Dysphagia 11:48–58 (1996)

Dysphagia

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Effect of Oral Sensorimotor Treatment on Measures of Growth and Efficiency of Eating in the Moderately Eating-Impaired Child with Cerebral Palsy

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Abstract. Thirty-five children with cerebral palsy and moderate eating impairment were studied to determine the effect of oral sensorimotor treatment (OST) on eating efficiency and measures of growth (weight gain). After taking effects of maturation into account, 11 children who received OST (group A) exceeded their expected centile line by 1.7 percentile points after 10 weeks of treatment. Chewing exercises alone (group B) had no effect on weight gain. Although small decreases occurred in the time needed to eat three standard textures of food (solid, viscous, puree) in groups A and B, these were not significant. Children maintained their weight-for-age percentile line although at the lower end of expected norms. These children will be at risk of growth failure because of the increased energy demands once they enter their teenage growth spurt. The clinical implications of these findings are that prolonged mealtime and oral-motor therapies may be adequate through the childhood years. Thereafter, children's growth must be monitored carefully, and oral caloric supplementation is suggested to provide the necessary energy for growth.

Key words: Sensorimotor intervention — Eating impairment — Eating efficiency — Growth — Nutritional status — Deglutition — Deglutition disorders.

Inadequate food intake, decreased appetite, psychosocial deprivation, and eating problems are common in children with cerebral palsy (CP) [1–6]. The child who has an eating problem has difficulty maintaining appropriate body weight and supplying energy needed for growth [1,3,7–10]. Feeding in children with severe CP may take up to 15 times longer compared with normals [5,11]. Some authors find that in everyday practice, mealtimes of children with severe oral-motor deficits are not longer than those of healthy children [1], and that children do not receive more frequent meals, because many families with disabled children experience feeding times as unpleasant and stressful [4]. As a consequence, eating-impaired children may be offered and consume less food than healthy, age-matched controls [1]. In children with mild CP, other authors noted that children are offered equal amounts of food compared with normal age mates. However, mildly affected children eat less, because they take longer than their healthy peers and are often not given extra time to consume all their food [12]. Martin [13] claims that nutritional deficiencies after the first year of life affect the ability of the child to learn and to attain and sustain interest in a learning task. Similarly, Reilly and Skuse [1] emphasize the importance of adequate weight gain in the first 6 months of life for adequate cognitive and psychomotor development. Martin urges that the feeding difficulties in this group of children should not be simply accepted as a consequence of their neurologic deficits, since it is known that malnutrition in itself can permanently affect brain size and central nervous system function [14–16].

In the past, two approaches have been used to address eating problems in children with CP. In the first, oral sensorimotor stimulation is applied to the circum-oral and intra-oral structures and is purported to decrease oral hypersensitivity as well as to facilitate chewing and swallowing. However, work by Ottenbacher et al. [17,18] with severely neurologically impaired children showed no change in oral-motor function nor in weight gain after a 9-week sensorimotor treatment period. Otten-

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bacher et al. did not take the nutritional needs of their subjects into account, nor did they address the need for a prolonged feeding time [5] to compensate for the severe oral-motor deficits of their patients. A study by Sobsey and Orelove [19] showed similar results to those of Ottenbacher et al. The poor treatment outcomes have led to questioning of some of the treatment methods employed. A study by Korabek et al. [20] found improvement in food intake in profoundly handicapped children, following intensive staff training in a state home for the developmentally disabled. However, the feeding time doubled to achieve this goal. At a time where many institutions experience staff cutbacks, an increase in service demand may place a strain on already limited resources.

Feeding of the neurologically impaired child with feeding problems may be complicated by behavior problems unique to the feeding situation (food refusals, food expulsion, bizarre food habits). Riordan et al. [21,22] observed that abnormal feeding patterns were not due solely to organic impairment, but that environmental factors may play a significant role in the development, maintenance, and exacerbation of feeding problems. Thus, behavior modification techniques were applied to reinforce the ingestion of nutritionally and age-appropriate foods. Although subjects gained weight and showed adequate feeding skills, ideal weight was not achieved after an 8-week treatment period [21]. In a later study, Riordan et al. [22] emphasized that the impact of their treatment lay in the fact that children accepted a nutritionally balanced diet and continued to do so at follow-up, 2 months after discharge. The socially more acceptable diets as well as the children's more appropriate behavior at mealtimes made them more compatible with their social environment and so must be regarded as an important developmental achievement.

In the second approach, Patrick et al. [9] have used nasogastric infusion of enteral feeds in severely eating-impaired children with CP. This has resulted in significant weight gains over a 5-week treatment period. However, the work by Patrick et al. did not address long-term problems of either having to return to inadequate oral feedings [17,18] or having to resort to invasive methods such as permanent gastrostomy feeding [23,24].

Though Patrick et al. clearly identify their study sample (children who have skinfold thicknesses below age-based standards and failure to gain weight in the previous year), Ottenbacher et al. [18] only give a range of ages and pretherapy weights. Judging from the weights of the children at the upper end of the reported range [18], there may have been some children who were less severely undernourished than others in their group. In addition, there were two children who gained 17 pounds, which was 65% of all weight gained in the experimental group of 10 children. These findings suggest that Ottenbacher et al. may have had a range of children with differing oral-motor skills and that the less severely involved had indeed benefitted from oral-motor therapy. Hence, it would seem important to determine whether children who can benefit from oral sensorimotor therapy (marginal oral feeders) can be discriminated from those who cannot be fed orally (nonfunctional oral feeders).

