

Original

Characteristics and Alterations of Food Intake in Children with Pervasive Developmental Disorders —Behavioral Analysis of Spoon Feeding—

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Abstract: Studies on feeding behaviors of children with pervasive developmental disorders (PDD) have focused mainly on problematic behaviors such as food selectivity and how to deal with them. Few studies have addressed the motor aspects of feeding behavior. This study aimed to determine the characteristics of feeding behavior of children with PDD using a spoon. The study participants consisted of 8 children with PDD attending a children's disability center (6 boys and 2 girls; mean±SD=36.1±4.2 months). Feeding behaviors of the participants at lunch time were videotaped. They were also assessed with the Enjoji Scale of Infant Analytical Development Test on the same day. These 2 assessment procedures were repeated about one year later. The control group consisted of 5 healthy children (2 boys and 3 girls; mean±SD=43.2±7.4 months). The following results were obtained. Comparison between the children with PDD and controls showed significant differences in “motion of lips during food intake” and “neck rotation”. Correlations between the feeding assessment and the Enjoji Scale were as follows. On the first assessment, “motion of the lips during food intake” did not correlate significantly with any items of the Enjoji Scale. However, on the second assessment, this item showed significant correlations with all Enjoji Scale items. The characteristics of children with PDD were considered to lesser motion of the lips and neck rotation. We speculate that development of lip motions might be greatly influenced by therapeutic education.

Key words: feeding function, spoon feeding, lip motions during food intake, The Enjoji Scale of Infant Analytical Development Test, Pervasive Developmental Disorders.

Feeding function can be investigated or treated based on a 5-stage process of ingestion: pre-oral (anticipatory), preparatory, lingual, pharyngeal, and esophageal.¹⁾ Oral intake of food starts in the preparatory stage, and this process is considered to have a large effect on subsequent processes.^{2,3)}

In healthy infants, feeding function develops along with the change of food material. After birth, feeding behavior is mostly restricted to sucking milk. In the weaning period, infants start to acquire solid food intake functions. The oral function for solid food intake consists of swallowing, capturing, and mastication.⁴⁾ In the later weaning period, infants gradually become independent in eating by starting to feed themselves with the fingers.⁵⁾

This “finger feeding” leads to motor coordination development of the jaw, lips, arms, and fingers. After this process, they begin “spoon feeding.”

For the purpose of identifying and treating problems as early as possible, a number of assessment methods for feeding function of infants have been reported; however, most oral assessments are restricted to mastication function. In these assessments, the lips are assumed mainly to serve a sealing function during mastication. An assessment method for evaluating hand-mouth coordination during spoon feeding in healthy infants was developed.⁶⁾ This assessment method, designed to evaluate hand-mouth coordination and lip motions during food intake, was subsequently applied to a study of hand-

mouth coordination during food intake in intellectually handicapped children.⁷⁾

According to the Diagnostic and Statistical Manual for Mental Disorders IV TR,⁸⁾ PDD consists of Asperger's disorder, Childhood autism, PDD not otherwise specified, Rett's disorder and Childhood disintegrative disorders.

The diagnostic criteria for autistic disorder include qualitative impairment in social interaction, qualitative impairment in communication, restricted repetitive and stereotyped patterns of behavior, interests and activities. A significant research effort was made to investigate the underlying causes of these conditions, and developmental impairment in the central nervous system has been considered to play an important role.⁹⁾ While communication is an important aspect of diagnostic evaluation of children with autistic disorder, the presence of sensory and motor impairments also has been indicated.^{10, 11)} Children with PDD display a variety of feeding-related behavior problems. Food selectivity and pica are frequently observed.¹²⁾ In addition, other problematic behaviors such as eating while walking around, throwing food, and shoveling food into the mouth have been reported.¹³⁾ These feeding-related behavior problems emerge in infancy and disturb parents.¹⁴⁾ Therapeutic approaches for these problematic behaviors have also been reported.¹⁵⁾ On the other hand, the number of studies focusing on motor aspects of feeding function is small. Although there is a report indicating lesser mastication,¹⁶⁾ the underlying cause has not been clarified. Given that feeding function is a motor act triggered by sensory input, sensory and motor aspects of feeding disorders in children with PDD warrant study.¹⁷⁾ Oral intake of food starts in the preparatory stage, and this process is considered to have a large effect on subsequent processes. This study aimed to determine the characteristics of lip motion and hand-mouth coordination during food intake in children with PDD, using the assessment criteria developed by Tamura et al⁶⁾ and to identify factors related to the developmental changes.

