CAN CHEWING EXERCISES IMPROVE MASTICATION AND ARTICULATION? A COMPARISON OF TWO DIFFERENT TREATMENTS.

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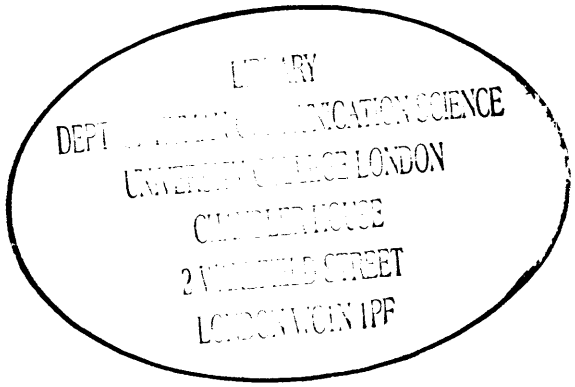

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To Paul, you provide my stability, thank you.

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ABSTRACT

Jaw stability is thought to be necessary for adequate chewing skills and for articulatory proficiency but it is not known whether chewing exercises, aimed at increasing jaw stability where weakness is suspected, would improve mastication and articulation. The effects of two different chewing therapies were investigated; therapy tools (chewy tubes and ark grabbers) combined with food chewing exercises versus food chewing exercises alone. Effects on chewing performance, articulation and oral motor function were measured in two groups of children and compared with a control group. All children were aged between 4;0 to 5;11 years and had no known neurological impairment. Results found that therapy groups had significantly improved chewing performances. Non-significant trends suggested that children may have had improved articulation and oral motor skills following therapy. Finally, trends (non-significant) indicated that therapy tools combined with food chewing exercises may have been more beneficial on all measures. Therefore chewing exercises were found to have a significant effect on mastication and additional research is necessary to further investigate their effect on articulation.

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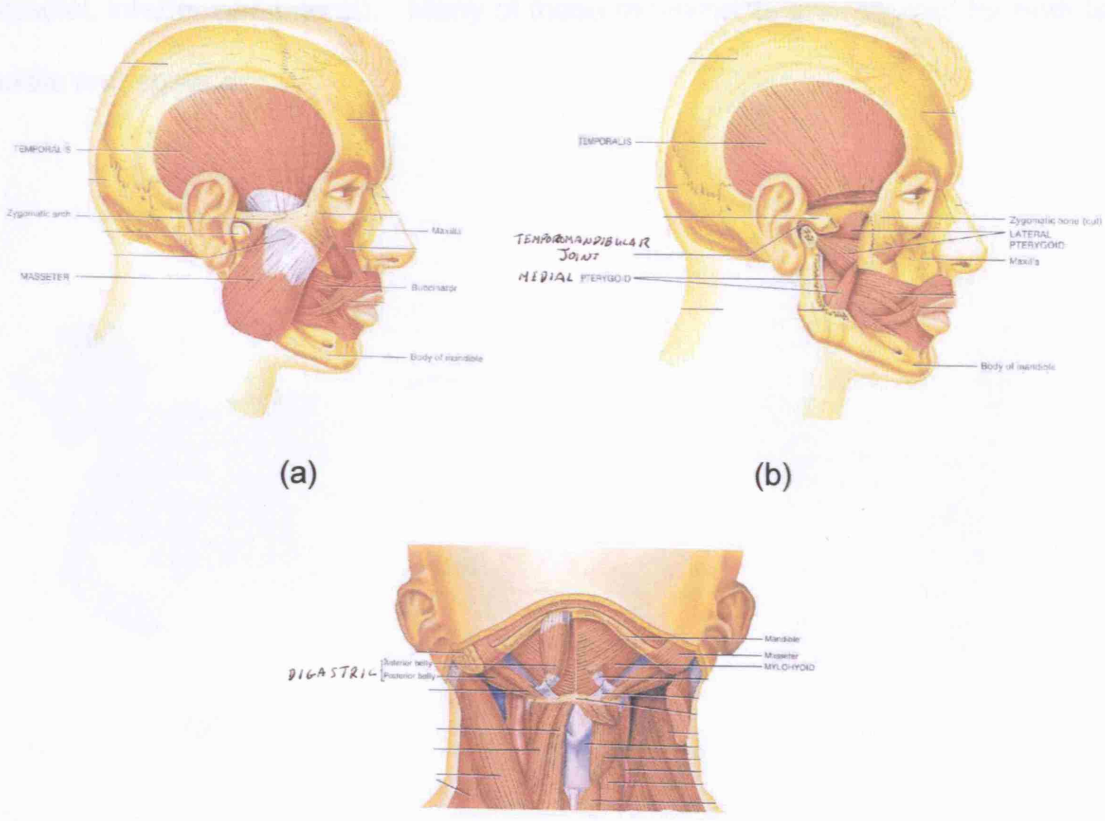
INTRODUCTION

Oral exercises, tactile cues and feeding techniques including chewing exercises are oral motor (OM) therapy activities proposed to normalise the function of the oral motor structures. This may be for the purpose of improving feeding difficulties (Arvedson & Rogers, 1997) or for the remediation of articulation difficulties (Dworkin, 1991). OM therapy has recently found a renewal of interest with new therapy programmes and tools available, for example the Beckmann programme (1988), the Chapman-Bahr programme (2001) and Talktools (Rosenfeld-Johnson, 1993). These do not only target children with neurological impairments unlike most previous therapy recommendations; children with no known organic cause of oral muscle-based weakness are also included.

Adequate jaw muscle strength and stability is considered necessary for oral movements (Rosenfeld-Johnson, 1993). The jaw provides stability in order that tongue and lip muscles can move independently with finely graded movements, necessary for both feeding skills and speech production. Strength and stability in the jaw is developed in childhood through feeding, specifically chewing solids. Clients who demonstrate a muscle-based jaw weakness would therefore benefit from chewing exercises tailored to increase jaw muscle strength. These will facilitate improved feeding patterns and are also suggested to provide the necessary motor foundation for speech clarity (Rosenfeld-Johnson, 1993).

Anatomy and physiology of the jaw:

The jaw consists of the maxilla, the mandible and the temporomandibular joint (TMJ). The mandible articulates with the temporal bone via the TMJ and is capable of elevation/depression, protrusion/retraction and lateral movements. These can be combined to provide more complex movements, for example a rotational motion required for adult-like chewing. There are seven muscles responsible for these movements: Masseter, Temporalis, Medial and Lateral Pterygoid, Digastricus, Mylohyoid and the Geniohyoid (Figure 1).

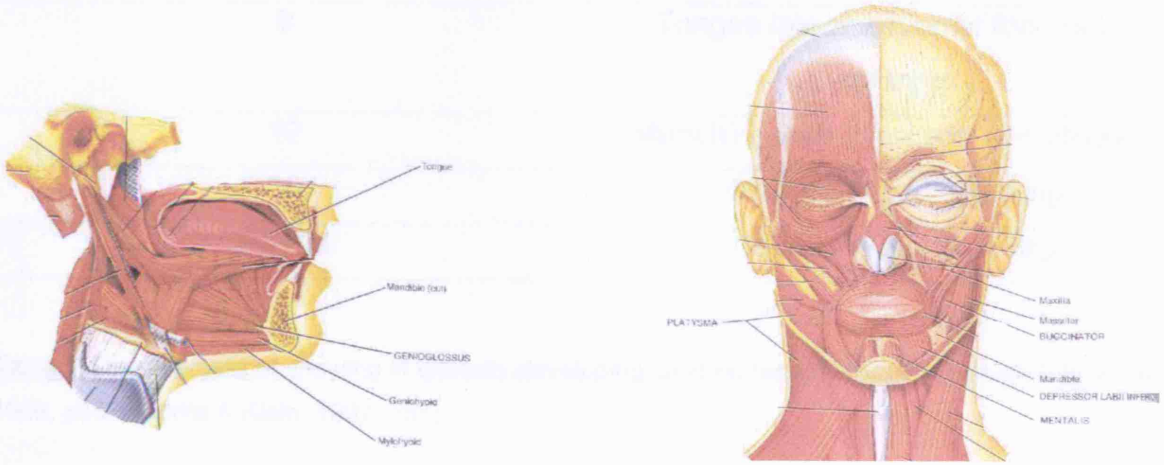


(a) (b)

(c)

Fig 1: Muscles required for movement of the mandible (a) right lateral superficial view; (b) right lateral deep view and (c) anterior superficial view (Tortora & Grawbowski, 1993).

