, sensation avoiding: 0.6970 and low threshold: 0.8307.

Play observation

Each child participated in a 15-minute play observation, during which the child could choose from different play materials related to their chronological age. The examiner was an experienced occupational therapist observed by an occupational therapy student of the Master's programme and video recorded. The play objects were construction play material; an assembly car; puzzle; pencil, paper and crayons; ball and play dough. During the observation period, the focus was on evaluating spontaneous play behaviours related to motor praxis, discrimination and modulation such as hypersensitivity to touch, low tone, sensation seeking, play repertoire, attention span or very slow organization of play and material manipulation. The observation was discussed with the parents to see if the type of play behaviours observed were part of the regular pattern of play exhibited by the child. The video was analysed by the examiner and the student with regard to which behaviours were related to SPD, and the results of the play observation were integrated in a qualitative report given to the parents.

Identification of SPD indicators in the child was based on Sensory Profile scores and clinical observations.

Children were identified as having SPD indicators if they had a score of atypical performance in any category of the Sensory Profile and showed indicators in the clinical and the play observation.

Procedure

Each child was evaluated initially with a play session of 15 minutes, in which the mother, the examiner and the occupational therapy student were present. The play session was followed by the evaluation of the child with the PCD-R by a health professional trained in its application. While the child was being evaluated, the mother completed the ITSP or the BPS/SSP and the INDIPCD-R with the collaboration of another therapist.

Data analysis

For this study, SPD indicators were considered as existing if the child had at least one score more than 2 SDs below the mean in either version of the Sensory Profile and showed behaviours that interfered with their play, for example, clumsiness or inability to initiate or attend to play. If the child had coefficient of development scores in any area of the PCD-R within one or two SDs below the norm in any developmental area, it was considered a developmental delay in that area. If the INDIPCD-R showed scores below 1 or 2 standards deviations, the child would be considered at risk of SPD.

Data entry of the BPS/SSP, the ITSP, INDIPCD-R and PCD-R was made by a graduate student. SPSS 20 version was used for the data analysis. The Mann–Whitney *U*-test was conducted for unpaired samples to verify if there were significant differences between children with apparent SPD indicators (referred to the clinic) and children with no apparent difficulties (the non-referred children evaluated to obtain PCD-R certification). The Spearman rho was used to identify the correlations between the INDIPCD-R with the different areas of development of the PCD-R. An analysis of sensitivity to identify the proportion of children with a condition (SPD indicators) and specificity (without SPD indicators) was made with the INDIPCD-R and the Sensory Profile using the formula for sensitivity or true positive rate = true positive $[TP]/P = TP/(TP +$ false negative $[FN])$, specificity or true negative rate = true negative $[TN]/N = TN/(TN +$ false positive $[FP])$, TP = correctly identified; FP = incorrectly identified; TN = correctly rejected; FN = incorrectly rejected. No correlation was carried out with the two versions of the Sensory Profile because of the instruments' difference in scoring.

Results

Table 2 shows main trend measurements of PCD-R's development areas for all children.

The Mann–Whitney *U*-test for unpaired samples showed significant differences of $p \leq 0.01$ in all areas. Results appear in Table 3.

Table 2. Means, medians and data dispersion for the sample of this study

Developmental areas evaluated by PCD-R	Stand	Gait	Expressive language	Receptive language	Emotional	Feeding	Fine motor	Cognitive	Praxis
N	51	51	51	51	51	48*	51	51	51
Mean	85.27	90.82	90.35	95.84	94.88	92.71	90.27	94.94	85.06
Median	85.00	90.00	97.00	100.00	98.00	95.50	93.00	99.00	87.00
Standard deviation	20.642	16.149	24.772	20.798	20.953	19.073	19.861	19.170	21.720
Minimum DC	28	52	20	19	38	39	47	25	20
Maximum DC	122	119	128	129	123	123	121	127	122

PCD-R, Profile of Developmental Behaviors; DC, developmental coefficient.

*Three children refused to eat during the evaluation.