Methods

Participants and Procedures

Study participants were selected from among children with PDD attending a children's disability center. Informed consent for study participation was obtained from the parents. Eligible 8 children (6 boys and 2 girls; age range, 31–42 months, mean±SD=36.1±4.2 months) capable of self-feeding were videotaped while eating at 2 time points with the intervals of about one year. Participants ate a dish of rice in their therapy room. None of therapists helped them.

This study was conducted between July 2008 and December 2009. To evaluate feeding behavior changes, participants were videotaped while eating. In addition, The Enjoji Scale of Infant Analytical Development Test¹⁸⁾ (Table 1) was implemented on the same day because this scale test was derived from a large scale survey conducted in 1977 on 1,718 infants (854 boys and 864 girls) and has been widely used in Japan.

The videotaping was performed by the first author, and the assessment was done by all authors. We had more than fifteen years' experiences for conducting the assessment. The assessment criteria for food intake behavior are shown in Table 2. These items were revisions of the criteria developed by Tamura et al⁶⁾ and Nomoto et al.⁷⁾ Examples of the assessment are shown in Fig. 1.

The control group consisted of 5 typically developing children with neither body structure nor function abnormalities (2 boys and 3 girls; age range, 32–52 months, mean±SD=43.2±7.4 months). Their feeding behaviors were videotaped under the same conditions as those for the PPD children.

In the feeding assessment, the participant ate white rice using a spoon and dish which they had been using at the disability center. No one highly preferred white rice or disliked it. All of them moderately preferred.

Scores for each of the assessment items were compared between two datasets, i.e., the first vs. the second assessment for the PDD children; the first assessment

Table 1 The Enjoji Scale of Infant Analytical Development Test (part).

Age (months)	Exercise		Sociality		Language	
	Physical movement	Hand movement	Basic daily habits	Personal relations	Speaking	Understanding of language
46	Child can hop with one foot for a few times.	Cut a sheet of paper along a straight line.	Child can wash his body by himself to some extent.	Go to a friend's house to play giving a mother notice beforehand.	Give the parents' names and address.	Give instructions of objects by their usage.
42	Child can jump forward with both feet.	Child can write a cross.	Child can blow his nose.	Use things by turns with friends.	Repeat a sentence. e.g. A pretty flower is in bloom.	Understand the numerical concept.
38	Child can tumble by himself.	Child can fasten buttons by himself.	Child can wash his face by himself.	Ask permission such as : Can I do this?'	Have a conversation with the children of the same age.	Understand the difference between high and low.
35	Stand still for a few seconds on one foot.	Child can cut a piece of paper with scissors.	Child can take off a coat by himself.	To be able to play house.	Repeat two combined words.	Understand the difference between red, blue, yellow, and green.
32	Turn around while standing	Child can write a circle following the example.	Child can put on his shoes by himself.	Try to look after smaller children.	Repeat two combined numbers.	Understand the difference between long and short.



Typically developing child

Child with PDD

3	Positioning of spoon bowl during food intake	2
3	Motion of the lips during food intake	2
3	Neck rotation	2
3	Occupancy of spoon bowl to aperture of mouth	3

Characteristics of Food intake behavior
 This typically developing child is in a stable upper body position, and ingesting food by closing the lips. The child is putting the spoon into the mouth at the middle of the lips.
 This child with PDD, rotating the neck to the right, is ingesting food by pulling the spoon out of the mouth because of poor strength of the lips. The position of the right upper limb is apart from the middle of the trunk.