Gisel and Patrick [5] have shown that distinction of children with marginal oral feeding skills from those with nonfunctional oral skills is possible through the use of different food textures. Nonfunctional oral feeders have significantly longer feeding times than weight-based standards when ingesting a solid and pureed texture, whereas marginal oral feeders have a significantly longer feeding time only when ingesting a pureed texture. Given the ability to identify children with marginal oral feeding skills and the evidence that they may benefit from oral sensorimotor therapy, the purpose of the present study was to examine the efficacy of oral sensorimotor therapy in a group of moderately eating-impaired children with CP who were all marginal oral feeders.

Materials and Methods

Subjects

Thirty-five children (19 boys, 16 girls) participated in this study. They ranged in age from 4.3 to 13.3 years. They were assigned randomly to three groups (A,B,C). Group A (n = 11, 5 boys, 6 girls) was 6.3 ± 1.4 years; group B (n = 12, 8 boys, 4 girls) was 7.3 ± 2.1 years; and group C (n = 12, 6 boys and 6 girls) was 7.7 ± 2.7 years of age. One girl (no. 12 in group A) died due to causes unrelated to this study. It was not possible to recruit another child, because the death occurred past the midpoint of our study. Childrens' weight was at the 5th percentile for their age and at or below the 35th percentile for skinfold measures (triceps, subscapular). All children had a diagnosis of CP with moderate-to severe-motor impairment. Twenty-seven children were wheelchair bound, 5 were ambulatory and 3 used tricycles for ambulation. All children needed assistance with activities of daily living (bathing, toileting, eating) and manifested a range of hypo- to hypertonicity in their trunk and all extremities. Although most children were quadriparetic, the severity of spasticity varied between upper and lower extremities and between the right and left body sides. Children were only selected if they were able to eat a standard solid texture within 1 SD and a puree at or below 2 SD of established time norms [25,26]. Children were recruited from three special schools in the city of Montreal between January 1990 and December 1991. Institutional and parental consent were obtained before entry into the study.

Procedures

Following a series of initial tests, children were randomly assigned to one of three groups: A-sensorimotor treatment, B-chewing only treatment, C-control. Group C followed the school routine in regard to feeding for 10 weeks (control) and then received 10 weeks of sensorimotor treatment. Groups A and B received 20 weeks of their respective treatment. On weeks 10 and 20, the same series of tests were administered as at the onset of the study.

Testing

Children were weighed (panties on only) in the school's nursing office. Videophotography was performed in a room exclusively used for testing. The interval between testing and the last meal was at least 1½ h. Children were either seated in their custom-fitted wheelchairs, or if ambulatory, in a chair that permitted flexion of hips and knees at 90° with feet flat on the floor and the back well supported by a backrest. Special attention was paid to head alignment in a straight axis with the trunk and a 30° chin tuck position. Arms were placed in a flexed position on the child's lap tray or on the feeding table in front of the child.

The video camera was positioned 1.8 m to the left or right of the chair to obtain a semiprofile view of the child's face and neck. A camera operator followed the child if he/she moved during feeding. Each child was offered 10 trials each of three textures of food: puree (P: unsweetened applesauce), viscous (V: 10 raisins), and solid (S: 10 bites of a graham biscuit). If a child was unable to eat raisins or the graham biscuit, cereal rings (S: "Cheerios"), and orange gelatin (V) were substituted [27].

The same tester fed children throughout the course of this study. All children were told what food was going to be offered, although many children could not respond verbally to a spoken interchange, nor could they make their needs known in a verbal manner. Testing took no more than 20 min. Chewing duration (in sec) was measured between placement of the food in the mouth and completion of the first swallow. Most children swallowed more than once. Therefore, the time between the first and last swallow or termination of mandibular movement for 2 sec was also measured. This interval will be called *clearing time*. A mean of 10 swallows was used for statistical comparisons.

Mealtime Observation

To obtain a measure of the child's "natural" feeding performance, the child was observed in the school cafeteria at lunchtime. Children were assigned to a feeding assistant who fed the same child or children (maximum 2–3) daily. A modified version [28] of the Functional Feeding Assessment subtest of the Multidisciplinary Feeding Profile [29] was administered. Concurrent validity of the modified version (FFAm) and the Gisel video assessment [25] was shown to be high ($r = -0.61$; $p < 0.0001$) [12]. The negative correlation indicates that as eating time decreases, oral-motor skills as measured by the FFAm increases. Length of the lunch meal from the onset of feeding until the completion of the meal was noted.

Sensorimotor Treatment (Groups A and C)

Sensorimotor treatment was based on the child's performance on the FFAm. Treatment lasted 5–7 min daily, Monday through Friday, prior to lunch. Emphasis was placed on three major areas of oral-motor functioning: tongue lateralization, lip control, and vigor of chewing. Movements aimed for were always elicited with small food stimuli. This was deemed preferable, because they elicit a natural eating reaction, in contrast to manual manipulation by the therapist or use of "foreign objects" such as chewing on plastic tubing or brushing with tooth brushes.

Tongue Lateralization

A small drop of peanut butter was placed on the lateral border of the tongue to the right and left alternately. Tongue-following to the side of the stimulus was aimed for. When the full range of the desired motion was achieved, the stimulus was placed in the cheek pocket, so that the tongue had to remove it from the cheek in order to swallow. When this skill was fully achieved, the stimulus was placed on the four corners of the lips alternately—left corner, middle of lower lip, right corner, middle of upper lip—so that the tongue had to remove the stimulus from outside the oral cavity.

