Impact of sensory processing dysfunction on fine motor skills in autism spectrum disorders

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Abstract

Introduction. Children with autism spectrum disorders predominantly exhibit social impairment but significant physical features are manifested as motor delays and deficits affecting their daily living. Though sensory integration is a basic component required for motor skills, the impact of sensory processing dysfunction on fine motor skills is not clear, which is explored in this study.

Methods. This cross sectional study was carried out in Vidy Sadha – school for children with special needs. Overall, 56 children diagnosed with autism spectrum disorders with the Childhood Autism Rating Scale were included in the study. Peabody Developmental Motor Scale-2 was used to assess the level of their fine motor skill, and the sensory profile served to evaluate their sensory processing dysfunction.

Results. Pearson’s correlation showed a strong positive correlation between the fine motor quotient and auditory, visual, vestibular, and tactile processing, with r > 0.7 and p ≤ 0.05. Beta value of logistic regression of tactile, vestibular, and visual processing was 0.554, 0.288, and 0.191, respectively, which conveys that tactile dysfunction has a major impact, followed by vestibular and visual processing deficits.

Conclusions. The study concludes that tactile, vestibular, and visual sensory dysfunctions appear to influence the fine motor skills, with tactile dysfunction exerting a greater impact. The result strongly emphasizes that paediatric therapists should individualize treatment on the basis of sensory dysfunction, which should be considered and simultaneously addressed when training fine motor function and activities of daily living.

Key words: autism spectrum disorder, sensory profile, fine motor skill, Peabody Developmental Motor Scale, sensory processing dysfunction

Introduction

Autism spectrum disorder (ASD) is a heterogeneous condition that affects social communication and social interactions, with restricted, repetitive, stereotyped patterns of behaviour, interests, and activities. The symptoms together limit and impair everyday functioning. ASD is a diverse condition affecting groups of individuals with a wide variety of disability and intellectual dysfunction [1]. ASD is a neurodevelopmental disorder with a serious developmental disadvantage to the child in the form of poor schooling and social function; it also affects adult productivity [2]. Globally, the incidence of autism is found to be 62/10,000 and there was an increasing incidence from 1998 to 2015, which reflects an increased level of recognition and documentation [3, 4]. According to WHO, 1 in 160 children had ASD in the year 2019, and an estimated prevalence of ASD in a selected population of school children in India was established to be 0.23%, whereas the prevalence in European countries ranged from 0.33% to 3.13% [5, 6]. Careful diagnosis and interdisciplinary approach with cooperation are mandatory to shorten the suffering of the ASD population [7].

Although ASD is considered a psychiatric disorder, physical features are associated with it and motor impairments in these individuals have been categorized as ‘associated symptoms’. Hypotonia, motor apraxia, reduced ankle mobility, history of gross and fine motor delay and toe-walking are the motor deficits clinically found in children with ASD [8]. These children showed similar deficits in gross and fine motor skills (FMS) as children with developmental delay, which indicates that all children with ASD should receive complete developmental evaluation, including assessment of their motor functioning [9]. Gross and fine motor assessment and programmes should be part of the early intervention plans to prevent further decline and isolation from social interaction with peers [10]. An empirical support for a direct link between motor and social impairments in ASD was found, which brought about general and specific implications for physical therapy [11]. The mean age of parental recognition of any abnormality in a child with ASD was 23.4 months, with a mean time lag of 4 months to seek professional help, and the final diagnosis established at 32 months of age [12]. Variations from typical development and delayed language progress are identified in many children with ASD by 24 months of age, and unusual slowing in performance occurred between 14 and 24 months of age [13].

Literature reveals that ASD children present gross and fine motor delay; gross motor deficits improve over time and the child gains motor independence at the time they reach for professional help but deficits in FMS interfere with the children’s activities of daily living even after interventional therapy, thereby blocking the child’s development. Reaching and grasping appear to be delayed in infants at risk for ASD. A mean delay of 8 months in FMS was observed over the first...
and second years of life in a range of behaviours, including clapping, pointing, playing with blocks and puzzles, and turning doorknobs [14, 15]. Motor performance in ASD children was slower and weaker in hand grip strength, which would affect their FMS [16].

Smooth, targeted, and accurate movements, both gross and fine, require a harmonious functioning of sensory input, central processing of information in the brain, and coordination with the high executive cerebral functions [17]. Sensory integration is the ability to receive information through the senses of touch, movement, smell, taste, vision, and hearing and to combine the resulting perception with prior information, memories, and knowledge which is already stored in the brain, in order to derive coherent meaning from the processed stimuli. A distinctive pattern of sensory processing and evidence of a variety of sensory processing dysfunction (SPD) are common with ASD [18, 19]. Ninety percent of children with ASD showed some degree of SPD of under-responsiveness or sensation seeking in auditory filtering and tactile sensitivity [20]. Early onset of extreme sensory modulations in toddlers with ASD was found and 95% of the sample demonstrated some degree of SPD and sensitivity to tactile input [21, 22].