Fig. 1 Examples of assessment when taking in food.

for the PDD children vs. the assessment for the controls; the second assessment for the PDD children vs. the assessment for the controls. The data were statistically

analyzed using the Mann-Whitney U test, with SPSS ver. 19.0. Subsequently, correlations between the feeding assessments (first and second) and Enjoji Scale were

Table 2 Criteria for Functional Examinations of Eating Behavior.

1. Positioning of spoon bowl during food intake
1) Passing across the front teeth
2) Contact with front teeth
3) Touch lip or food in spoon
2. Motion of the lips during food intake
1) Not working (capturing with the teeth)
2) Working slightly (food intake by spoon handling)
3) Food capturing with the lips
3. Neck rotation
1) Frequent
2) Occasional
3) Never
4. Occupancy of spoon bowl to aperture of mouth ^a
1) Parallel
2) Less than 45 degrees
3) More than 45 degrees

Criteria for the functional examinations were composed of 3 categories, assigned scores of, 1, 2 or 3 points, respectively.

^a Occupancies of spoon bowl were divided into 3 groups based the angulation on the horizontal plane between the long axis of the spoon and the aperture of the mouth.

calculated using Spearman's rank correlation test, again with SPSS.

This study was approved by the ethics committee of the School of Dentistry, Showa University (approval No. 2008-12).

Results

1. Proportions of each score in the feeding assessment

The proportions of each score in the feeding assessment for children with PDD (first and second assessments) and the controls are shown in Fig. 2.

As for "positioning of spoon bowl during food intake" in the PDD group, the values decreased from 73% to 58% for Score 1 (passing across the front teeth), and increased from 21% to 42% for Score 2 (contact with front teeth). Behavior of Score 3 (touching lip or food in spoon) was not observed. As for "motion of the lips during food intake," the values increased from 10% to 29% for Score 1 (not working), decreased from 80% to

48% for Score 2 (working slightly), and increased from 10% to 23% for Score 3 (food capturing with the lips). As for "neck rotation," all responses were judged to be Score 2 (working slightly) for both the first and the second assessment. As for "occupancy of spoon bowl to aperture of mouth," the values decreased from 33% to 19% for Score 1 (parallel), increased from 54% to 56% for Score 2 (less than 45 degrees) and from 13% to 25% for Score 3 (more than 45 degrees).

In the control group, 90% of the responses to "positioning of spoon bowl during food intake" were judged to be Score 1 and the remaining 10% to be Score 2. As for "motion of the lips during food intake" and "neck rotation", all responses were judged to be Score 3. As for "occupancy of spoon bowl to aperture of mouth," 60% of responses were judged to be Score 2 and the remaining 40% to be Score 3.

2. Comparison between the feeding assessment datasets

The results of the analysis are shown in Table 3.

Comparison between the first and second feeding assessments in the PDD group revealed a significant difference only in "occupancy of spoon bowl to aperture of mouth" ($p < 0.05$). There were no significant differences in other items.

Comparison between the first assessment in the PDD group and the assessment in the control group revealed significant differences ($p < 0.01$) in "motion of the lips during food intake," "neck rotation," and "occupancy of spoon bowl to aperture of mouth" but not in "positioning of spoon bowl during food intake."

Comparison between the second assessment in the PDD group and the assessment in the control group revealed significant differences in all items ($p < 0.01$) for "positioning of spoon bowl during food intake", "motion of the lips during food intake" and "neck rotation" as well as in "occupancy of spoon bowl to aperture of mouth" ($p < 0.05$).