Lip Control

Children were encouraged to close their lips around a licorice stick (7 mm in diameter). Once this skill was achieved, they were encouraged to hold a straw between the lips and blow into it (easier than sucking). Next, sucking motions were demonstrated and the child was encouraged to repeat the motion. Straws were cut in half to facilitate the early sucking efforts. Thickened liquids were used with children who had poor sucking control.

Vigor of Chewing

Small pieces of tea biscuits were placed over the molars to the right or left alternately and the child was encouraged to chew these. The hardness of the biscuit ranged from a medium to a strong resistance and was increased as the child showed greater vigor in chewing movements.

Chewing-only Treatment (Group B)

Children were offered small pieces of fruit gelatin to chew. The pieces were of a medium-to-hard viscosity. The number of pieces varied depending on the child's ability to chew. However, the time of 5–7 min was kept constant. As children progressed they were given harder textures, i.e., firm cereal bits or pieces of hard biscuits. Treatment proceeded from Monday through Friday prior to lunch.

Lunch Textures

In our school system children bring their lunches from home. Food textures were examined and a plan was established for each child to increase the texture in at least one food item. This could consist of a softly cooked vegetable instead of puree, or of adding a piece of soft apple instead of cooked fruit compote. Hence, as childrens' oral-motor agility improved, lunch textures were made more resistive, so that new oral-motor skills were reinforced at regular meal times.

Treatment Compliance

Treatment in this study was administered by feeding assistants who were instructed by the tester in what manner and how long to apply treatment. A small box of supplies was given to each assistant working with study children. A treatment checklist was taped to the child's lunch table and was checked daily. If the assistant was absent, a substitute was designated to administer the treatment. If for any reason the treatment could not be given, the feeding assistant had to indicate the reason on the checklist. If the child was absent due to illness, or a medical appointment, the assistant noted the reason for the child's absence on the checklist. This careful monitoring allowed computation of absences due to illness. Sick days were subtracted from the total possible treatment days and compliance was calculated as a percentage of the remaining treatment days.

Results

Eating Time of Standard Food Textures

In the healthy normal child, increased eating efficiency is marked by a decrease in chewing duration [25]. If oral sensorimotor therapy is beneficial, then eating time is expected to decrease. Table 1 illustrates eating time for

Table 1. Eating time for three standard textures of food in moderately eating-impaired children with CP

	Week 0			Week 10			Week 20		
	A[a] (n)	B (n)	C (n)	A (n)	B (n)	C (n)	A (n)	B (n)	C (n)
Puree									
Apple sauce	8.3 ± 3.9 (11)	6.6 ± 3.1 (12)	5.9 ± 4.9 (12)	6.4 ± 1.3 (11)	7.1 ± 4.2 (12)	5.6 ± 3.5 (12)	7.7 ± 3.2 (11)	6.2 ± 2.9 (12)	6.7 ± 5.0 (12)
Viscous									
Raisins	16.6 ± 7.9 (5)	22.4 ± 6.7 (7)	13.7 ± 4.8 (8)	17.8 ± 6.2 (6)	20.8 ± 9.4 (8)	14.7 ± 5.5 (9)	15.9 ± 8.5 (6)	20.3 ± 8.7 (6)	14.0 ± 6.5 (10)
Fruit gelatin	11.9 ± 6.4 (6)	10.3 ± 4.6 (5)	11.0 ± 6.8 (4)	11.6 ± 4.3 (5)	11.7 ± 6.8 (4)	7.9 ± 3.2 (3)	12.3 ± 4.3 (5)	9.2 ± 3.5 (6)	8.0 ± 4.7 (2)
Solid									
Biscuits	23.1 ± 5.8 (8)	22.7 ± 7.3 (11)	17.2 ± 5.0 (10)	22.5 ± 5.7 (8)	22.2 ± 7.7 (10)	18.3 ± 5.6 (11)	20.9 ± 8.9 (9)	21.4 ± 7.9 (10)	18.3 ± 6.0 (11)
Cereal ring	25.2 ± 12.7(3)	25.1 (1)	14.2 ± 5.5 (2)	17.6 ± 6.7 (3)	20.9 ± 13.7 (2)	12.2 (1)	12.5 ± 4.4 (2)	14.4 ± 1.8 (2)	19.5 (1)

Data represent means ± SD in sec.
[a]See Methods for definition of groups and presentation of textures.

Table 2. Eating time: test of difference between control and treatment periods for three standard textures of food

Group	Texture	Period	n	Mean	SD	t	*p*
A	Puree	W_0–W_{10}	11	1.882	3.440	1.814	0.100
		W_0–W_{20}	11	0.573	2.801	0.678	0.513
	Viscous	W_0–W_{10}	9	−0.067	5.679	−0.035	0.973
		W_0–W_{20}	10	1.520	6.048	0.795	0.447
	Solid	W_0–W_{10}	10	0.180	8.203	0.069	0.946
		W_0–W_{20}	11	6.036	16.813	1.191	0.261
B	Puree	W_0–W_{10}	11	0.318	2.123	0.497	0.630
		W_0–W_{20}	11	0.317	2.881	0.381	0.711
	Viscous	W_0–W_{10}	11	6.273	26.699	0.779	0.454
		W_0–W_{20}	10	9.090	28.634	1.004	0.342
	Solid	W_0–W_{10}	11	−0.382	4.469	−0.283	0.783
		W_0–W_{20}	11	2.582	5.578	1.535	0.156
C	Puree	W_0–W_{10}	11	−0.791	2.993	−0.876	0.401
		W_0–W_{20}	11	−1.091	3.605	−1.004	0.339
	Viscous	W_0–W_{10}	12	0.283	4.546	0.216	0.833
		W_0–W_{20}	12	−3.175	9.419	−1.168	0.268
	Solid	W_0–W_{10}	12	−0.917	6.388	−0.497	0.629
		W_0–W_{20}	12	−1.500	7.547	−0.689	0.505