The opposing actions of these muscles, as well as a system of ligaments, ensure that the TMJ and hence the mandible stay in a stable position. Of the many tongue muscles, only one, the Genioglossus, originates from the mandible. It forms the greater bulk of the lingual tissue and is the largest and strongest tongue muscle (Zemlin, 1988). Primarily it moves the tongue up and down but is involved in many other lingual movements, important for both feeding and speech. The lips are moved by a myriad of facial muscles, six of which arise from the mandible: Buccinator, Depressor Labii Inferior, Mentalis, Depressor Anguli Oris, Incisivus Labii Inferior and the Platysma (Fig 2). These cause various movements of the lower lip (e.g. depression, eversion, compression and lateral) and of the corner of the mouth (e.g. medial, inferior and lateral). Many of these movements are required for both feeding skills and speech.



(a) (b)

Fig 2: tongue and facial muscles originating from the mandible (a) right side view of lingual muscles and (b) anterior view of facial muscles (Tortora & Grawbowski, 1993).

The cortical regions involved in mastication have been identified using Magnetic Resonance Imaging (MRI). Bilateral activation of the primary sensorimotor cortex

and the primary sensory cortex for gum chewing was observed in adults (Onozuka, Fujita, Watanabe, Hirano, Niwa, Mishiyama & Saito, 2002). The primary motor cortex is also associated with motor production of speech (Duffy, 2005).

Normal development of chewing and jaw stability:

Chewing develops as part of a progression of maturing feeding patterns (Newman & Peterson, 1999). Table 1 shows the developmental sequence for chewing in typically developing infants.

Age (months)	Oral Motor Skills
6	Chewing pattern emerges - munching
7	Lips begin to move while chewing
8	Lip closure achieved
9	Tongue lateralisation of food bolus emerges
12	Munching with improved lateralisation
15	Diagonal rotary chewing
24 – 36	Circular rotary chewing

Table 1: Development of chewing in typically developing children (adapted from Newman & Peterson, 1999, p352; Morris & Klein, 1997, p87)

Jaw stability is dependent upon the postural support and stability of the body. A stable trunk and pelvis allow for development of stability in the head, neck and shoulder girdle (Woods, 1995). This in turn enables the hyoid complex to develop stability. The jaw depends on the hyoid complex for its stability. The pattern of central stability (e.g. trunk) being required for movement of distal structures (e.g. head) continues. The lips, cheeks and tongue are considered proximal to the jaw;

therefore jaw stability must be in place for movement of these structures (Morris & Klein, 1987).

Jaw stability develops in tandem with postural support and feeding development. By six months infants can sit without support; this trunk stability enables increased head control (Arvedson & Brodsky, 1993). With this comes the ability to safely manipulate and swallow thicker foods. Initially a munching pattern of vertical jaw movement emerges which is inefficient for all food types. Hence soft textured foods are introduced. This vertical pattern develops strength in the jaw muscles in preparation for biting and chewing. By nine months infants can move the jaw laterally when munching due to increased jaw muscular control. Foods with increasing texture and hardness can now be introduced. Diagonal rotary chewing is developed by 15 months. Following consistent jaw stability emerging by 24 months (Morris, 1985), circular rotary chewing (a smooth swinging motion) develops between the ages of 2 and 3 years (Morris & Klein, 1987). Increasing jaw strength and stability was demonstrated in a study examining the sequential development of control of the jaw and lips in typically developing participants ranging from one year olds to adults (Green, Moore & Reilly, 2002). Movement patterns of the jaw were found to be stable by 12 months of age while the lower and upper lips stabilised with maturity, in that order.

Inadequate jaw strength and stability:

Inadequate development of jaw stability may occur in individuals with low muscle tone (e.g. Downs syndrome, Autism and other genetic conditions). High muscle tone may also cause difficulties with muscular control of the jaw (e.g. Cerebral Palsy,

Head Injury). Children of unknown aetiology may also exhibit mild to severe levels of mandibular muscle weakness and instability manifesting as picky or messy eaters, restricted food preferences, gagging and/or difficulties with speech clarity, lisps and so on (Rosenfeld-Johnson, 1993). Inadequate development can have far reaching consequences. The ability to chew, position and swallow a bolus safely can be limited by poor oral motor skills (Kenny, Koheil, Greenberg, Reid, Milner, Moran & Judd, 1989). This may result in poor nutritional levels due to long mealtimes, inadequate intake and aversions to texture or taste of food and liquids (Reilly, Skuse, Wolke & Stevenson, 1999). The consequences of poor nutritional status include:

- Inadequate weight gain
- Affected cognitive development
- Poor motivation to learn and play
- Dental caries
- Prone to infections
- Behavioural difficulties.

A study found that a third of all children with neurological disabilities resulting in oral motor difficulties were significantly undernourished (Thommessen, Heiberg, Kase, Larsen & Riis, 1991). In another study focussing on children with Non Organic Failure to Thrive (no known aetiology causing low weight), a subset had significant oral motor difficulties (Reilly et al, 1999). Butler and Golding found 4% of five year olds were described as faddy eaters by their parents in a large population study (1986). Selective eating/faddiness is a common but usually transient occurrence in younger children. Sometimes however, it may not resolve. These children tend to maintain a normal weight but eat large quantities of their highly selective preferred

foods, drink a lot of milk or are extremely slow eaters. While there may be a motivational element involved in these children's difficulties, there may also be an oral motor based deficit (Burklow, Phelps, Schulz, McConnell & Rudolph, 1998). These studies illustrate that some children with oral motor difficulties may be at risk of inadequate nutritional intake.

Assessment of chewing:

A valid and reliable method of assessment of chewing is required for accurate diagnosis and treatment application. Several methods exist which vary in applicability and appropriateness. One method used to assess mastication is Electromyography (EMG). Electrodes are placed on the relevant mandibular muscles and electrical measures are taken during chewing. Indicators of chewing performances such as masticulatory time and number of chewing cycles are measured (Peyron, Lassauzay & Woda, 2002). This method has limitations: electrodes can be difficult to place on the exact muscles, effects from nearby muscles may be measured and the relationship between muscular activity and the force of contraction is not direct. Videofluoroscopy (VFS) is another method which can be used to visualise and evaluate chewing as part of a swallowing assessment (Logemann, 1998). However due to restrictions relating to radiation exposure from the procedure it is not suitable for children or adults unless aspiration of liquids or solids is suspected.

Less invasive methods have also been found to be reliable indicators of chewing performance. Masticatory time and number of masticatory cycles as measured by video analysis were found to be valid for participants with Downs Syndrome (Alison,

Peyron, Faye & Hennequin, 2004). Mean chewing time for different textures was found to be a sensitive indicator in a group of children with CP (Gisel, Alphonse & Ramsay, 2000). Liedberg and Owall suggested that bolus shape and mixing could be used to measure chewing performance (1995). These were found to be sensitive indicators in a group of children with CP using chewing gum (Edwards, 2002). Clinical assessments of feeding have been published which usually include a section on chewing. Quantitative assessments such as the Multidisciplinary Feeding Profile (Kenny et al, 1989) and the Schedule for Oral Motor Assessment (Reilly, Skuse & Wolke, 2000) are useful when measuring change and have adequate validity and reliability. However the former is reliable for use only with neurologically impaired populations and the latter is for use only with infants (8 -24months). Qualitative assessments are very often used by clinicians due to ease of use and availability. Examples include: the Paediatric Oral Skills Package (Brindley, Cave, Crane, Lees & Moffat, 1996) and the Oral Motor Feeding Rating Scale (Jelm, 1990). However these are lacking in normative data, a standard testing procedure and reliability measures.

OM therapy for feeding difficulties:

If oral motor deficits are identified then treatment must be initiated with the purpose of normalising oral motor activity for feeding and speech production (Alexander, 1987). Studies have attempted to evaluate the benefit of OM therapy, including chewing exercises, aimed at normalising feeding performance but with mixed results. Several studies with neurologically impaired children have been conducted (Gisel, 1994; Gisel, 1996). In the first study two groups of children with CP were compared; one group received 'Sensorimotor therapy' (tongue lateralisation, chewing and lip exercises) while the other group received chewing only exercises (1994). Chewing

exercises for the former group consisted of placing small pieces of biscuits on alternating back molars with encouragement to chew. For the 'chewing only' group, small pieces of gelatin were placed on the lingual midline with encouragement to chew; increasingly harder textures were offered with progress. After 20 weeks of therapy (five to seven minutes per day, weekdays), all the children had improved chewing competence scores (as rated on the MFP, Kenny et al, 1989). There were no differences between the improvements made by either group suggesting that chewing only therapy was just as effective as 'sensorimotor therapy'. However developmental changes could not be ruled out as a control group was not included. Subsequently, Gisel used the same method with similar groups of children while also including a control group (1996). This time measuring eating time for a meal and weight gain, there were no significant differences between the groups, suggesting that neither therapy was effective. However several of the children in the therapy groups were ill during treatment with subsequent weight loss which affected the results. Also, chewing time for a meal may not be a reliable measure of chewing performance.