3. Correlations between feeding assessment and Enjoji Scale

The obtained correlation coefficients are shown in

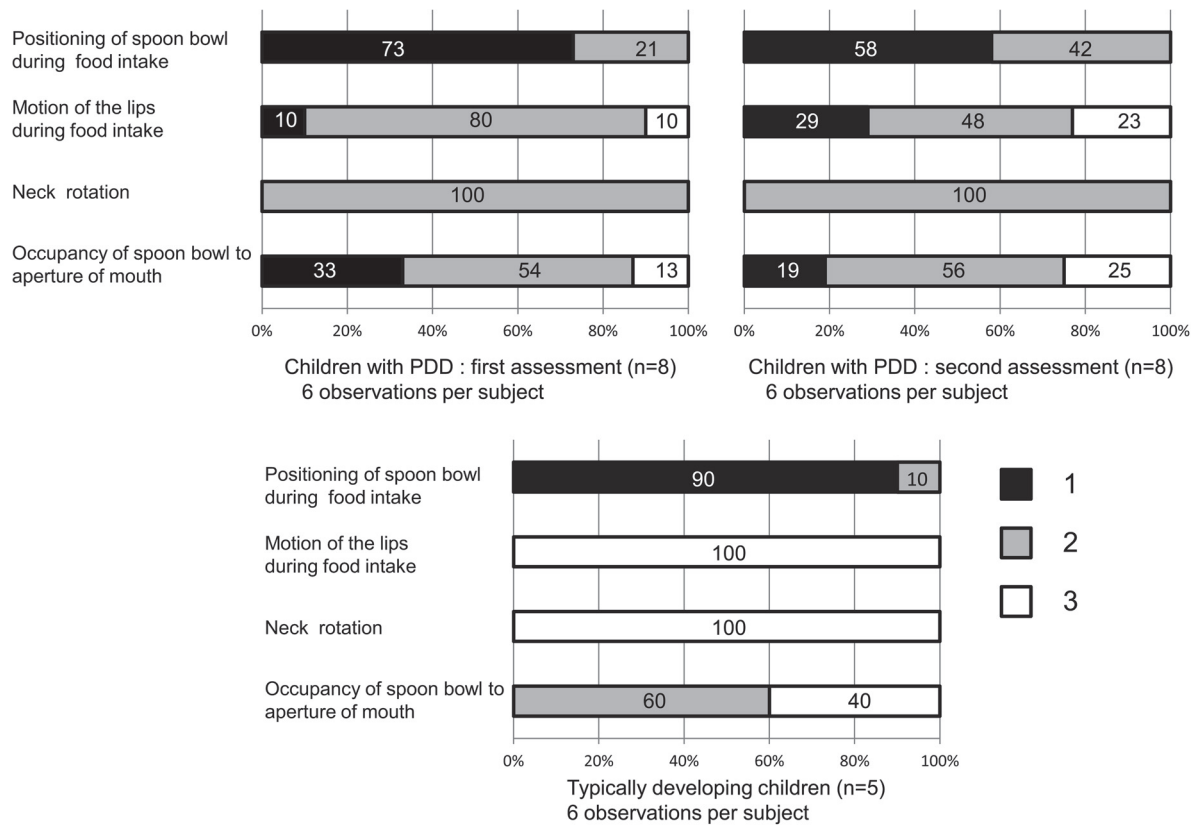


Fig. 2 Frequency of assessment items among total observations.

Table 3 Test of assessment items in children with PDD and typically developing children.

	Children with PDD (first assessment) vs. Children with PDD (second assessment)	Children with PDD (first assessment) vs. Typically developing children	Children with PDD (second assessment) vs. Typically developing children
Positioning of spoon bowl during food intake	n.s.	n.s.	**
Motion of the lips during food intake	n.s.	**	**
Neck rotation	n.s.	**	**
Occupancy of spoon bowl to aperture of mouth	*	**	*

n.s. not significant Mann-Whitney U *p<0.05 ** p<0.01

Table 4.