Puree—applesauce, viscous—raisins/fruit gelatin, solid—biscuits/cereal ring.
W_0–W_{10}—difference in time (sec) between week 0 and week 10.
W_0–W_{20}—difference in time (sec) between week 0 and week 20.
See Methods for definition of groups.
Differences in group size reflect refusal of some children to eat a given food texture.

the three groups at week 0 (W0, onset of treatment), and following 10 and 20 weeks of intervention. For statistical analysis, data from treatment groups A and B were combined and compared with the control group C. A *t*-test was used to first determine whether there were any differences at W0. Among the five foods tested, graham biscuit was significant ($t = 2.378$, $df = 26.0$, $p \leq 0.025$), indicating that children in the control group ate one solid texture in less time than children in groups A and B. Comparison of all other textures showed that there were no significant differences at week 0: cereal ring ($t = 1.637$, $df = 5$, $p = 0.163$), raisins ($t = 2.019$, $df = 17$, $p = 0.060$), orange gelatin ($t = 0.000$, $df = 16.0$, $p = 1.000$), and applesauce ($t = 1.009$, $df = 33$, $p = 0.320$).

A t-test for differences was then performed to determine whether each group differed from week 0 after 10 and 20 weeks of treatment. No significant differences were found for either the puree, the viscous, or the solid texture at either week 10 or 20 (Table 2). It should be noted, however, that in groups A and B most differences were positive, indicating that eating time tended to decrease following treatment, whereas in the control group most differences were negative, indicating that after the control period (week 10) and the treatment period (week 20), mean eating time tended to increase. Group B showed marked improvement in eating the viscous texture and group A showed marked improvement in eating the solid texture. However, no significant differences were found in either group because of the large variations within each group.

A one-way analysis of variance (ANOVA) followed to determine if there were between-group differences due to the different treatments; no significant differences were found (Table 3: unadjusted). Further scrutiny of our data indicated that absences due to illness

Table 3. Differences between control and treatment periods for three standard textures of food

Group	df	Unadjusted[a] MS	F	p	Adjusted[b] MS	F	p
Puree							
W_0–W_{10}	2	19.83	2.35	0.113	18.247	2.05	0.148
W_0–W_{20}	2	8.90	0.92	0.409	2.105	0.21	0.815
Viscous							
W_0–W_{10}	2	136.36	0.52	0.600	139.673	0.52	0.598
W_0–W_{20}	2	412.93	1.38	0.268	243.508	0.74	0.488
Solid							
W_0–W_{10}	2	3.28	0.08	0.925	6.656	0.15	0.861
W_0–W_{20}	2	163.83	1.35	0.274	72.770	0.65	0.533

Puree—applesauce, viscous—raisins/fruit gelatin, solid—biscuit/cereal ring.
W_0–W_{10}—difference in time (sec) between week 0 and week 10.
W_0–W_{20}—difference in time (sec) between week 0 and week 20.
[a]One way ANOVA.
[b]ANCOVA with age and illness as covariates.

Table 4. Clearing time for three standard textures of food in moderately eating-impaired children with CP

	Week 0			Week 10			Week 20		
	A[a] (n)	B (n)	C (n)	A (n)	B (n)	C (n)	A (n)	B (n)	C (n)
Puree									
Apple sauce (SD)	3.0 ± 1.9 (9)	1.2 ± 0.9 (10)	2.3 ± 1.3 (11)	3.0 ± 2.6 (8)	1.8 ± 1.8 (8)	2.8 ± 2.1 (12)	2.5 ± 2.2 (10)	1.7 ± 0.8 (11)	1.7 ± 1.3 (7)
(p)				(0.950)	(0.617)	(0.551)	(0.876)	(0.077)	(0.076)
Viscous									
Raisins (SD)	2.9 ± 1.8 (2)	2.6 ± 2.6 (4)	1.5 ± 1.1 (6)	2.1 ± 1.3 (5)	3.1 ± 2.5 (3)	1.8 ± 1.8 (8)	2.2 ± 0.9 (3)	0.8 (1)	2.2 ± 2.3 (5)
(p)				(0.848)	(0.891)	(0.506)	(0.626)		(0.522)
Fruit gelatin (SD)	2.0 ± 1.2 (2)	2.1 ± 1.4 (6)	2.2 ± 1.9 (5)	2.2 ± 2.1 (2)	1.0 ± 0.6 (3)	6.2 (1)	3.7 ± 3.6 (2)	2.6 ± 1.5 (3)	1.5 ± 1.3 (3)
Solid									
Biscuits (SD)	3.5 ± 2.1 (9)	2.6 ± 1.8 (8)	3.5 ± 2.9 (9)	3.3 ± 3.3 (6)	2.5 ± 2.5 (6)	2.0 ± 1.4 (10)	2.8 ± 2.8 (9)	2.7 ± 2.4 (8)	2.5 ± 1.5 (7)
(p)				(0.715)	(0.802)	(0.052)	(0.465)	(0.231)	(0.453)
Cereal ring	—	1.3 (1)	7.1 (1)	4.0 (1)	—	—	—	—	0.8

Data represent mean ± SD in sec.
(p) p-levels were computed on the differences from week 0, i.e. (W_0–W_{10}) and W_0–W_{20}; data were combined in raisin and fruit gelatin as well as in biscuit and cereal ring.
(n)—group A: n = 11, group B: n = 12, group C: n = 12. Not all children swallowed repeatedly, accounting for the smaller numbers in various groups.
[a]See Methods for definition of groups.

may not have been equally distributed between the first (W0-W10) and second (W10-W20) treatment period. This could adversely affect results in that these children are often weakened following a period of illness. Therefore, a one-way analysis of covariance (ANCOVA) was performed, adjusting for illness, as well as discrepancies in age between the groups. Under "Adjusted" in Table 3 between-group differences remained nonsignificant when adjusted for illness and age. Thus, discrepancies in age and illness did not contribute to these results, with one exception: illness significantly contributed to eating of the solid texture in the second treatment period (W0-W20), (solid: MS = 655.658, df = 1, F = 5.820, $p \leq 0.024$).