Table 3. Significance level between two groups evaluated with the PCD-R in the Mann–Whitney *U*-test

	PCD-R for referred and non-referred children		
	Referred group	Non-referred group	
PCD-R	*N* = 36 Median (Q1, Q2)	*N* = 15 Median (Q1, Q2)	*p* value*
Standing	80 (68, 91)	98 (87, 116)	0
Gait	86 (75, 98)	105 (97, 113)	0
Expressive language	89 (65, 103)	103 (97, 120)	0.004
Receptive language	93 (83, 109)	108 (100, 115)	0.002
Emotional	93 (81, 107)	112 (95, 118)	0.002
Feeding	96 (84, 106)	94 (90, 109)	0.013
Manual skill	93 (77, 110)	87 (81, 98)	0.01
Cognitive skill	99 (80, 109)	100 (83, 105)	0.011
Praxis	83 (75, 97)	93 (77, 102)	0

PCD-R, Profile of Developmental Behaviors; Q1, first quartile; Q3 third quartile.

*Mann–Whitney *U*-test.

Table 4. INDIPCD-R T Mann–Whitney *U*-test for referred and non-referred children

	Number of indicators for each group		
Group	Median	Q1, Q3	*p* value*
Referred group *N* = 36	6	3, 12	0
Non-referred group *N* = 15	2	0, 3	

INDIPCD-R, Indicators of Developmental Risk Signals; Q1, first quartile; Q3 third quartile.

*Mann–Whitney *U*-test.

The INDIPCD-R items with significant differences in the Mann–Whitney *U*-test between children referred to the clinic and the non-referred children are presented in Table 4. INDIPCD-R Items with a significant difference between children referred to the clinic and the children showing no delays are presented in Table 5.

In the correlational analysis of INDIPCD-R indicators and the PCD-R areas, it was observed that the items with the highest number of correlations were those related to the organization of hand movement (up to nine correlations), as well as the organization of general movement (mainly seven out of nine correlations). The ones related to emotional regulation also showed a high number of correlations. The items with the least number of correlations were those related to modulation.

Table 6, includes all the correlations that were significant in the different areas of development. It is interesting to note that the emotional/social area of the PCD-R showed significant correlations at $p \leq 0.01$ in several risk indicators that ranged from $r = 0.631$ in "Child does not participate in games and routines" to $r = 0.437$ in "Child does not respond looking back at adult", "Child only eats one food type", "Child does not express emotions" and "Child drops objects extending fingers".

Other indicators with high correlations related to play were as follows: ("Child does not explore toys") $r = 0.538$ and ("Child does not play alone") $r = 0.437$. These correlations were strong with moderate in accordance with Portney and Watkins (2009). Results are presented in Table 6.

When comparing the INDIPCD-R with the Sensory Profile, as we already mentioned, we have to take into account the scores of the two Sensory Profile instruments, the ITSP for children from 6 to 36 months and the BPS/SSP for children older than 36 months. If one score showed a definite difference, it was considered positive. On that basis, the INDIPCD-R showed high sensitivity ($n = 36$) and specificity ($n = 15$), both being 100%.

Table 5. Item significant difference between the two groups of children

Items in the INDIPCD-R	Mann–Whitney *U*-test	*Z*	Sig. asympt. (bilateral)
Difficulty to roll	202.500	−2.113	0.035
Difficulty to crawl	202.500	−2.113	0.035
Difficulty to reach sitting position	202.500	−2.113	0.035
Little movement variation	165.000	−2.808	0.005
Little body control	127.500	−3.517	0.000
Difficulty to stand up	183.000	−2.228	0.026
Child does not integrate two hands in required activities	150.000	−3.086	0.002
Child falls down often	160.500	−2.734	0.006
Child does not rotates hand	172.500	−2.670	0.008
Difficulty to chew food	210.000	−1.969	0.049
Child does not imitate tracing	189.000	−2.218	0.027
Difficulty to anticipate and catch ball	160.500	−2.816	0.005

INDIPCD-R, Indicators of Developmental Risk Signals.

*Bonferroni correction was used in the Mann–Whitney *U*-test to control type 1 error rate to determine significance at $p = 0.004$.