OM therapy for articulation:

OM therapy is recommended for the remediation of articulatory delays/disorders on the basis that a motor deficit underlies the disorder (e.g. Rosenfeld-Johnson, 1993). This is controversial for various reasons. Firstly the underlying cause(s) of articulation delay/disorders are not definitively known. Secondly studies have demonstrated that oral motor exercises can not alone improve articulation (Abrahamsen & Flack, 2002; as cited in Lof, 2006). Finally there are several

hypotheses upon which this premise has been based, none of which have been irrefutably proven.

One hypothesis suggests that articulation develops as oral skills mature. Speech is a learned skill, usually mastered by approximately eight years of age (Sanders, 1972). Oral skills are developed over time through feeding maturity. Therefore exercises using feeding skills (e.g. chewing, sucking) are thought to improve motor skills for speech development in those with identified feeding and speech deficits. This connection is not empirically established. Different mandibular muscle activity patterns for chewing and articulation were found in adults and in 15 month old children (Moore, 1993; Moore & Ruark, 1996) but similar in nine month olds (Steeve, Moore, Green & Engel, 1999 as cited in Morris & Klein, 1987). This may indicate that there is a shared neural control in early development which is usually differentiated by 15 months of age.

Whether feeding is a precursor or not, oral skills have been observed to significantly influence the development of speech. A developmental sequence of jaw and lip movement patterns for speech in a study involving infants, older children and adults was found (Green et al, 2002). The jaw was the first to reach adult-like movement patterns for CVCV productions with the lower lip next, then upper lip. The authors suggested that children will use their existing oral motor abilities to best produce speech, for example if only the jaw is stable then bilabial stops will be easiest whereas the phoneme /f/ will develop when greater lip control is present. This follows known developmental patterns of phoneme acquisition. The evidence presented is far from conclusive and there are methodological issues which affect

validity; foremost being the difficulty of assessing speech production in very young children.

Another hypothesis suggests that there is inadequate oral muscular strength for speech. This raises an interesting question. Children who have a diagnosis of phonological delay/disorder have, by definition, had an organic cause ruled out. If there is a muscular weakness this would suggest a dysarthria which is caused by a neurological deficit (Darley, Aronson & Brown, 1975). Perhaps then children presenting with oral muscular weakness should be referred for a neurological evaluation. Oral muscular weaknesses are often identified using subjective measures (i.e. asking the client to produce force against clinician provided resistance). A perceptual judgement is then made regarding adequacy of force. There is insufficient data indicating how much strength is required for speech to compare this judgement with. Current data suggests that only 10 to 20% of the maximum force of the lips, 20% of the maximum lingual force and 11 to 15% of the maximum mandibular force is needed for speech in adults (Forrest, 2002; Lof, 2006).

Furthermore there is no evidence demonstrating that children with an articulation delay/disorder demonstrate a weakness of the oral musculature. This does not mean that there is no weakness and if there is, then oral motor exercises only aim to increase strength to normal levels and not beyond. The effects of strengthening exercises on oral muscles are thought to be highly specific, so while chewing exercises should improve the jaw muscles for mastication this may not transfer to speech. However OM therapy aims to obtain the movement first and then transition this new skill to an appropriate speech task (Rosenfeld-Johnson, 1993).

Despite the theoretical debate surrounding OM therapy, its use is still recommended. Tongue, lip and jaw muscle strengthening exercises are recommended for clients with weaknesses causing speech difficulties in adult neurological populations, unless contra-indicated (Duffy, 2005; Dworkin, 1991). The Nuffield Dyspraxia Programme utilises many oral motor exercises prior to working on speech (Williams & Stephens, 2004). Exercises to improve feeding are also suggested as a foundation for speech development in very young children (Lancaster & Pope, 1989).

Some studies have been conducted investigating the efficacy of OM therapy for articulation. No improvement on measures of articulation following OM therapy (e.g. blowing and sucking) was demonstrated (Abrahamsen & Flack, 2002; Guisti & Cascella, 2005 as cited in Lof, 2006). When OM therapy was combined with traditional articulation therapy mixed results emerged. In a study by Christensen and Hanson, tongue retraction exercises carried out in conjunction with traditional articulation therapy were just as effective as traditional therapy alone in the remediation of lisps (1981). However several of the children were later found to have other difficulties which may have impacted their performance (e.g. malocclusion). The authors also noted that it was difficult to measure how much home practice was conducted as this may have had a variable effect on the results. Recently children who received traditional articulation therapy with oral motor exercises, demonstrated fewer articulation errors than another group who received traditional therapy alone (Fields & Polmanteer, 2002 as cited in Lof, 2006). However the children's difficulties in the latter group were more severe which may have reduced this groups' potential progress rate.

The evidence suggests that OM therapy, including chewing exercises, aimed at improving children's feeding skills produces conflicting results. OM therapy in isolation, aimed at improving articulation has not been found to have any beneficial effects, but there are some positive reports when it is combined with traditional articulation methods. None of these latter included chewing exercises. Despite the lack of baseline information and conclusive evidence and the greater emphasis on evidence based practice, SLT's continue to use OM therapy to improve children's feeding and articulation skills. Many new types of oral motor exercises and tools have been developed. Chewy Tubes and Ark Grabbers are new therapy tools recommended to improve chewing and jaw stability and have not been investigated previously. The aim of this experiment was to compare their effectiveness in combination with chewing exercises using food versus the latter alone in two groups of children measuring chewing performance, articulation and oral motor skills. Children had no known cognitive or physical disability but were identified with oral motor weakness. A control group of similar children was included for comparison purposes.

Hypotheses:

The hypotheses were:

1. Ho - any difference in the change in **chewing skills** between participants who have and have not been treated is due to chance

   H1 - any difference in the change in chewing skills between participants who have and have not been treated is unlikely to be accounted for by chance
2. Ho - any differences in the changes in chewing between the groups is due to chance

H1 - any differences in the changes in chewing between the groups is unlikely to be accounted for by chance.

3. Ho - any difference in the change in **articulation skills** between participants who have and have not been treated is due to chance

   H1 - any difference in the change in articulation skills between participants who have and have not been treated is unlikely to be accounted for by chance

4. Ho - any differences in the changes in articulation between the groups is due to chance

   H1 - any differences in the changes in articulation between the groups is unlikely to be accounted for by chance

Considerations:

1. Posture:

Correct body posture during feeding is essential. This provides for good alignment of the alimentary tract, minimal occurrence of a gag reflex, normal breathing and normal movement of the head and oral motor structures (Kenny et al, 1989). The ideal position is:

- Level pelvis with a 90 degree seat-to-back angle
- Hips, knees and ankles at 90 degree angles
- Shoulders relaxed
- Hands towards the midline
- Good alignment of the head with the trunk
- Head forward facing

- Chin tucked in slightly

(Woods, 1995)

2. Texture and chewing:

Texture can have an effect on the chewing behaviour of children and adults and is defined as "an attribute determined principally in the mouths of consumers" (Purslow, 1991). Stolovitz and Gisel, found that solids cause the tongue and jaw to work harder, consequently encouraging more mature feeding behaviours in children aged 6 months to 2 years (1991). Using EMG readings of jaw movements for chewing in healthy adults, a significant texture effect was also found, where real food items of increasing texture resulted in higher muscle activity (Kohyama, Mioche & Martin, 2002). This suggests that increasing hardness/texture of foods causes the muscles of mastication to work harder.

3. Non-neurological impairment:

This experiment aimed to investigate children with no known neurological impairment therefore children with suspected physical or cognitive disabilities were excluded. In the health service where the research study was conducted these children are referred elsewhere for diagnosis and further services. On this basis, participants were considered to have no known neurological impairment.

4. Identification of oral motor weakness:

Due to the lack of appropriate clinical assessments children's' oral motor abilities are usually assessed by means of informal observations in the SLT Department where the study was conducted (e.g. strength is often assessed perceptually by asking the client to produce force against resistance which is provided by the SLT). Children who were identified as potential candidates for the study would have had oral motor weaknesses identified in this way.

METHODOLOGY

Design:

This research study was a small scale quasi-experimental efficacy study which aimed to examine the effects of two different chewing therapies on children aged between 4;0 to 5:11 years. It was a mixed 2 X 3 factor design. Differences between two treatment groups and a control group were compared and changes within groups over time were measured. The independent variables (IV's) were

- treatment/no treatment, with three levels: two treatment groups and a control group
- time, with two levels: pre and post-assessment.