Clearing Time for Standard Food Textures

It has been observed clinically that many children with oral-motor problems swallow several times in contrast to healthy children who may swallow once or at most, twice on a bite of food [30]. This period of after-swallows was denoted as clearing time. Thus, although no decrease in eating time occurred, the number of swallows per bite of food may have decreased and so the clearing time would be expected to decrease. Therefore, the time for these repeated after-swallows was measured (Table 4). The same statistical tests were used as for eating time. A t-test at Time 0 comparing groups A and B to C showed no significant differences: graham biscuit ($t = 0.450$, $df = 24$, $p = 0.657$), cereal ring ($n = 1$), raisin ($t = 1.186$, $df = 10$, $p = 0.263$), orange gelatin ($t = -0.173$, $df = 11$, $p = 0.866$), and puree ($t = -0.340$, $df = 11$, $p = 0.737$). No significant differences were found at week 10 and 20 in any of the groups or textures (Table 4). There was no specific pattern to changes, either with respect to texture or to the length of the treatment period. Thus, group comparisons based on the changes in clearing time were also not significant.

Duration of Mealtime

Children were observed in their school cafeteria during their regular lunch time. We expected that if children's

Table 5. Duration (min) of lunch at school of moderately eating-impaired children with CP

	A[a] (n = 11)	B (n = 12)	C (n = 12)
Week 0	34.0 ± 8.5	31.0 ± 13.6	28.8 ± 13.4
Week 10	28.1 ± 6.0	31.8 ± 11.8	27.7 ± 9.6
Week 20	34.1 ± 11.5	33.4 ± 12.1	28.9 ± 11.7

Data represent means ± SD in min.
[a]See Methods for difinition of groups.

Table 6. Texture changes in lunch meals of moderately eating-impaired children with CP

Texture	Week 0	Week 10	Week 20
Solid	40.0	31.4	60.0
Viscous	25.7	42.9	20.0
Mash	31.4	20.0	14.3
Puree	2.8	2.8	2.8
Not tested		2.8	2.8

Data represent texture achieved (in percent) at lunch in the sample of 35 children.

eating time improved, we should find a concomitant decrease in the time needed to feed them during regular meals. Table 5 illustrates the duration of mealtimes for the three groups. A one-way ANOVA was performed to determine whether there were between-group differences in the changes from the baseline (week 0) duration of meals. No significant differences were found at week 10 (MS = 151.73, df = 2, F = 1.56, $p = 0.226$) or week 20 (MS = 8.39, df = 2, F = 0.05, $p = 0.954$).

Part of our treatment program focused on making the transition to more advanced textures. It is known that harder textures take longer to chew [25,26]; thus, it could be argued that children may have made progress by eating more advanced textures, although there may not have been a decrease in the duration of their mealtime. When recording the different food textures, the "most advanced" texture was noted (i.e., if a child ate both puree and solids) the solid texture was recorded. From week 0 to week 20 there was an increase of 18% (group A), 16.7% (group B), and 25% (group C) of children who made the transition to eating some solid foods. There was a decrease in mashed textures during the same period of 18% (group A), 16.7% (group B), and 16.7% (group C). One child (9%) remained on puree in group A but there were no children in group B and C who were fed pureed textures. In groups B and C there was a decrease of 8.3% in viscous textures in both groups. The two children in group A who received viscous textures (18%) showed no change over time.

The ability to advance to a more solid texture after 10 and 20 weeks of treatment was tested using logistic regression, with group and age as independent variables. No significant between-group differences were found at week 10 ($\chi^2 = 0.207$, df = 2, $p = 0.902$), at week 20 ($\chi^2 = 0.207$, df = 2, p = 0.902), nor between weeks 10 and 20 ($\chi^2 = 1.653$, df = 2, $p = 0.438$). Similarly, when asking whether the ability to advance to a viscous texture was significant, no differences were found at week 10 ($\chi^2 = 0.454$, df = 2, $p = 0.797$) and week 20 ($\chi^2 = 0.396$, df = 2, $p = 0.820$), nor between weeks 10 and 20 ($\chi^2 = 0.215$, df = 2, $p = 0.898$). Table 6 illustrates the percent of texture changes achieved at lunchtime for the entire group.

Weight Changes Following Sensorimotor Treatment

Table 7 illustrates the mean weights and weight changes of children in each group. Expected weight changes in normal children between 6 and 7 years are approximately 2.0–2.2 kg and 1.6–2.0 kg for 7–8-year-old children. Thus, the 1.0–1.5 kg weight gain in groups B and C would be slightly above the expected averages, following a 5-month intervention program. The small loss of weight between weeks 10 and 20 in group A is due to 6 children who did not gain weight and 2 who lost weight. Normalized weights were calculated (percentiles) to take sex and age differences into account and to describe the nutritional state of these children. Weight-for-age ranged between the 7th and 20th percentile at week 0. On average, group A showed a 2.63 percentile gain from week 0 to week 10, but an 8.2 percentile loss from week 10 to week 20 for the reasons explained above. During the control period (W0-W10), group C, on average, showed a percentile gain of 0.9 and another 0.9 percentile gain during the treatment period (W10-W20). Negligible percentile changes (0.42 W0-W10, 0.13 W0-W20) were observed in group B.