Table 6. Correlation analysis of Indicators of Developmental Risk Signals (INDIPCD-R) and Profile of Developmental Behaviors (PCD-R) developmental areas

Indicators of developmental risks of INDIPCD-R	Standing	Gait	Expressive language	Receptive language	Emotional	Feeding	Manual skill	Cognitive	Praxis
Related to modulation									
Child does not respond looking back at adult			0.474***	0.469**	0.437***	0.355**	0.477**	0.358**	0.389***
Noises bother child								0.358***	0.321*
Child only eats one food type			0.307*		0.437***	0.589***			
Child is slow to answer when someone speaks to him or her			0.454***	0.502***	0.467***	0.384***	0.450***	0.386***	
Child does not turn when listening to a sound				0.344**	0.319*				
Child drops objects extending fingers			0.307*	0.433***	0.437***	0.546***	0.301*	0.314*	
Motor organization with sensory base									
Difficulty to roll	0.378***	0.382***	0.365***			0.309*	0.345**	0.443***	0.324*
Difficulty to crawl		0.356**	0.483***	0.298*	0.430***	0.473***	0.429***		0.356**
Difficulty to reach from a sitting position	0.334**	0.484***	0.483***	0.442***	0.566***	0.608***	0.429***		
Child falls down often	0.433***	0.282*	0.366***	0.266*	0.270*	0.377***		0.355**	
Child does not integrate two hands in activities that require it	0.585***	0.533***	0.365***	0.336**	0.432***	0.438***	0.395***	0.356**	
Difficulty to chew solids		0.360***			0.334**	0.559***			
Child takes too much time to eat		0.347**	0.315*	0.302*	0.467***	0.738***			
Difficulty to initiate patterns of movement	0.469***	0.523***	0.349**	0.386***	0.381***	0.475***	0.333**		
Discrimination									
Little movement variation	0.481***	0.544***	0.539***	0.371***	0.492***	0.480***	0.514***	0.334**	0.457***
Little body control	0.421** 0.354**	0.319*	0.521***	0.337**	0.355**		0.449***	0.434***	0.423***

(*Continues*)

Table 6. (Continued)

Indicators of developmental risks of INDIPCD-R	Standing	Gait	Expressive language	Receptive language	Emotional	Feeding	Manual skill	Cognitive	Praxis
Difficulty to anticipate and catch ball									
Language not understandable to adults			0.444***	0.282*	0.288*		0.266*		
Child does not imitate vertical and horizontal tracing			0.390***	0.287*	0.287*	0.312*	0.309*		
Child does not rotate hand to accommodate	0.531***	0.591***	0.405***	0.402***	0.526***	0.545***	0.417***	0.305*	0.327**
Emotional regulation, social participation									
Child does not express emotions			0.329**	0.466***	0.437***	0.348**	0.331**	0.351**	
Hard for child to calm down			0.385***	0.544***	0.538***	0.416***	0.380***	0.593***	
Child does not participate in games and routines		0.398 ***	0.474***	0.469***	0.631***	0.589***	0.421***	0.403***	
Child does not show affection			0.329**	0.466***	0.437***	0.348**	0.331**	0.351**	
Praxis									
Child does not play alone	0.325*	0.271*	0.307*	0.469***	0.437***	0.399***	0.301*	0.403***	
Child does not explore toys			0.385***	0.576***	0.538***	0.455***	0.380***	0.593***	
Child does not draw a circle									0.286*
Child does not fulfil three simple orders				0.282*	0.288*	0.355**			
Child does not draw square						0.329*			0.324*
Child does not express verbally what he or she wants			0.582***	0.424***	0.407***	0.344**	0.382***	0.462***	
Does not start play				0.502***	0.467***	0.384***	0.303*	0.386***	

***Spearman correlation value. Significant correlation at 0.0001 level.

**Spearman correlation value. Significant correlation at 0.01 level (bilateral).

*Spearman correlation value. Significant correlation at 0.05 level (bilateral).

Discussion

This research showed that there is a difference in development of the children with SPD indicators and children with no SPD indicators of risk, a finding that has been pointed out in other research (Castillejos, 2006; Reebye and Stalker, 2007).