There were three dependent variables (DV's): scores on tests of

- chewing,
- articulation,
- oral motor skills

Participants:

Thirty children were invited to participate in the study (7 girls, 23 boys). Consent forms were returned for 22 children. Two children dropped out; hence twenty children completed the study (4 girls, 16 boys). They ranged in age from 48 to 71 months (mean 59.6 months, SD 7.6 months). The children were matched for age and severity of chewing difficulty as measured by the Oral-Motor Feeding Rating Scale (Jelm, 1990) administered during the pre-assessment and then randomly assigned to three groups (A, B, C). The mean age of group A (n= 7, 2 girls, 5 boys) was 61.3 months, SD 7.2; group B (n = 7, 1 girl, 6 boys) was 56.9 months, SD 8.3; and group C (n = 6, 1 girl, 5 boys) was 60.7 months, SD 7.7. The median chewing score for group A was 6, IQR 7; group B was 7, IQR 2; and group C was 7, IQR 9.

All children were engaged in the SLT service; all had identified oral motor weaknesses. Of these, 15 had either a phonological delay or disorder while five had a feeding difficulty. None of the children had either a physical or cognitive disability. Fourteen of the children had attended for previous therapy sessions (either OM therapy only, phonology therapy only or a mix of both). The mean number of total previous therapy sessions for group A was 4.57 (SD 5.77), for group B was 5.71 (SD 3.2) and for group C was 5.33 (SD 4.55). Of those who had received some form of OM therapy before, none had used the techniques involved in this study. Table 1 provides a detailed summary of the participants.

N	Group	Age (Yrs)	Diagnosis	Amount of Therapy			
				OM	Phon	Mix	Total
1	A	5;6	Phon delay	0	0	7	7
2	A	4;8	Phon delay	0	0	0	0
3	A	5;8	Phon delay	0	5	0	5
4	A	4;10	Phon disorder	0	0	4	4
5	A	5;10	Phon delay	0	0	0	0
6	A	5;2	Phon disorder	0	0	16	16
7	A	4;2	Phon disorder	0	0	0	0
8	B	4;0	Phon delay	0	0	3	3
9	B	4;4	Feeding	0	0	0	0
10	B	4;8	Feeding	0	0	8	8
11	B	5;4	Phon delay	6	0	0	6
12	B	5;11	Feeding	0	0	6	6
13	B	4;10	Phon delay	0	5	4	9
14	B	4;1	Phon delay	8	0	0	8
15	C	5;8	Phon disorder	0	0	0	0
16	C	4;0	Phon delay	0	0	10	10
17	C	4;9	Feeding	0	0	0	0
18	C	5;4	Feeding	4	0	6	10
19	C	4;11	Phon delay	7	0	0	7
20	C	5;8	Phon disorder	5	0	0	5

Table 2: Table with participant information: treatment group, age (in years), diagnosis (e.g. phonological delay or disorder, feeding difficulties) and amount of previous therapy (OM therapy only, phonological therapy only, mixture of both, total).

Materials:

Chewy Tubes:

These are oral motor tools used to provide resistance to the jaw during chewing and can be used to aid chewing, biting and oral sensory skills (Fig 3). They are made of

a thermo-elastic polymer material which is FDA approved and CE marked. They are non-toxic, latex and lead free and do not contain PVC or phthalates. Two different colours were used in this study: red and yellow. The red tube has a larger stem with an outside diameter of 3/8" while the yellow tube has a narrower stem with a ½" outside diameter. They are manufactured by Speech Pathology Associates LLC, (www.chewytubes.com).

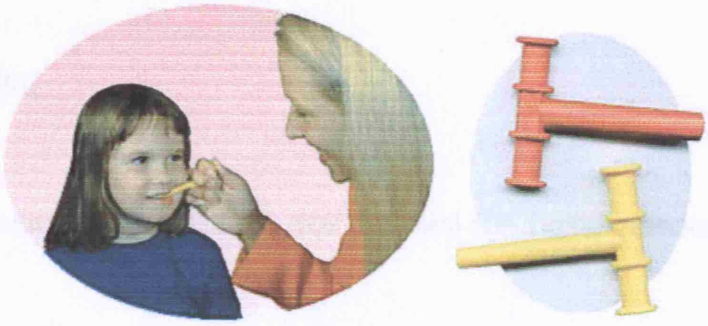


Fig 3: Red and yellow Chewy Tubes

Ark Grabbers:

These are oral motor tools used for mouth exploration and jaw movement (Fig 4). They are made of a medical grade, chewy, resilient material, which is latex free. Both the material and the colours are FDA approved. Two different colours were used in this study: purple (Ark Grabber) and green (Ark Grabber XT). The green is an Xtra Tough version, being made of a firmer material while still being chewy and resilient. They are manufactured for ARK Therapeutic Services Inc (www.arktherapeuticservices.com).

Fig 4: Purple Ark Grabber and green Ark Grabber XT

Video Recorder:

A JVC video camcorder (GR DVL 107 EK mini DV digital videocassette) was used.

Procedure:

Participant identification:

Ethical permission for this research was granted by the University College London Research Ethics Committee, Project ID number 0983/001 (appendix I). Following this the SLT Manager of County Galway Primary, Community and Continuing Care (PCCC), Health Services Executive West, Ireland was approached and permission to conduct the research in that service was given. County Galway PCCC policy regarding ethical permission states that research must be approved by the applicant's university prior to granting permission (appendix II). Suitable participants for the study were identified in two ways. Firstly, criteria were furnished to SLT staff, who identified potential children from their caseloads. Secondly, a list of children from the therapy waiting list with identified oral motor weaknesses had already been

compiled for therapy planning purposes. Further potential participants were identified from this. Criteria included:

- male or female
- aged between 4;0 years and 5;11 years
- jaw muscle weakness
- articulation delay (optional)
- restricted diet/soft food preferences (optional)
- normal cognitive ability
- no known physical disability
- no previous therapy with the techniques used in this study

A letter, with an invitation to participate along with information about the research, was sent to parents who were asked to return signed consent forms if willing to allow their child to participate (appendix III).

Pre-assessment:

Once consent was received an appointment was sent for the pre-assessment. This was conducted in the SLT clinic by one of two assessors. Both were experienced SLT's working in the clinic who received training from the researcher on the administration of the battery of assessments. Each child attended individually with a parent present. Assessor 1 tested seven children and Assessor 2 tested 14 children (an equal division of assessments was not possible due to the assessors' work commitments).

Post-assessment:

Following completion of the treatment phase, appointments were given for the post-assessment. Each child attended individually with a parent present and was seen by one of the same two assessors using the same battery. Assessor 1 assessed seven different children from the pre-assessment and Assessor 2 assessed 14 children (7 different and 7 same children). The assessors were not informed of which group the children had been assigned to.

Assessments:

1) OMFRS - Oral-Motor/Feeding Rating Scale (Jelm, 1990) – 'Biting' and 'Chewing' sections. This is a non-standardised assessment using observation to subjectively rate children's feeding abilities (appendix V). In the 'Biting' and 'Chewing' sections, a rating on a scale of one to five for lip/cheek, tongue and jaw functions when biting soft and hard textures and chewing was provided. This was used as a score for the severity of chewing deficit.

2) POSP - Paediatric Oral Skills Package (Brindley et al, 1996) – 'Structure and Function' section and 'Movement' section. This also is a non-standardised assessment using structured observation to create a profile of children's oral function (appendix V). In the two sections used, a normal/abnormal score was provided for the physical structure of the oral components and their functional abilities. This was used as a score for the severity of oral motor deficit.

3) EAT - Edinburgh Articulation Test (Anthony, Bogle, Ingram & McIsaac, 1971). This is a standardised test for children aged between three to six years (appendix V). It provides a standardised score of articulation ability based on an analysis of pronunciation errors. This was used as a score for the severity of articulation difficulties.

Therapy:

Upon completion of the pre-assessments, children were matched according to age and severity of chewing ability. Children in each group of three matched children were then randomly assigned to one of two treatment groups or a control group. Group A received therapy tools (chewy tubes/ark grabbers) and food chewing exercises; group B received food chewing exercises only and group C were the delayed therapy group (control group). Treatment groups (A and B) attended in small groups of three to four children twice a week for four weeks with the researcher. Each session lasted approximately 40 minutes and were separated by a minimum of two days. One child attended individually due to parental difficulties attending at the appointed group time. Parents waited in the nearby waiting room with the exception of one mother whose child would not willingly separate. Children attended a minimum of six out of the eight sessions to be included in the research. The mean number of sessions attended by group A was 7.3 (SD .76) and by group B was 6.86 (SD 1.1).