Our study set out to answer the following questions: Are oral-motor therapies effective in terms of improving eating efficiency and do children with moderate eating impairment gain weight? Our data indicate that some children benefit, but as a group, only small improvements were found in the efficiency of eating. There was weight gain but as a group, weight was maintained at the same percentile-for-age as at the onset of the study. This raised the question: Which children within the moderately impaired group did benefit from treatment in contrast to those who did not? Several factors were reexamined to determine their contribution to treatment outcome. To examine these factors, children were divided by weight gain: those who gained an average of 8% during the first 10, as well as the second 10 weeks (group G, n = 14) and the remaining children who gained less or even lost weight (group NG, n = 21). Treatment compliance, illness of children, degree of mental retardation, ambulatory status, and ability to feed independently were examined according to status of weight gain. Treatment

Table 7. Mean weights of moderately eating-impaired children with CP following oral sensorimotor treatment

	Group[a]					
	A		B		C	
	Kg	Percentiles	Kg	Percentiles	Kg	Percentiles
Week 0	16.52 ± 4.11	17.22 ± 29.95	17.38 ± 3.60	10.67 ± 17.27	18.02 ± 5.96	7.13 ± 15.05
Week 10	16.97 ± 4.37	19.85 ± 29.77	18.11 ± 4.40	11.09 ± 15.87	19.44 ± 6.13	8.03 ± 16.59
Week 20	16.54 ± 3.52	11.63 ± 18.39	18.47 ± 4.78	10.80 ± 15.78	19.48 ± 6.75	8.92 ± 17.73

Data represent mean (kg and percentiles-for-age) ± SD.
See Methods for definition of groups.
[a]Mean age of group at week 0 in years: A-6.3 ± 1.4, B-7.3 ± 2.1, C-7.4 ± 2.7.

Table 8. Reliability of measures between two observers

			Mean values[a] of	
	Texture	Correlation (p-value)	Observer 1	Observer 2
			(p-values for the difference)	
Time	Puree	0.77	3.3	3.9
		(0.0001)	(0.76)	
	Viscous	0.95	17.6	17.5
		(0.0001)	(0.79)	
	Solid	0.94	22.6	24.6
		(0.0001)	(0.13)	

[a]Values: time in sec.

compliance was 86% as compared with 79% in the NG group. Frequency of illness was 4.1% vs. 7.7%, respectively. Moderate and severe retardation as judged by the ability to respond to instructions and to communicate needs was 62% vs. 77%. Ambulation with or without an assistive device was 30% vs. 20%, and the ability to self-feed was 35.5% vs. 41.1%. Although the differences between groups with respect to the various factors is not very large, the children who gained weight consistently had a more favorable status than children who gained little or no weight with regard to these factors, except in self-feeding.

Treatment Compliance

Treatment compliance for the three groups combined was 78.6 ± 2.1%. This figure reflects unavailability of assistants to provide treatment or other contingencies in the school cafeteria. Compliance among the individual groups was 80.9 ± 9.2% in group A, 79.6 ± 3.6% in group B, and 75.5 ± 4.4% in group C. An ANOVA was performed to determine if the groups differed in the amount of treatment received. There were no differences (MS = 278.36, df = 2, F = 1.86, $p = 0.162$) between these groups.

Observer Reliability

Two independent observers analyzed all videotapes on weeks 0, 10, and 20. Observer 2 had been trained by the author (observer 1) who did not test any of the children. Eating time of the three standard textures from week 0 of the two observers was correlated. A high correlation indicates that high concordance exists between the two observers. Correlations ranged from 0.77 to 0.95 indicating high reliability between the two observers (Table 8). A t-test of differences between the values of observer 1 and 2 confirmed that there was no systematic tendency of one observer to report higher-lower values than the other.

Discussion

Oral-motor Responses in Relation to Weight Gain

No significant decreases in time to eat three standard textures of food were observed after 20 weeks of oral-motor treatment, although groups A and B showed a consistent decrease in time, whereas the control group (C) showed mainly an increase in time. Overall, the decrease in both groups A and B was greater from week 0 to 20 than from week 0 to 10. The increase in group C was also greater from week 0 to 20 than from week 0 to 10. This raises the question of whether the treatment period was not long enough to show a significant change. This question is best addressed in conjunction with the observed changes in weight. Group A showed a very small net gain [2.63(A) − 0.9(C) = 1.73] of 1.73 percentile points after 10 weeks of treatment, after subtraction

of 0.9 percentile points attributed to maturation. Following the same reasoning there is a slight percentile loss in group B [0.42(B) − 0.9(C) = −0.22]. The percentile gain (0.9 percentile points) in group C following treatment from week 10 to week 20 is the same as during the control period, thus, this gain should probably not be attributed to treatment. The reason for the loss in group A between week 10 and 20 is the fact that 2 children lost weight due to illness and refusal to eat following placement in a foster home, and 6 children did not gain any weight, which is an effective weight loss. Careful review of the 8 children who did not gain weight indicated that treatment compliance of assistants in treating these children improved from week 10 to 20 (i.e., 85.2% from week 0 to 10, vs. 91.5% from week 10 to 20). Therefore, lack of weight gain could not be attributed to lack of treatment consistency during the two periods. However, inspection of the data regarding all 8 children's illnesses indicated that absences due to illness were 3.5% between week 0 and 10 and 6.8% between week 10 and 20. This suggests that 8 children in group A experienced longer illnesses during the second half than during the first half of treatment which may account for the lack of weight gain. This interpretation is consistent with our findings of a significant contribution of illness to the eating of the solid texture during the second half of treatment. The minor change in group B (0.13 percentiles) from week 0 to 20 indicates that chewing exercises alone are not sufficient to induce catch-up growth. Overall, children fared best when given oral sensorimotor treatment with the proviso that they stayed healthy during the treatment period. However, all groups essentially only maintained their percentile line; they did not show catch-up growth [28].