In the first assessment, “positioning of spoon bowl during food intake” had significant negative correlations with all items of the Enjoji Scale (p<0.01 for “physical movement,” “hand movement,” “basic daily habits,” and “speaking”; p<0.05 for “age,” “personal relations,” and “understanding of language”), whereas “motion of the lips during food intake” and “occupancy of spoon bowl to aperture of mouth” showed no significant correlations with any items of the Enjoji Scale. Computing of

the correlation coefficient was not possible for “neck rotation.”

In the second assessment, “positioning of spoon bowl during food intake” had significant negative correlations with all items of the Enjoji Scale (p<0.01 for “physical movement,” “hand movement,” “basic daily habits,” “speaking,” and “understanding of language”; p<0.05 for “age” and “personal relations”). “Motion of the lips during food intake” also had significant correlations with all items of the Enjoji Scale (p<0.01 for “hand

Table 4 Correlations between assessment items and each Enjoji Scale Item of the Infant Analytical Development Test. First Assessment

		Age	Physical movement	Hand movement	Basic daily habits	Personal relations	Speaking	Understanding of language
Positioning of spoon bowl during food intake	Correlation coefficient	-0.344 *	-0.504 **	-0.559 **	-0.45 **	-0.313 *	-0.515 **	-0.331 *
Motion of the lips during food intake	Correlation coefficient	0.091 n.s.	-0.01 n.s.	0.151 n.s.	0.021 n.s.	0.142 n.s.	0.06 n.s.	0.091 n.s.
Neck rotation		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Occupancy of spoon bowl to aperture of mouth	Correlation coefficient	0.128 n.s.	0.151 n.s.	0.186 n.s.	0.179 n.s.	0.069 n.s.	0.146 n.s.	0.07 n.s.

		Age	Physical movement	Hand movement	Basic daily habits	Personal relations	Speaking	Understanding of language
Positioning of spoon bowl during food intake	Correlation coefficient	-0.295 *	-0.424 **	-0.399 **	-0.371 **	-0.366 *	-0.387 **	-0.510 **
Motion of the lips during food intake	Correlation coefficient	0.345 *	0.289 *	0.417 **	0.561 **	0.539 **	0.712 **	0.573 **
Neck rotation		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Occupancy of spoon bowl to aperture of mouth	Correlation coefficient	0.281 n.s.	-0.188 n.s.	0.076 n.s.	0.103 n.s.	0.123 n.s.	0.058 n.s.	0.060 n.s.

n.s. not significant Spearman ρ * $P < 0.05$ ** $P < 0.01$

movement,” “basic daily habits,” “personal relations,” “speaking,” and “understanding of language”; $p < 0.05$ for “age” and “physical movement,” whereas “occupancy of spoon bowl to aperture of mouth” showed no significant correlations with any item of the Enjoji Scale. Computing of the correlation coefficient was not possible for “neck rotation.”

Discussion

1. Proportions of each score in the feeding assessment

1) Food intake function

Children with PDD showed a distinctly different pattern from that of the controls in “motion of the lips during food intake.” Whereas all responses of the controls were judged to be Score 3 (food capturing with the lips), those of children with PDD showed a variety of responses (i.e., Score 1, 2, or 3). In the analysis of change from the first to the second assessment, decreased values were observed for Score 2, whereas increased values were found in Scores 1 and 3. Chigira et al²⁾ reported that normally developing children became able to capture food with the lips around 5 to 6 months of age. Morris

and Klein¹⁹⁾ reported that normally developing children begin capturing food with the lips in spoon feeding around 7 months of the age, and capturing food with the teeth around age 15 months. They commented that lip-capturing is followed by teeth-capturing. The present study revealed that children with PDD showed lesser lip motion during food intake. We consider this to be one of the characteristics of children with PDD in spoon feeding. They tend to capture food with the teeth rather than the lips. This tendency may be related to the sensitivity of their front teeth.²⁰⁾ On the contrary, their lesser lip motion may result from sensitivity of the lips.²¹⁾ It has been reported that children with PDD have a variety of sensory disorders.²²⁾ Therefore, forced use of the lips may not be an appropriate treatment. On the other hand, the sensory abnormality was reportedly alleviated by intervention using a kind of sensory integrative approach.²³⁾ Sensory assessment and treatment were therefore recommended before instructing children to use the lips during food intake.