Group A:

Activities were introduced in the following order: therapy tools, cube placement and slow feed.

- *Therapy tools:*

Each child worked through the set of four chewy tubes and ark grabbers over the eight sessions. For hygiene reasons each child had their own set of tools and sharing was never permitted. The tools were used following a hierarchy of increasing chewing difficulty: red then yellow chewy tube, followed by purple then green ark grabber (Rosenfeld-Johnson, 2005). Each tool provides increasing resistance to the jaw, therefore increasing the difficulty. The following procedure was adapted from that proposed by Rosenfeld-Johnson (2005). Children were taught the "good sitting" posture: sitting upright in a child size chair with 90 degree angle in the hips, knees and ankles. With the child's hands in his/her lap and the researcher facing the child at eye level to encourage an upright head and straight neck, the end of the red chewy tube was placed on the child's right back molars (sterile gloves were worn by the researcher). The child was instructed to "chew, chew, chew" up to a count of 10 chews while the researcher continued to hold the handle of the chewy tube and simultaneously modelled a chewing movement. This was then repeated on the left side. The child was observed for indicators of difficulty such as:

- jaw jut or jaw slide
- head turning towards the chewy tube
- attempts to compensate by putting a hand up to support the jaw

- fixing in a body part.

Each chew was considered successful if the tube was fully depressed so that the inner sides of the tube meet. When a child failed to do this or if any of the above indicators occurred, the tool was removed and the number of successful counts noted to monitor progress (appendix VI). If a count of ten successful chews on each side was achieved then this was considered as completion of that tool and the next tool on the hierarchy was introduced (i.e. yellow chewy tube). If two or more chews were achieved, then the next more difficult tool in the hierarchy was also introduced. This was continued until the child failed to achieve a minimum of two chews. This procedure was repeated in each session.

- *Cube placement:*

Each child practiced chewing using food cubes. A checklist of food preferences was completed by parents prior to the start of therapy. The following procedure was adapted from Rosenfeld-Johnson (2005). Food items were cut into ½ inch square cubes and placed into plastic pots (appendix VII). Initially soft textures were used which increased in hardness as the children's abilities progressed. An array of six or seven different food types was presented for selection in each session. Each was identified and children were asked in turn to choose a cube for chewing. Once he/she was sitting in the "good position", a cube of this food type was placed on the child's back right molars and the child was instructed to "chew, chew, chew" until it was "all gone" (sterile gloves were worn by the researcher). The child was observed for the same indicators as described above but also for lip closure and excessive chewing time (appendix VI). Children were reminded to chew the cube only on the

same side as it was presented on. This procedure was repeated on the left side. In order to increase the range of food types attempted in the session and to eliminate children simply choosing their favourite food items for all attempts, children were not allowed to chew two items from the same food type twice unless they had tried all their preferences. Disliked food types were never forced upon any of the children. The researcher remained impassive regarding any negative reactions to food. Between two to four cubes were chewed by each child per session.

- *Slow Feed:*

Each child practiced biting and chewing using long strips of food. This procedure was also adapted from Rosenfeld-Johnson (2005). Initially starting with soft textures and progressing to harder textures, food was cut into very thin but long strips (approximately 1/2cm x 7cm) and placed on a plate for selection (appendix VII). Again children were given a variety of items to choose from. Once the child was sitting in the "good position", the end of a strip was placed on the back right molars but not beyond the inside surface of the teeth. The remainder of the strip stuck out of the child's mouth at right angles to the teeth (sterile gloves were worn by the researcher). The child was instructed to "bite, bite, bite" as the researcher modelled same. As the tip of the food was bitten off the researcher replaced the food strip on the molars. The child was observed for the same indicators as noted above. The child was then instructed to chew any remainder until it was "all gone". Jaw support was given by the researcher in order to help the child maintain the head in the midline and was decreased with the child's increasing skill. This procedure was repeated on the left. Children were encouraged to try all preferred food types. Between two to four strips were consumed by each child per session.

- *Homework:*

After the session parents attended for feedback on their child's progress. Training and handouts were given to the parents on the 'good sitting' position, chewy tube/ark grabber practise, cube placement and slow feed for homework practise (appendix VIII). The homework procedure was explained and parents encouraged to fully comply with practice recommendations for maximal benefit to their child. A homework record sheet with individual instructions for each session was also given (appendix VIII). It was recommended that the unit for each activity should be practised five to ten times per day (in one sitting or spread throughout the day) three days per week. This was adapted from the guidelines proposed by Rosenfeld-Johnson (2005). Regular feedback from the parents regarding homework was elicited.

Parents were loaned therapy tools for home practice. Instruction for their care and cleaning was given verbally and included on the handout. Homework using these depended on the child's performance during the session for each level of the hierarchy. If symmetrical performance was found (e.g. 6 chews on the right, 6 on the left) then one unit of practice was six chews on the right followed by six on the left. If asymmetrical performance was shown on both sides (e.g. 2 chews on the right, 5 on the left) then one unit of practice was two chews on the right, five on the left and two on the right. This was to provide extra work for the weaker side. Finally if asymmetrical performance on one side was evident (e.g. 10 chews on the right, 7 on the left) then one unit of practice was seven chews on the left. Units were given for each level of the hierarchy achieved during the session. One unit of practice for the cube placement was a cube on the right followed by a cube on the left (minimum of

10 -20 cubes total per day). One unit of practice for the strip placement was one strip on the right followed by one strip on the left (minimum of 10 -20 strips total per day).

Group B:

Children in this group followed the same procedure as group A except for the therapy tools activity and related homework. The order of activities was cube placement followed by slow feed. Separate handouts were given to the parents with instructions for the 'good sitting' position, cube placement and slow feed activities (appendix VIII). Separate homework record sheets were also given (appendix VIII). After completion of the study the children were offered group treatment sessions to complete the therapy tools exercises.

Group C:

This was the delayed therapy/control group who received no OM therapy during the treatment phase. These children were on the waiting for therapy list or on a break from their therapy programme and were offered the treatment protocol experienced by group A following completion of the study.

Inter-rater reliability:

To check for reliability of scoring for the OMFRS and the POSP, 10% of the assessments were randomly selected for videotaping with parental permission (appendix IV). An experienced SLT, blind to the purpose of the experiment

subsequently watched and rated these. This was not done for the EAT as this is considered a reliable measure of children's articulation.

RESULTS

This research study was a small scale quasi-experimental efficacy study which aimed to examine the effects of two different chewing therapies on mastication and on articulation in children aged between 4;0 to 5;11 years. Within and between subject differences were measured. Statistical package SPSS 11.0 was used with significance set at 95%.

Participants:

Children were matched for age and severity of chewing difficulty prior to random assignment to one of three groups. All were aged between 4;0 years and 5;11 years. A one way ANOVA was performed for any differences in age between the groups. There were no significant differences ($F = .66$, $df = 2, 17$, ns). The OMFRS was used to rate severity of chewing difficulties in the pre-assessments. It is a rating scale and therefore provides ordinal data requiring non-parametric tests. A series of Mann Whitney tests were performed to check for any between group differences from the pre-assessment scores. No significant differences were found; between groups A and B ($U = 21.5$, ns), between A and C ($U = 18$, ns) and between B and C ($U = 20.5$, ns).

Some of the children had previously attended for OM therapy, phonology therapy or a mixture of both. A one way ANOVA was performed for any differences between the groups; no significant differences were found ($F = .11$, $df = 2, 19$, ns). Attendance of a minimum of six sessions was required for inclusion in the study. The mean number of sessions attended by group A was 7.3 (SD .76) and by group B was

6.86 (SD 1.1). An independent t-test was performed to check for differences in attendance between the two groups. No significant difference was found (t(12) = .866, ns). By the last session of treatment, five of the children in group A had completed the hierarchy of therapy tools completely; the other two reached but did not pass the criteria for the last tool. All the children in both treatment groups (A and B) were chewing and biting textures that required more effort by the last session (e.g. cubes of meat, cheese, hard apples etc).

Assessments:

Table 3 shows scores attained by the participants for the pre-assessment and the post-assessment on the three measures used. A standard score increase in the EAT showed improvement in articulation. However an improvement in oral motor abilities required a decrease in the scores on the POSP. Similarly the OMFRS rates biting and chewing abilities on a scale of 0 to 5 where 0 is normal ability and 5 indicates severe difficulties; therefore a decrease in the rating showed an improvement in chewing abilities.