Would a longer treatment period have insured catch-up growth? I do not believe so. During a 5-week treatment period of nasogastric feeding, Patrick et al. [9] achieved 25% weight gain, compared with pretreatment weight, in a more severely affected group of children with CP. Hence, catch-up growth occurs over a short period of time if children are provided with sufficient calories for growth. Children in the present study were treated over a 20-week period, four times longer than the period by Patrick et al. [9], therefore children who had been carefully selected for their potential for oral-motor improvements had ample time to achieve the oral-motor skills necessary for more efficient eating. I show elsewhere that oral-motor changes occur, but not in sufficient magnitude to affect catch-up growth [31].

The question of whether more frequent treatments would be more effective also needs to be addressed. Although my data do not permit me to answer this question directly, I have data indicating that some children of younger age (up to 8 years) have better weight-age percentiles than older children (beyond 8 years) [39]. When parents were questioned regarding oral-motor treatment given at home and feeding frequency, it became evident that these children were not given treatment, but were fed more frequently than children with poorer weights. Having drawn this sample from special schools that have a mandate to provide treatment, all of these children have had some oral-motor intervention in the course of their schooling. Thus, poorer weight-for-age in older children may indicate that remedial measures such as prolonged feeding [20], or sensorimotor therapy [17,21,22] may no longer keep pace with the growth demands of the teenage years. Thus, nutritional requirements for growth spurts may have to be met with caloric supplementation.

Krick et al. [32] have recently discussed the estimation of caloric needs for tube-fed quadriparetic children with CP and suggested that the 10th percentile weight-for-height is used as ideal with upward adjustment of measures if energy stores (arm circumference and triceps skinfolds) are below the 5th percentile. The authors also note and support observations by Thomessen et al. [3] who showed that energy intake when calculated on the basis of age is low for these children, but adequate and often exceeding recommended values when calculated on the basis of weight. My data describe a group of children who are just above the minimum described by Krick et al. but who remain marginal oral feeders. Thus, they represent a group of children who will need to be monitored carefully as they enter their teenage growth spurt.

In view of the daily commitment and effort that oral-motor therapies require, there are other everyday realities that need to be considered. We regard meal contingent treatments as most meaningful and feasible for both feeder and child. The 80% compliance which was achieved in my study is an indicator of the difficulties of sustaining treatment over a protracted period of time. Considering that mealtimes are often the only time when a family meets as a unit, setting aside time for treatment more than once a day may not be realistic. However, oral feeding provides for the important socialization that occurs at mealtimes. Alternatives such as tube feeding are not necessarily more cost effective in terms of service time required. Preparation for tube feeding and time and supervision to infuse meals can take up to 90 min per meal (personal observation). Tube feeding in many school systems must be administered by a qualified nurse. It has been our observation that increased tube feeding would require more nursing personnel than is currently available. In terms of life expectancy, follow-up studies of tube feeding in children with CP have not shown a decrease in mortality for these children [9,33]. Thus, maintaining optimal oral-motor skills becomes critical to support the oral ingestion that will have to be combined with calorically denser meals.

Clearing Time

In clearing time, 8 of 14 possible responses were decreases and 5 were increases between weeks 0 and 20. The changes in clearing time reflected no consistent pattern of change following oral sensorimotor therapy. This may be due to the wide variety of eating problems among these children. Some had no problems with the swallowing phase of ingestion and others were able to swallow only in a suckle-swallow pattern. These findings are in contrast to clearing times observed in a group of children with mild CP [12]. Whereas normal healthy children show an average clearing time of 3 sec across puree, viscous, and solid textures, children with mild CP have an average clearing time of 8 sec for solids and 7, 6, and 4.5 sec for viscous, sticky (cheese), and pureed textures, respectively. Thus, the dry, solid textures cause the greatest effort for clearing the mouth and so have the longest clearing time. Whether children with mild CP will show improvement in clearing time following oral sensorimotor intervention remains to be determined.

The accurate determination of clearing time is complicated by the fact that visual observation of swallowing only permits determination of the presence or absence of the swallow. It is not possible to identify the contents of swallow, i.e., food vs. saliva. It seems, however, that clearing time is determined by two factors: the facility of collecting chewed food particles and the ease with which they are propelled into the pharynx and esophagus during swallowing. The first phase of collecting food particles may indeed be amenable to change through greater oral-motor agility, whereas swallowing per se may be more difficult to modify because, once swallowing is initiated voluntarily, the ensuing food propulsion through the pharynx is involuntary.

Duration of Meals and Food Textures in Relation to Nutrition

Many authors have recently questioned whether children are given sufficient time to eat their meals and whether the meal content is calorically adequate. Careful weighing and noting of lunch contents in this study indicated that children's meals consisted of carbohydrates, fats, and proteins, accounting for 200–300 kcal of energy; this was eaten in 30–40 min. Reilly and Skuse [1] observed that the mealtime of a group of children with CP, 19.5 months of age, was 18.4 min when fed at home and did not differ from a group of healthy controls, but children with CP were offered and consumed less food than their healthy controls. Children with CP ate pureed and mashed foods whereas their healthy peers were offered regular table foods. Parents reported that they had great difficulty introducing more solid textures because their children with CP were unable to bite and chew [1].