Abnormalities in responses to sensory stimuli include both hypo- and hypersensitivity to stimuli that could be in low threshold (LT) or high threshold (HT), which inhibits participation in productive activities and burdens the activities of everyday life [23]. Though sensory integration is a basic component required for motor skills, the impact of sensory integration deficits on FMS is not clear. Hence, this study tries to explore the influence of SPD of various senses on FMS; the results would be helpful in setting realistic goals in comprehensive rehabilitation of children with ASD.

**Subjects and methods**

**Subject recruitment**

The subjects were recruited from the Vidya Sudha – school for children with special needs, Sri Ramachandra Institute of Higher Education and Research. A total of 56 children of both genders (48 males and 8 females), aged 3–5 years (mean age: 43.03 months), diagnosed with ASD with the Childhood Autism Rating Scale were included in the study.

Children diagnosed with ASD by a psychologist using the Childhood Autism Rating Scale were included in the study after due informed consent from their parents or caretakers. PDMS-2 was used to assess the level of their fine motor development; depending on the chronological age, the items were administered in each subtest in accordance with the guidelines provided in the manual, and the raw score was calculated. The obtained raw score for each subtest was converted to age equivalent, percentile, and standard. The sum of the standard scores for the fine motor subscale was converted to FMQ. On the basis of the standard scores and quotient scores, the infant motor development was ranked as very superior, superior, above average, average, below average, poor, or very poor. After the assessment with the sensory profile, where the caregiver answered the questionnaire to evaluate the child’s sensory processing deficits, the components were scored accordingly.

**Instrumentation**

**Peabody Developmental Motor Scale-2**

The Peabody Developmental Motor Scale, 2nd edition (PDMS-2) is composed of 6 subtests that measure interrelated abilities in early motor development. It was designed to assess gross motor skills and FMS in children from birth through 6 years of age [24]. The subtest measures are: reflexes, stationary, locomotion, object manipulation, grasping, and visual motor integration. All of the PDMS-2 subtests contribute to the total motor quotient, which is considered as the best estimate of overall motor abilities. The grasping and visual motor integration subtests contribute to the fine motor quotient (FMQ) score.

The grasping subtest measures a child’s ability to use their hands. It begins with the ability to hold an object with one hand and progresses up to actions involving the controlled use of the fingers of both hands to button and unbutton garments.

The visual motor integration subtest measures a child’s ability to use their visual perceptual skills to perform complex eye-hand coordination tasks, such as reaching for and grasping an object, building with blocks, and copying designs.

**Sensory profile**

The sensory profile provides a standard method to measure a child’s sensory processing abilities and to profile the effect of sensory processing on functional performance in the daily life of a child. The sensory profile is a judgment-based caregiver questionnaire. Each item describes the child’s response to a particular sensory experience [25]. The caregiver who has daily contact with the child completes the questionnaire by reporting the frequency with which these behaviours occur (always, frequently, occasionally, seldom, or never). The professional then scores the responses in the questionnaire.

**Procedure**

Children diagnosed with ASD by a psychologist using the Childhood Autism Rating Scale were included in the study after due informed consent from their parents or caretakers. PDMS-2 was used to assess the level of their fine motor development; depending on the chronological age, the items were administered in each subtest in accordance with the guidelines provided in the manual, and the raw score was calculated. The obtained raw score for each subtest was converted to age equivalent, percentile, and standard. The sum of the standard scores for the fine motor subscale was converted to FMQ. On the basis of the standard scores and quotient scores, the infant motor development was ranked as very superior, superior, above average, average, below average, poor, or very poor. After the assessment with the sensory profile, where the caregiver answered the questionnaire to evaluate the child’s sensory processing deficits, the components were scored accordingly.

**Data analysis**

The data were analysed with the SPSS software, version 17.0. Pearson’s correlation was used to find the relationship of FMS with LT and HT of various senses, and backward logistic regression served to determine the SPD which predominately influenced FMS in ASD.

**Ethical approval**

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of Sri Ramachandra Institute of Higher Education and Research (IEC/NI/14/JAN/38/11).

**Informed consent**

Informed consent has been obtained from the legal guardians of all individuals included in this study.

**Results**

Table 1 presents the demographic characteristics of the investigated children and the sensory processing results.
LT and HT subscales scores of auditory, visual, vestibular, and tactile dysfunction were positively correlated with FMS, with a statistically significant $p$ value of $< 0.05$ (Table 2).