N	Group	OMFRS	OMFRS	EAT	EAT	POSP	POSP
		Pre	Post	Pre	Post	Pre	Post
1	A	8	2	66	62	23	8
2	A	5	0	94	92.5	9	4
3	A	0	0	76	84	4	6
4	A	18	13	57	64	19	8
5	A	9	0	86	86+	9	8
6	A	2	0	64	76	10	6
7	A	6	0	69	74	9	12
8	B	7	4	94	91	8	8
9	B	2	3	109	109	3	3
10	B	6	2	99	99	8	4
11	B	6	1	87	84.5	5	8
12	B	18	15	106	100	5	10
13	B	8	9	74	71	6	5
14	B	7	3	83	101	11	11
15	C	17	13	56	46	14	8
16	C	3	0	85	88	16	11
17	C	6	6	125	122	1	0
18	C	11	8	114	114	7	1
19	C	8	8	65	73	8	4
20	C	4	6	50	46	7	6

Table 3: scores attained by the participants from the pre-assessments (pre) and post-assessments (post) for groups A (therapy tools and food chewing exercises), B (food chewing exercises only) and C (control). The EAT (Edinburgh Articulation Test, Anthony et al, 1971) provided a score for articulation ability; the OMFRS (Oral-Motor/Feeding Rating Scale – 'Biting' and 'Chewing' sections only, Jelm, 1990) provided a score for chewing ability and the POSP (Paediatric Oral Skills Package – 'Structure and Function' and 'Movement' sections only, Brindley et al, 1996) provided a score for oral motor abilities.

Changes in chewing scores:

The hypotheses to be tested were:

1. Ho - any difference in the change in chewing skills between participants who have and have not been treated is due to chance

   H1 - any difference in the change in chewing skills between participants who have and have not been treated is unlikely to be accounted for by chance

2. Ho - any differences in the changes in chewing between the groups is due to chance

   H1 - any difference in the changes in chewing between the groups is unlikely to be accounted for by chance.

The data from the OMFRS is on an ordinal scale; hence non-parametric tests were used. Median and interquartile ranges (IQR) for the three groups for both the pre and post-assessments are shown in Table 4.

		Group A		Group B		Group C	
		Mean/ Median	**SD/IQR**	**Mean/ Median**	**SD/IQR**	**Mean/ Median**	**SD/IQR**
OMFRS	**Pre**	6	7	7	2	7	9
	Post	0	2	3	7	7	4
EAT	**Pre**	73.14	13.04	93.14	12.64	82.5	31.21
	Post	77.07	11.5	93.64	12.66	81.5	32.65
POSP	**Pre**	11.86	6.64	6.57	2.64	8.83	5.42
	Post	7.43	2.51	7.0	3.06	5.00	4.20

Table 4: a summary of the means/medians and standard deviations (SD)/interquartile ranges (IQR) for all tests used in the pre and post-assessments. Medians and IQR's are for the OMFRS data only whereas means and SD apply to the EAT and the POSP.

To examine within group differences the Wilcoxon Test was considered to be appropriate. From the medians it was observed that both the treatment groups made improvements following therapy while the control group made no change from the

pre to the post-assessment (Table 4). As there were three groups a series of Wilcoxon tests were performed. One tailed significance results are reported as a prediction was made. The results shown in Table 5, found a significant change in scores for group A ($Z = 2.21$, $p = .01$) and group B ($Z = 1.87$, $p < .05$) but not for group C ($Z = 1.47$, ns). The first null hypothesis can be rejected because the treatment groups did show a significant change following therapy and the control group did not.

	Wilcoxon Z	Significance
Group A	2.21	0.01
Group B	1.87	0.03
Group C	1.47	0.08 (n.s)

Table 5: Wilcoxon Signed Ranks test and significance results for groups A, B and C when comparing pre and post-assessment scores for each group to demonstrate change over time.

To examine between group differences the Mann Whitney statistical test was chosen. Descriptive statistics suggested that only the treatment groups made improvements following therapy, with group A making more than group B (Table 4). As there were three groups, a series of tests were performed. Differences between pre and post-assessment scores for each group were calculated and these were used in the testing. As a prediction was made one tailed results are presented. Results (Table 6) showed a significant difference between groups A and C ($U = 7$, $p = .05$, one-tailed) but failed to show a significant difference between group A and B ($U = 11$, ns) and between groups B and C ($U = 15$, ns). The second null hypothesis was partially rejected as the results show a significant difference in the change in chewing between group A and C following therapy.

	Mann Whitney U	Significance
Group A v Group C	7	0.05
Group A v Group B	11	0.10 (n.s)
Group B v Group C	15	0.45 (n.s)

Table 6: Mann Whitney and significance scores obtained when comparing each group's improvements from pre to post-assessment.

Changes in articulation scores:

The hypotheses to be tested were:

1. Ho - any difference in the change in articulation skills between participants who have and have not been treated is due to chance

   H1 - any difference in the change in articulation skills between participants who have and have not been treated is unlikely to be accounted for by chance
2. Ho - any differences in the changes in articulation between the groups is due to chance

   H1 - any differences in the changes in articulation between the groups is unlikely to be accounted for by chance

The EAT is a standardised assessment providing a standardised score of articulation ability based on an analysis of correct pronunciation and is norm referenced. Scores are therefore on an interval scale and are considered parametric data. Mean and standard deviation scores for the three groups from the pre and post-assessments are provided in Table 4. Corresponding histograms indicated that the scores did not deviate significantly from the normal distribution. There were no outliers evident in the stem and leaf or boxplot. It was appropriate to use parametric tests with this data.

The data was analysed using a two way mixed ANOVA. This was chosen because there were both within and between measures for three groups. Despite random distribution of the participants, Levene's test was significant for the pre-assessment scores ($p = .01$) and for the post-assessment scores ($p < .01$). This lack of homogeneity of variance did not satisfy the assumptions for a two way mixed ANOVA. Inspection of the data found a high within group variability (particularly in the control group). To overcome this, the pre and post-assessment articulation scores were tested for correlation using Pearson's Correlation Coefficient and found to be highly related ($r = .95$, $p < .001$). The corresponding histograms showed normal distribution with no outliers present in the boxplots, and a scattergram showed a positive linear relationship, hence satisfying the assumptions for this test.

As these scores were highly related, differences between them were considered to be homogenous. Therefore mean difference scores were calculated and a one way ANOVA corrected for variance (Welch's test) performed. Corresponding histograms for groups A and B did not show normal distribution but this may have been due to the small sample size. There was one outlier present for group B but was considered essential data and not removed. Between group differences were found to be non-significant ($F = .94$, $df = 2, 17$, ns). None of the mean difference scores differed significantly from zero, indicating there were no within group differences following therapy (see figure 5). Therefore the null hypotheses were supported. However, closer inspection of the difference means did show a non-significant trend in the predicted direction.

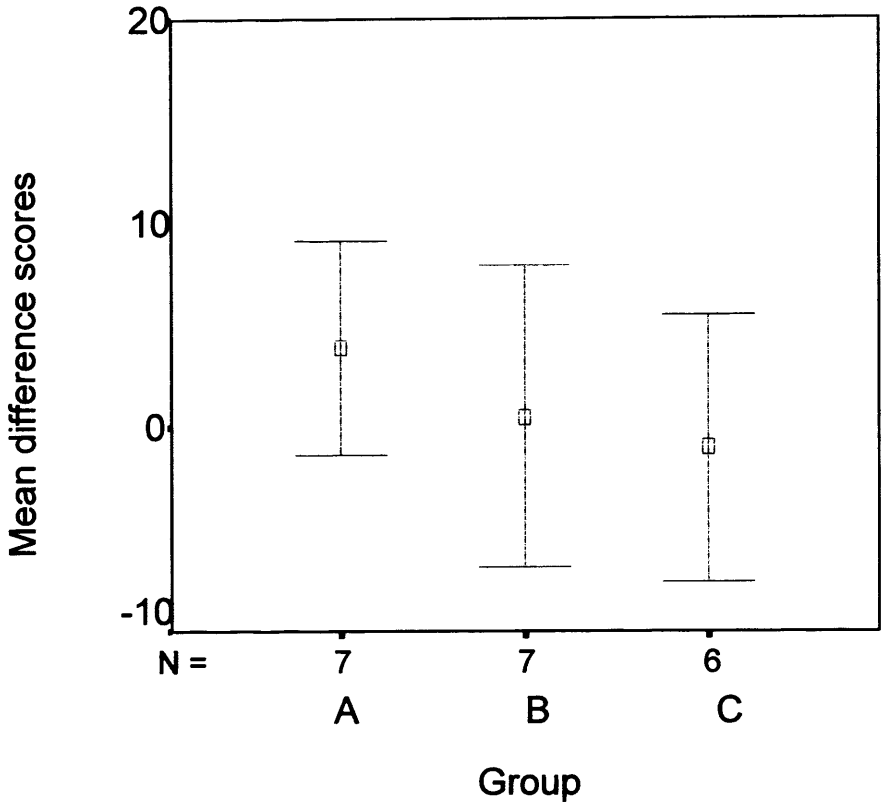


Fig. 5: Graph of the mean difference scores for groups A, B and C with 95% Confidence Intervals.