Nomoto et al⁷⁾ investigated feeding disorders of intellectually impaired children using the same items as in the present study. They reported that the score

became 3 in 8 of 10 subjects 1 year after receiving therapeutic intervention for food intake skills, incision of the front teeth, and so on. In the present study, no therapeutic interventions were performed. As previously noted, sensory impairment was considered to be one of the reasons for failing to capture food with the lips. Considering the marked improvement observed in Nomoto et al's subjects, the lesser improvement in our subjects might be partly attributable to the absence of therapeutic intervention. Further evaluation of the effectiveness of therapeutic intervention for food intake skills and incision of the front teeth for children with PDD is awaited.

As for "positioning of spoon bowl during food intake," most of the responses were judged to be Score 1 (passing across the front teeth) for both groups. It has been reported that children with immature food capturing skills tend to put the spoon deep into the oral cavity when the bowl part of the spoon is smaller than the width of the lips.⁶⁾ In the present study, the participants used spoons which they had been using at the center. It was assumed that the bowl part of the spoon was small. Therefore, the aforementioned result might be partly attributable to the size of the spoon bowl. As an alternative explanation, the children had developed awareness of eating such that they tried to put the spoon deep into the oral cavity in order to compensate for immature hand and mouth functions.

2) Hand-mouth coordination

If a child has a restricted range of shoulder joint motion, he or she may compensate by rotating the neck or putting the spoon into the mouth from the lateral side. Thus, "neck rotation" and "occupancy of spoon bowl to aperture of mouth" are considered to be related. The present results are consistent with this idea.

Comparison between the first and second assessments for children with PDD revealed no change in "neck rotation," but there was an improvement in "occupancy of spoon bowl to aperture of mouth" (the proportions of Scores 2 and 3 increased). We speculate that children with PDD might have been compensating for restricted

shoulder joint motion by neck rotation.

In the control group, all observations of "neck rotation" were judged to be Score 3 whereas "occupancy of spoon bowl to aperture of mouth" was judged to be Score 2 or 3 (more than half of responses were Score 2). The controls were considered to be compensating for restricted range of shoulder joint motion by the putting spoon into the mouth from the lateral side. Considering that ages of the controls started at 32 months, neck rotation as a compensating behavior may not appear earlier than this.

In the present age-matched study, the children who had Score 2 for "neck rotation" and Score 3 for "occupancy of spoon bowl to aperture of mouth" were fewer in number than those with PDD, as compared with the control group. This allows us to hypothesize that children with PDD might have restricted range of shoulder joint motion. It has been reported that children with PDD are clumsy, i.e. have poor motor skills.²⁴⁾ We consider restricted range of shoulder joint motion to possibly be one of the developmental delay of motor-skills in children with PDD.

2. Comparison between feeding assessment datasets

Comparison between the first and second assessments for children with PDD revealed a significant difference only in "occupancy of spoon bowl to aperture of mouth" ($p < 0.05$), suggesting that children with PDD showed a certain degree of development in the range of shoulder joint motion during the study period.

Comparison between the children with PDD and the control group revealed significant differences ($p < 0.01$) for both the first and second assessment in "motion of the lips during food intake." We consider evaluating the role of the lips (including evaluation of sensory impairment of the lips, as previously described) to be important when assessing food intake behavior of children with PDD. There were also significant differences ($p < 0.01$) for both the first and second assessment in "neck rotation." As previously noted, the children with PDD showed a certain degree of neck rotation even in the second assessment, suggesting that neck rotation is also one

of the important items in the assessment of food intake behavior in children with PDD.