The differences between children identified with SPD and children with a normal pattern of development indicate that the use of developmental scales together with screening instruments (in this case PCD-R along with INDIPCD-R) in the early years can provide valuable information to identify SPD and thus begin early intervention. SPD is often related to other pathologies such as autism (May-Benson *et al.*, 2009), cerebral palsy, attention deficit disorders, developmental coordination disorders and regulatory disorders (DeGangi, 1991; Reebye and Stalker, 2007).

This study also found significant correlations between risk indicators associated with SPD and different areas of development. This provides evidence that the presence of developmental risk indicators during early stages of development can be associated with delays in different developmental areas, especially with the areas of emotional regulation and sensory processing. According to Cermak and Larkin (2002), compromised areas of development when associated with SPD, impact the child's occupational development, particularly with regard to personal care, feeding, sleep, hygiene, education and play/leisure.

The results of this study support the findings of Reebye and Stalker (2007), which demonstrate that children with sensory processing problems show response patterns and visible behaviours that interfere with the child's normal development. The INDIPCD-R detected risk indicators such as difficulties in integrating both sides of the body, which begin to be present in the early months, and that can still be present at 4 years of age.

It should be emphasized that in the developmental profile of children with SPD, some areas are within normal limits, while other areas show delays of 1 or 2 SDs,

while children with normal patterns in all areas have a more homogeneous development. Children with sensory processing indicators were particularly affected in areas of emotional regulation, motor organization and expressive language. Areas such as cognitive level and receptive language were less affected. This implies that children with SPD have difficulties in engaging in age-appropriate tasks in certain developmental areas.

Because 95% of the children tested achieved early developmental milestones (like sitting, crawling and walking) at the expected age, the results point to a need to test beyond only milestone achievement, underlining the importance of studies developed around risk signals at an early age that are not dependent on milestones.

The limitations of this study were age coverage, the uneven distribution of children per age range and sample size.

It did not include all the INDIPCD-R ages; the number of children for each age group varied considerably, showing significant differences in the distribution of ages of the sample, and the sample size was small. Another limitation was that a more rigorous qualitative analysis for the play observations was not included.

Regarding the BPS/SSP and the ITSP, because of the different types of results used by these instruments, it was not possible to integrate them.

Further studies will be needed to verify if the INDIPCD-R could be used for early screening of children with different pathologies: longitudinal studies to evidence the impact of intervention versus no intervention on the development of children with risk factors and validation studies with other sensory processing instruments and developmental scales.

The clinical utility for the occupational therapist is that it is a standardized screening instrument, easy to apply and grade and that it complements parents' perception with direct observation by the therapist. It can also give the therapist a quick overview of the different components that need further evaluation.

Conclusions

This study emphasizes the importance of early detection using reliable and valid screening instruments (AAP, 2006; Sices, 2007; BID, 2011)

This pilot study demonstrated that the INDIPCD-R is a valid instrument to be used independently from PCD-R, for children aged 18 months to 4 years. Furthermore, it can correctly discriminate between children at different developmental stages with or without developmental delays and disorders related to SPD.

The INDIPCD-R does include items from the different diagnostic subtypes of the Sensory Processing Theory of Miller *et al.* (2007). It not only focuses on modulation risk signals, including the emotional regulation criteria of Miller *et al.*, but unlike other available tests, it includes discrimination and praxis. Hence, it is in a better position than other existing instruments to discriminate children at risk of SPD.

The presence of developmental delays is always an indicator of risk signals. However, to exclusively consider developmental milestones is not a reliable way to identify more subtle problems like SPD. To assess a child's development and sensory processing patterns based only on the acquisition of developmental milestones such as sitting, standing and walking, can result in the delayed recognition of the problem rather than early identification.

Furthermore, considering motor problems, language delays, feeding disorders, behavioural problems, attention difficulties and other occupational performance difficulties as isolated developmental problems, may leave the underlying SPD problem unattended.

Additional studies are required with a larger sample to determine the utility of this instrument for outcome studies and whether it is valid and reliable to identify children at risk of different pathologies. A factor analysis with a larger sample would be useful to study whether the proposed theoretical organization of clusters, organized in accordance with Miller's nosology, is confirmed.