Changes in oral motor skills:

This data was collected as support for the primary hypotheses regarding the effects of chewing exercises on mastication. Any improvement in oral motor skills measured by the POSP would support an improvement in chewing abilities. The hypotheses to be tested were:

1. Ho - any difference in the changes in the POSP between participants who have and have not been treated is due to chance

   H1 - any difference in the changes in the POSP between participants who have and have not been treated is unlikely to be accounted for by chance

2. Ho - any differences in the changes in the POSP between the groups is due to chance

   H1 any difference in the changes in the POSP between the groups is unlikely to be accounted for by chance.

The POSP is a non standardised assessment which creates a profile of oral function. In the two sections used, a normal/abnormal score was provided. Scores were therefore on an interval scale and so were considered parametric data. Mean and standard deviation scores for the three groups from the pre and post-assessments are provided in Table 4. Corresponding histograms indicated that the scores did not deviate significantly from the normal distribution. There were two outliers evident in the boxplot for the pre-assessment but these were not removed due to the small sample size. Parametric tests were considered appropriate.

The data was analysed using a two way mixed ANOVA. This was chosen because there were both within and between measures for three groups. Levene's test was not significant for either the pre or post-assessment scores indicating that the assumption of equality of variance was satisfied. The main effect of time for within subjects (i.e. difference between pre and post-assessment scores within groups) was non-significant ($F = 2.84$, $df = 1, 17$, ns). The main effect of group (i.e. difference between the groups) was also non-significant ($F = .102$, $df = 2, 17$, ns). There was no significant interaction effect between group and time ($F = .84$, $df = 2, 17$, ns). Figure 6 shows a plot of the means for POSP scores for the three groups from the pre and post-assessments. These results indicated that treatment made no significant difference to the groups, no further analysis was warranted and the null hypotheses were supported.

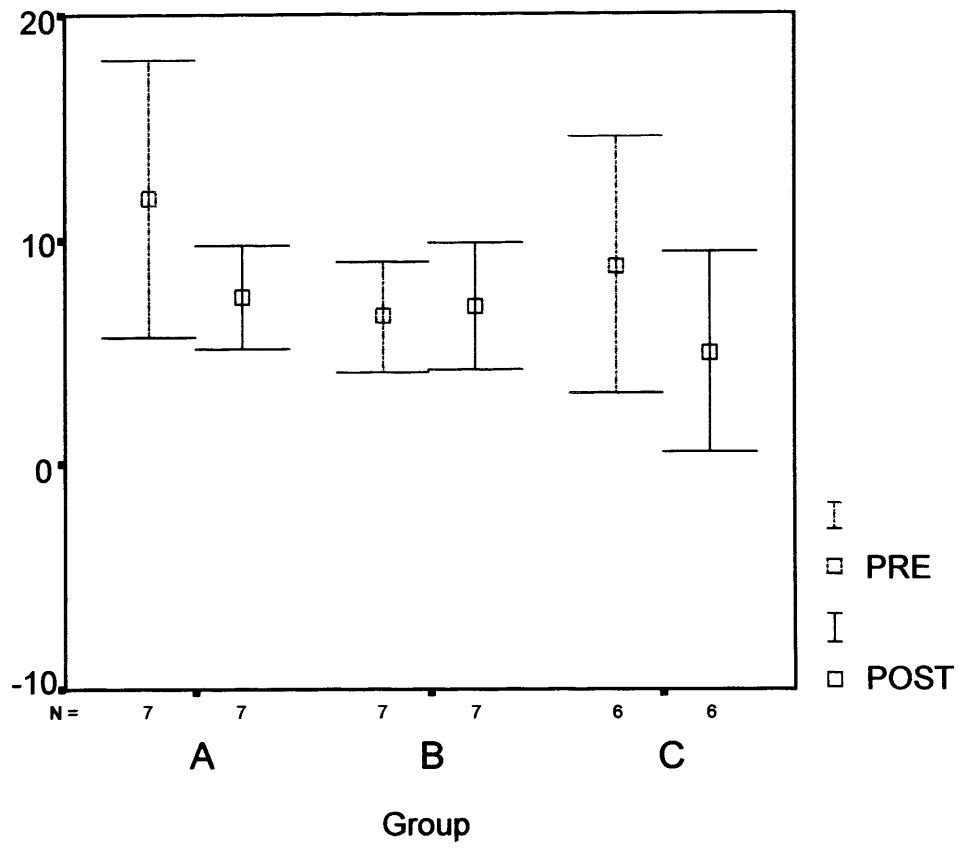


Fig. 6: Error bar plot with 95% Confidence Intervals for mean pre and post-assessment POSP scores for groups A, B and C.

Inter-rater reliability:

Inter-rater reliability was calculated for each assessor for the OMFRS and POSP scores using correlation testing. Spearmans rank correlation (rho) was used for the OMFRS data (ordinal scale) and Pearsons product-moment correlation (r) was used for the POSP data (interval data). All correlations were significant indicating that the scores were related and show a high degree of agreement. Table 7 illustrates correlation and significance scores.

	OMFRS	POSP
Assessor 1	Rho = .89, $p < .05$	R = .913, $p < .01$
Assessor 2	Rho = 1.0 (complete agreement)	R = .94, $p < .05$

Table 7: correlation scores for each assessor for the OMFRS and the POSP

DISCUSSION

Effects on chewing:

Chewing exercises, using either therapy tools (chewy tubes and ark grabbers) or food, improved chewing performance as rated by a trained observer using the OMFRS in children aged 4;0 to 5;11 years. This was evident in the significant change in scores from the pre-assessment to the post-assessment for both of the treatment groups but not for the control group and suggested that therapy was effective for those children receiving treatment. Further evidence to support this was found when comparing the groups. Differences between pre and post scores for each group were calculated and this 'gain in chewing' score was used for comparison. A significant difference was found between groups A and C which was not surprising because group C, the control group, made no significant change over time whereas group A (therapy tools and food chewing exercises) did.

However there was no significant difference between groups A and B (food chewing exercises only). Both groups made a significant change following therapy which suggested that neither therapy was more effective than the other. No significant difference between groups B and C was observed which suggested that food chewing exercises alone were of no benefit to children when compared with no therapy. Due to the lack of significant difference between groups A and B this implied that therapy tools and food chewing exercises combined were also of no benefit. The sample size may not have been large enough to demonstrate significant results therefore the medians and Z scores were inspected. A (non-significant) trend in the predicted direction was found, with both therapy groups (A and B) showing

improvements and the control group showing none. Therefore this, in combination with the significant within group changes for the therapy groups, suggested that therapy may improve chewing performance. The therapy tools and food chewing exercises group also showed a trend for more improvement than the food chewing exercises only group. This may mean that the former therapy was more beneficial to children.

These results do not support those found in a previous study where feeding performance following therapy was evaluated in two groups of children with CP and a control group of typically developing children (Gisel, 1996). No significant differences were found between the groups suggesting that the therapies used (tongue lateralisation, chewing and lip exercises versus chewing only exercises) were not effective. However chewing performance was tested by measuring feeding time for meals which may not have been a reliable indicator. The results do concur with an earlier study comparing rated competence scores for feeding behaviours for two groups of children with CP using the same therapies described above (Gisel, 1994). Improved chewing competence was found for both of these groups. No between group difference was observed suggesting that chewing only exercises with real food were just as effective as tongue lateralisation, chewing and lip exercises. In the current study children received less therapy in comparison to either of the above described studies (Gisel, 1994; Gisel, 1996). In the latter, children received five to seven minutes per day, five days per week for 20 weeks compared with 40 minutes per session, two sessions per week for four weeks in a group setting in this study. This may be a reflection of the population samples involved in each: children with no neurological involvement may take less time to make changes.

Effects on articulation:

Chewing exercises may improve articulation abilities as measured by the EAT in children aged between 4;0 and 5;11 years. A non-significant trend in the predicted direction was observed for each group's mean difference scores. Both therapy groups had larger difference means than the control group implying a therapy effect. Group A (therapy tools and chewing food exercises) also demonstrated a larger mean difference (non-significant) than Group B (chewing exercises only). This may indicate that therapy using therapy tools and chewing food exercises may be more beneficial.