Alphonce-Schweizer [12] examined a group of 5-year-old children with mild CP (ambulatory, able to self-feed, understood simple verbal instructions) in a school setting and compared them with healthy controls. Children with mild CP took 28.5 ± 8.0 min compared with 12.4 ± 5.0 min in healthy controls. The most striking feature of these meals was that the food textures of children with CP tended to be much softer than those of the controls, consisting of softly cooked pastas, soups, puddings, or yoghurts, whereas healthy children had sandwiches, fresh fruit, and other regular table foods. When tested with our standard textures of food [25], children with mild CP took significantly longer to eat the solid texture, but not the viscous or pureed texture. These findings may suggest that the average mealtime of 34 min for children with moderate CP may be the lower limit for providing adequate nutrition for these children. Functionally, however, half an hour may be the upper limit for demanding these children's attention because of their poor attention span and high distractibility. Thus, all of these factors point to the desirability of greater caloric density in meals so that feeding time can be kept within reasonable limits without compromising nutritional adequacy.

Thomessen et al. [3] examined nutritional state in a group of 5.5-year-old children with CP. They found that weight-for-height was significantly lower if children were unable to feed themselves, and so received assistance at mealtime, had oral-motor dysfunction, and had difficulty with food textures. The relative energy intake/kg body weight did not differ between their two groups of children who had or did not have feeding problems. In fact, the children with eating problems ate slightly more/kg body weight than those without eating problems [3], but they ate less when compared on the basis of age. Thomessen et al. [3] report also that feeding problems existed from an early age and that 60% of parents found the introduction of solid foods very troublesome. Mealtimes for some children were described as time consuming and exhausting because of children's inability to chew and swallow.

From these studies a consistent picture begins to emerge. The child with eating problems shows difficulty with chewing [1,3,31]. Problems appear early and are already present in infancy [1]. Problems are aggravated during weaning when children are unable to make the transition to the eating of solid textures [3]. Efficient chewing requires tongue lateralization so that food can be moved onto the molar tables for chewing [34,35]. The child who does not develop tongue lateralization invariably also fails to develop vigor in chewing. This may be perceived as extremely frustrating by teachers and parents, however, it may be a protective mechanism for the child in that it prevents morsels of food from entering the

mouth which, if not adequately chewed, may later lead to gagging and choking. I have observed that when eating-impaired children show the rudiments of tongue lateralization, the movement can be shaped through exercises which I described earlier (see Materials and Methods). However, I found it more difficult to achieve greater vigor in chewing through exercises than to achieve tongue lateralization. Texture changes (Table 6) reflect an increase from mashed foods at week 0 to more viscous textures at week 10 and a further increase to more solid textures at week 20. As was pointed out earlier, this always involves a greater chewing effort by the child and so may initially increase feeding time. The 20% increase (week 0 to week 20) in solid textures and the 20% decrease in mashed textures with a change toward more viscous and then solid textures represents the best achievement of approximately one-third of the children. From week 0 to week 10, 10% of the children made the change from mash to a viscous texture, and half of the children between week 0 and week 20 from puree to mash. The increase in eating effort must be carefully balanced against the nutritional requirements of the child, and may be one more reason to argue for nutritional supplementation when indicated. This argument is further supported by the observation that illness of children, degree of mental retardation, and ambulatory status may influence a child's response to therapy. Thus, it is our contention that the moderately eating-impaired child may benefit from oral sensorimotor therapy, but that these factors, in combination, may influence eventual treatment outcome.

What then have we learned by looking at both the oral-motor skills and measures of growth following sensorimotor training in a group of moderately eating-impaired children with CP? It is clear that this is a group of fragile children who maintain their growth trajectory at the lower end of established norms, if they remain healthy. Any challenge such as illness or a growth spurt puts these children at great risk for growth failure. Increasing the duration of their mealtime may be appropriate up to an age of approximately 8 years. Within the context of a family's everyday routine, mealtimes of more than half an hour may be unrealistic [1,36]. This is also true for feeding children in institutions [9]. Consistent, long-term support to families with children who have eating impairments is essential for teaching age-appropriate feeding techniques, as well as for monitoring a child's progress. Griggs et al.[37] report that although time to feed did not decrease in a group of severely eating-impaired children, parental satisfaction was expressed for the ongoing evaluation and guidance of children's eating problems offered by a therapist. In addition, ongoing training of feeding assistants who usually feed these children in schools is essential to insure the safety as well as the quality of the service rendered.

One last point concerns the quality of life of these children. Studies of nutritional supplementation with severely eating-impaired children indicate that their mood improved [8,24] and that some children showed marked developmental gains [24]. Evans et al. [38] note that although immobility and severe mental subnormality are the strongest predictors of mortality in children with CP, the majority of even the most severely affected children survive to adulthood. Our current state of knowledge suggests that the moderately eating-impaired child with CP should be fed orally but at the same time be monitored carefully in terms of his/her indicators of growth. To achieve a desirable nutritional state, oral nutritional supplementation should be considered when indicated.

Acknowledgments. I am grateful to Drs. Sh. Vanden Noven, P. McKinley, and M. Abrahamowicz for critical comments on previous drafts of this manuscript. This research was supported through a grant by the National Health Research and Development Program #6605-3306-45 to the author and in part by a postdoctoral fellowship through the American Occupational Therapy Foundation.

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