REFERENCES

Ahn RR, Miller LJ, Milberger S, McIntosh DN (2004). Prevalence of parents' perceptions of sensory processing disorders among kindergarten children. The American Journal of Occupational Therapy 58(3): 287–293.

American Academy of Pediatrics (AAP) (2006). Identifying infants and young children with developmental disorders in the medical home: an algorithm for developmental surveillance and screening. [Recovered in July 12 de 2013 pediatrics.aappublications.org] (Available at: www.pediatrics.org/cgi/doi/10.1542/peds.2006-1231doi:10.1542/peds.2006-1231)

Banco Interamericano de Desarrollo (BID) (2011). Programa Regional de Indicadores de Desarrollo

Infantil (PRIDI). Marco Conceptual. Equipo Gerencial del PRIDI. División de Educación, (SCL/EDU) NOTAS TÉCNICAS # IDB-TN-290.

Bayley N (1993). Manual for the Bayley Scales of Infant Development II. San Antonio, TX: Psychological Corporation.

Belinchón M, Hernández JM, Sotillo M (2008). Personas con Síndrome de Asperger, Funcionamiento, Detección y Necesidades. Madrid: Centro de Psicología Aplicada de la Universidad Autónoma de Madrid (CPA-UAM), Confederación Autismo España (CAE), Federación Española de Asociaciones de Padres de Autistas (FESPAU), España: Fundación Once.

Bolaños C, Mina-Lara MM, Ramos-Ortega G (2015). Indicadores de riesgo del Perfil de Conductas de Desarrollo como instrumento para la detección temprana de retrasos y alteraciones del desarrollo. Acta Pediátrica de México 36(3): 135–146.

Bolaños C (2012). Manual Indicadores de Riesgo PCD-R. México: Instituto de Terapia Ocupacional.

Bolaños C, Golombek L, Marquez A, De la Riva M, Sanchez Galicia C, Gutierrez García O, Elorza Perez Tejeda H (2006). Validez de Correlación del Perfil de Conductas de Desarrollo con la Escala de Desarrollo Infantil Bayley II. Acta Pediátrica de México 27(4): 190–199.

Bolaños C (2005). Perfil de Conductas de Desarrollo Revisado. México: Instituto de Terapia Ocupacional.

Bolaños C (2003). Estudios de validación del Perfil de Conductas de desarrollo (PCD) como instrumento para evaluar el nivel de desarrollo de los niños de 0–4 años. Boletín Médico del Hospital Infantil de México 60: 79–89.

Bundy AC, Shia SQ, Miller LJ (2007). How does sensory processing dysfunction affect play? The American Journal of Occupational Therapy 61: 201–208.

Castillejos L (2006). Relación entre los trastornos regulatorios y el desarrollo de niños de 3 años. Thesis to obtain the Master in Occupational Therapy. Mexico: Instituto de Terapia Ocupacional.

Center on the Developing Child at Harvard University (2008). In brief: the science of early childhood development. (Available at: http://developingchild.harvard.edu/download_file/-/view/64/) (Accessed February 2014.)

Center on the Developing Child at Harvard University (2010). The foundations of lifelong health are built in early childhood. (Available at: http://developingchild.harvard.edu/library/reports_and_working_papers/foundations-of-lifelong-health/)

Cermak S (1985). Developmental dyspraxia. In: Roy EA (ed). Neuropsychological Studies of Apraxia and Related Disorders (pp. 225–248). Amsterdam, North Holland: Elsevier Science.

Cermak S, Larkin D (2002). Developmental Coordination Disorder. Canada: Delmar.

De la Riva M (2007). Validez de Constructo de la Escala Perfil de Conductas del Desarrollo Revisado. Thesis to obtain the Master in Occupational Therapy. México: Instituto de Terapia Ocupacional.

DeGangi G (1991). Assessment of sensory, emotional and attentional problems in regulatory disordered infants. Infants & Young Children 3(3): 1–8.