Feeding function has a major effect on life maintenance, vitality, and growth and development. Feeding-related behavior problems in children with PDD have been a concern for parents and specialists, and a significant research effort was made in this area.²⁵⁾ The Parental Concerns Questionnaire (a 13-item questionnaire for parents of children with autism spectrum disorders) includes an item on “eating habits”.²⁶⁾ The Brief Autism Mealtime Behavior Inventory (BAMBI) is a questionnaire focusing on feeding behavior.²⁷⁾ Children with autism display a variety of inappropriate behaviors such as food selectivity, distaste for new foods, pica, selectivity for cooking methods, holding food in the mouth, spitting food, throwing food, and eating place selectivity. Many investigators have focused on food selectivity.²⁸⁾ While there is significant difference in food intake behavior between children with PDD and controls, we advocate that evaluation of food intake behavior be included in the screening tests. The effects of sensory impairment and motor programming disorders on eating behavior in children with autism have been noted.²⁹⁾ The lesser motion of lips during food intake in children with PDD may partly result from hypersensitivity of the lips. The developmental delay in hand-mouth coordination may partly result from a motor programming disorder.

3. Correlations between feeding assessment and Enjoji Scale

Among the screening tests for infants with suspected developmental delay, the Denver Developmental Screening Test II is widely used in pediatrics in western countries.³⁰⁾ In Japan, the Enjoji Scale has been widely used in research and clinical practice.³¹⁾ There is an opinion that appropriate timing of intervention for feeding function disorders in children with developmental delay should be determined based on developmental rather than chronological age.³²⁾ Development of feeding function has a strong relationship with developmental age in children. Although there are many developmental screening tests for children with PDD,³³⁾ the Enjoji Scale

was employed in the present study. This scale had been used in the children’s disability center attended by our participants.

“Neck rotation” and “occupancy of spoon bowl to aperture of mouth” had no significant correlations with any Enjoji Scale items on the first or the second assessment. These 2 items were considered to be influenced by motor development, i.e., range of shoulder joint motion development.

“Positioning of spoon bowl during food intake” had significant correlations with all Enjoji Scale items for both the first and second assessment ($p < 0.05$ or 0.01). The Enjoji Scale items showing significant correlations ($p < 0.01$) for both the first and second assessment were “physical movement,” “hand movement,” “basic daily habits,” and “speaking.” These items are related to motor-skills development. The items showing significant correlations ($p < 0.05$) for both the first and second assessment were “age” and “personal relations.” “Understanding of language” showed a significant correlation for the first ($p < 0.05$) and for the second assessment ($p < 0.01$). The “positioning of spoon bowl during food intake” correlated negatively with “physical movement,” “hand movement,” “basic daily habits,” “speaking,” and “understanding of language,” suggesting that feeding behaviors such as putting spoon deep into the oral cavity or capturing food with the front teeth cannot be explained by developmental delay in motor function. As mentioned above, awareness of feeding might be related to these behaviors.

“Motion of the lips during food intake” had no significant correlations with any Enjoji Scale items for the first assessment, but showed significant correlations with all items for the second assessment. Significant correlations ($p < 0.01$) were found in “hand movement,” “basic daily habits,” “personal relations,” “speaking” and “understanding of language”, and in “age” and “physical movement” ($p < 0.05$). It was suggested that therapeutic education for children during the about 1-year period might have influenced these results.

Preschool children have great plasticity in the brain.

During this developmental period, therapeutic education by teachers, therapists or parents can be highly effective. Recently, the efficacies of various intervention methods have been evaluated.³⁴⁾ As shown in the present study, food intake functions, especially lip function, can easily be evaluated in medical settings, schools or the home, and the effects of intervention are easily understandable. In conclusion, among the wide range of behavioral characteristics, lip function is considered to be an important index for assessing feeding behavior and language development in children with PDD.

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