Tactile, visual, and vestibular dysfunctions had a highly significant impact on FMS. Auditory dysfunction was found to exert an influence but comparatively lesser than the previous 3 factors. Multisensory and oral processing did not have an impact on FMS (Table 3).

**Discussion**

Children with ASD become anxious when they respond to and interpret their environment. As the child attempts to process the sensory information, their ability to concentrate and stay focused may become impaired. Fine motor activity demands focusing and attention, but attention becomes distracted in ASD children owing to various sensory processing abnormalities which make the processing slow, inconsistent, or abnormal. The purpose of this study was to

### Table 1. Study participants’ demographics and sensory processing results

| Factors                        | Mean (SD)         |
|--------------------------------|-------------------|
| Age                           | 43.03 (3.35)      |
| Gender                        |                   |
| Males: $n = 48$               |                   |
| Females: $n = 8$              |                   |
| Fine motor quotient           | 69.86 (9.422)     |
| Auditory processing           | 22.41 (5.546)     |
| Visual processing             | 29.39 (5.119)     |
| Vestibular processing         | 38.59 (6.161)     |
| Tactile processing            | 52.48 (7.006)     |
| Multisensory processing       | 22.55 (4.268)     |
| Oral processing               | 42.13 (7.025)     |

| Factors                        | n | Mean | SD  | $r$ (correlation with FMQ) | $p$       |
|--------------------------------|---|------|-----|---------------------------|----------|
| Auditory processing            |   | 17.67| 4.70| 0.701                     | 0.00     |
| Visual processing              |   | 23.58| 4.45| 0.617                     | 0.00     |
| Vestibular processing          |   | 23.39| 3.43| 0.620                     | 0.00     |
| Tactile processing             |   | 29.41| 5.62| 0.771                     | 0.00     |
| Multisensory processing        |   | 23.07| 3.32| 0.526                     | 0.00     |
| Oral processing                |   | 15.16| 4.00| 0.660                     | 0.00     |

FMQ – fine motor quotient, LT – low threshold, HT – high threshold

### Table 2. Correlations of fine motor quotient and sensory processing

| FMQ                             | n | Mean | SD  | $r$ (correlation with FMQ) | $p$       |
|---------------------------------|---|------|-----|---------------------------|----------|
| LT and HT subscales             |   | 69.86| 9.422|                           |          |
| Auditory processing HT          |   | 17.67| 4.70 | 0.701                     | 0.00     |
| Visual processing HT            |   | 23.58| 4.45 | 0.617                     | 0.00     |
| Vestibular processing HT        |   | 23.39| 3.43 | 0.620                     | 0.00     |
| Tactile processing HT           |   | 29.41| 5.62 | 0.771                     | 0.00     |
| Multisensory processing HT      |   | 23.07| 3.32 | 0.526                     | 0.00     |
| Oral processing HT              |   | 15.16| 4.00 | 0.660                     | 0.00     |
determine the impact of SPD on FMS in children with ASD. The mean FMQ was found to be 69.86, which shows that the subjects had poor performance in grasping and visual motor integration. This result was similar to the observation by Provost et al. [26], who compared the level of gross motor and fine motor development in children with ASD and concluded that the motor profile of children with ASD was analogous to that of children with developmental delay who did not have ASD.

The mean score for auditory, vestibular, tactile, and multisensory processing was 22.41, 38.59, 52.48, and 22.55, respectively, which indicates a definite difference in these components; the mean score for visual and oral processing was 29.39 and 42.13, respectively, which implies a probable difference in sensory processing leading to atypical performance with reference to normal children. This finding is in line with the results of a cross-sectional study performed by Kern et al. [27], who suggested that autistic people presented abnormal auditory, visual, tactile, and oral sensory processing as compared with the control group and that the deficits were global in nature and had a potential to improve with age.

The correlation between FMQ and SPD in LT and HT stimuli was positive for all sensory except oral processing, which is supported by a study by Liu [28], who revealed that delayed sensory processing of visual, auditory, and tactile stimuli was related to gross and fine motor difficulties in children with ASD. Tactile defensiveness may prevent manipulating objects and the decreased body awareness due to tactile processing dysfunction impairs learning to grasp objects efficiently. This is evident in the strong correlation of tactile processing of LT stimuli and FMQ, with $r$ value of 0.77. The result is supported by a study performed by Case-Smith [29], in which children with both defensiveness and discriminative problems demonstrated the least efficiency in all hand manipulation tasks and had significantly higher time scores on the turn and translation in hand manipulation tasks.

Children with vestibular processing dysfunction face difficulty in stabilizing their trunk, shoulder, and arms while using an upper limb for grasping objects and respond negatively to unexpected or loud distracting noises. FMS require concentration and focus on task, and this processing dysfunction may distract the child from completing the task; thereby, activities of daily living are also impaired. The authors state no conflict of interest.

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