Dorantes Rodriguez CH (2010). El Proyecto de Investigación en Psicología. De su génesis a su publicación. Mexico: Universidad Iberoamericana.

Dunn W, Westman K (1997). The sensory profile: the performance of a national sample of children without disabilities. The American Journal of Occupational Therapy 51: 25–34.

Dunn W (2002). Infant/Toddler Sensory Profile. User's Manual. San Antonio, TX: The Psychological Corporation.

Eeles AL, Spittle AJ, Anderson PJ, Brown N, Lee KJ, Boyd RN, Doyle lW (2013). Assessments of sensory processing in infants: a systematic review. Developmental Medicine and Child Neurology 55: 314–326. DOI:10.1111/j.1469-8749.2012.04434.x

Filipek PA, Accardo PJ, Ashwal S, Baranek GT, Cook EH, Dawson G, Gordon B, Gravel JS, Johnson CP, Kallen RJ, Ley SE, Minshew NJ, Ozonoff S, Prizant BM, Rapin I (2000). Practice parameter: screening and diagnosis of autism. Report of the Quality Standards Subcommittee of the American Academy of Neurology and the Child Neurology Society NEUROLOGY 55: 467–479.

Guz H, Aygun D (2004). Neurological soft signs in obsessive–compulsive disorder. Neurology India 52: 72–75. Available in: http://www.neurologyindia.com/text.asp?2004/52/1/72/6702

James K, Miller LJ, Schaaf R, Nielsen DM, Schoen SA (2011). Phenotypes within sensory modulation dysfunction. Comprehensive Psychiatry 52: 715–724.

Karoly LA, Kilburn MR, Cannon JS (2005). Proven Benefits of Early Childhood Interventions. Santa Monica, CA: RAND Corporation. Available in: http://www.rand.org/pubs/research_briefs/RB9145

Kramer P, Hinojosa J (2010). Frames of Reference for Pediatric Occupational Therapy. USA: Wolters Kluwer. Lippincott William & Wilkins.

May-Benson T, Koomar JA, Teasdale A (2009). Incidence of pre-, peri-, and post-natal birth and developmental problems of children with sensory processing disorder and children with autism spectrum disorder. Frontiers in Integrative Neuroscience 3: 31 Published online 2009 November 11. DOI:10.3389/neuro.07.031.2009 Recovered June, 2012.

McIntosh D, Miller LJ, Shyu V, Dunn W (1999). Development and Validation of the Short Sensory Profile. The Sensory Profile: Examiner's Manual. San Antonio, TX: The Psychological Corporation.

Meisels SJ, Provence S (1989). Screening and Assessment. Guidelines for Identifying Young Disabled and Developmentally Vulnerable Children and Their Families. Washington, DC: National Center for Clinical Infant Programs.

Miller LJ, Anzalone M, Lane S, Cermak S, Ostein E (2007). Concept evolution in sensory integration. A proposed nosology for diagnosis. The American Journal of Occupational Therapy 61: 135–139. DOI:10.5014/ajot.61.2.135

Miller LJ, Schaaf RC (2008). Sensory processing disorder in encyclopedia of infant and early childhood development, pp. 127–136.

Parham LD, Mailloux Z (2005). Sensory integration. In: Case-Smith J, Pratt ASPN (eds). Occupational Therapy for Children (pp. 356–409). San Louis Missouri: Elsevier Mosby.

Parker KC, Mainland MK, Amdur JR (1990). The diagnostic inventory for screening children. Psychometric, factor, and validity analysis. Canadian Journal of Behavioural Science 22(4): 361–367.

Portney L, Watkins M (2009). Foundations of Clinical Research: Applications to Practice (3rd edn.,). Upper Saddle River, NJ: Prentice Hall.

Reebye P, Stalker A (2007). Regulation disorders of sensory processing in infants and young children. BCMJ 49(4): 194–200.

Sices L (2007). Developmental screening in primary care: the effectiveness of current practice and recommendations for improvement. Commonwealth Fund Pub. 2007. (Available at: www.commonwealthfund.org/usr_doc/1082_Sices_developmental_screening_primary_care.pdf?section=4039) (Accessed July 2013.)