Despite the lack of statistically significant results the trends do have clinical significance. They are encouraging for clinicians who may have noted a co-occurrence of articulation difficulties with poor feeding patterns specifically poor chewing performance and that following OM therapy using chewing exercises improvements in articulation followed. Previous studies have not shown any benefits of OM therapy, in the form of blowing and sucking exercises, on articulation (Abrahamsen & Flack, 2002; Guisti & Cascella, 2005; as cited in Lof, 2006). No previous studies have examined the benefits of chewing exercises alone on articulation. Considering that adequate jaw stability is thought to be necessary for speech production this is surprising. These results suggest that further research investigating the effects of chewing on articulation is warranted.

Effects on oral motor skills:

Means for the pre and post-assessment scores on the POSP showed a non-significant trend for improvement in oral motor function following therapy using therapy tools and food chewing exercises but not for therapy using chewing food exercises only. A similar trend was observed in the control group suggesting that developmental changes may account for the trends observed. These results were surprising as chewing exercises are thought to increase jaw muscles strength and consequently increase jaw stability (Rosenfeld-Johnson, 2005). Increased jaw stability would then be expected to allow greater range of motion and accuracy of movement in the muscles of the tongue and lips. The POSP may not have been sensitive enough to pick up small improvements in range of motion and accuracy. Scores for tongue and lip movements were given on a normal/abnormal basis and therefore incremental improvements may not have been detected resulting in the lack of significant findings.

Limitations:

Definite conclusions regarding a specific effect due to chewing exercises using therapy tools could not be drawn. This was due to the lack of significant difference between the therapy groups on all measures. It was hoped that between group differences could be used to draw conclusions in this regard. Trends indicating that therapy tools and chewing exercises in combination may have been more beneficial were shown. This non-significant benefit may have been due to the inclusion of therapy tools or due to a cumulative effect. Further conclusions can not be drawn without stronger evidence.

A larger sample may have demonstrated significant therapy effects. Recruitment was based in only one SLT clinic and while 30 potential candidates were identified, only 20 of these completed the study. Statistical tests on small sample sizes are reduced in power and are therefore less likely to show significant between group differences. Age criterion for selection was set at a minimum of 4;0 years by which time adult-like chewing patterns are in place, however younger children could also have been included. In typically developing children, jaw stability should be consistent by two years old (Morris, 1985) and adult like patterns of chewing should be acquired by at least three years old (Morris & Klein, 1987). Therefore children from the age of three who have identified jaw muscle weakness could be included in future studies.

The small sample size, in combination with a significant articulation score variance within all of the groups meant that statistical tests lacked the power to detect small effects of therapy. The significant difference between the groups may have been due to the fact that five of the children did not have a diagnosis of phonological delay/disorder, three of these were in group B and two were in group C. This may have affected the scores as some children may have progressed more or less depending on their severity level. This was an unexpected variable; children were not matched on articulation ability prior to the treatment phase but random distribution was expected. However trends in the predicted direction were observed, therefore larger group sizes and control for articulation severity may have shown significant differences.

Assessment selection may have had effects on this experiment. Due to the lack of reliable assessments and normative data indicating minimal strength necessary for

chewing and articulation, subjective judgements were made by the participants' SLTs regarding the presence of jaw muscle weakness. This was one of the main criteria upon which children were selected for inclusion in this experiment. Therefore participating children may have had varying levels of jaw strength and potential improvements in jaw strength could not be objectively measured. However two of the assessments used in the study included the OMFRS, which rated children's chewing performance and the POSP, which evaluated basic jaw movement. Taken together these were considered to be an adequate evaluation of implied jaw strength.

Use of the OMFRS resulted in ordinal data and consequently non-parametric testing. These tests are not as powerful as parametric tests and multiple tests were necessary which increased the probability that a significant result could occur by chance. However the OMFRS was selected for its ease of use and clinical applicability, while non-parametric tests have the advantage of being unaffected by outliers and non-normal distributions. Furthermore inter-rater reliability measures showed a high degree of agreement for ratings by the assessors and an independent rater which further justifies its selection. Future research could use a quantitative assessment such as mean chewing time for various textures as an alternative test of chewing performance.

Results from the POSP did not demonstrate a therapy effect, thus failing to support the theory that chewing exercises will improve jaw stability and therefore allow for greater tongue/lip range of motion and accuracy. As improvements in chewing were seen, improvements in lip and tongue function were also expected, however the POSP (despite a high degree of inter-rater agreement also) may not have been sensitive enough. Hence small effects may not have been detected and an

alternative assessment which allows for small changes in oral movement to be measured may have found significant results.

Further confounding variables that could not be completely controlled include the effects of the researcher/assessors on the participants and parental motivation. Despite a standard procedure and efforts to treat all children in the same manner, it is possible that some children were more positively encouraged to perform, hence resulting in better results for some. Parental motivation to do the homework involved for the therapy groups could not be controlled. A considerable time commitment was required for the preparation of food cubes and strips and for the actual administration of the exercises. Every effort was made to encourage parents to carry out the home practice and feedback was taken after every session to judge how parents were doing. Despite this, children in the therapy groups may have experienced different levels of practice with consequent effects on their progress and post-assessment.

Finally, there were four female and 16 male participants in this study with a minimum of one female per group. Previous research has shown differences in adult chewing patterns due to gender differences (Gerstner & Parekh, 1995). It is not known whether this is similar for children, therefore with the small number of females included and their distribution among the three groups, it was not considered to be a limitation of the study.

Future research:

Further research is recommended:

- To investigate whether or not children with articulation delays/disorders exhibit a mandibular muscle weakness in comparison to children with typically developing articulation.
- To obtain normative data regarding the minimal jaw, tongue and lip strength required for articulation and mastication.
- To compare the use of therapy tools on their own versus food chewing exercises and with the combination of both in order to ascertain which is of the most benefit to chewing performance and articulation skills of children.
- To investigate the effects of chewing exercises in combination with traditional articulation therapy on measures of articulation.
- Using a larger sample size in order that significant therapy effects can be demonstrated.

CONCLUSION

This experiment found a significant improvement in children's chewing performance following therapy involving chewing exercises. Non-significant trends suggested that chewing exercises may also have improved articulation and oral motor skills. This supported the theory that chewing exercises increase jaw strength and stability where weakness has been identified and that adequate levels of strength and stability are required for mastication and articulatory proficiency. Additional research is warranted to investigate this further. Trends (non-significant) indicated that therapy tools combined with food chewing exercises may have had more effect on all measures than food chewing exercises alone. Therefore use of chewy tubes and ark grabbers (therapy tools) was not contra-indicated and may even be of greater benefit to children with chewing difficulties and possibly also articulatory difficulties. Further research is also warranted to investigate whether therapy tools alone can achieve this effect.

REFERENCES

Alexander, R. (1987) Oral Motor Treatment for Infants and Young Children with Cerebral Palsy. Seminars in Speech and Language, 8, 87 - 100

Alison, P.J, Peyron, M.A., Faye, M. & Hennequin, M. (2004) Video Evaluation for Mastication Validation in Persons with Down's Syndrome. Dysphagia, 19, 95 - 99

Anthony, A., Bogle, D., Ingram, T. & McIsaac, M. (1971) The Edinburgh Articulation Test (EAT). Edinburgh: E&S Livingston

Arvedson, J.L. & Brodsky, L. (1993) Pediatric swallowing and feeding: Assessment and management (2nd Ed). Albany: Singular

Beckman, D. (1988) Beckman Oral Motor Interventions. Course pack accompanying Oral Motor Assessment and Intervention workshop. Charlotte, NC.

Brindley, C., Cave, D., Crane, S., Lees, J. & Moffat, V. (1996) The Paediatric Oral Skills Package (POSP). London: Whurr Publishers

Burklow, K.A., Phelps, A.N., Schulz, J.R., McConnell, K. & Rudolph, C. (1998) Classifying Complex Pediatric Feeding Disorders. Journal of Pediatric Gastroenterology and Nutrition, 27, 143 - 147

Butler, N.R. & Golding, J. (Eds) (1986) From birth to five. A study of the health and behaviour of Britain's five year olds. London: Pergamon Press.

Chapman-Bahr, D. (2001) Oral motor assessment and treatment: ages and stages. Boston: Allyn & Bacon

Christensen, M. & Hanson, M. (1981) An Investigation of the Efficacy of Oral Myofunctional Therapy as a Precursor to Articulation Therapy for Pre-first Grade Children. Journal of Speech and Hearing Disorders, 46,160 -167

Darley, F.L., Aronson, A.E. & Brown, J.R. (1975) Motor speech disorders. Philapdelphia: Saunders.

Duffy, J.R. (2005) Motor speech disorders: substrates, differential diagnosis and management (2nd Ed). St Louis: Elsevier Mosby

Dworkin, J.P. (1991) Motor speech disorders: a treatment guide. St Louis: Mosby-Year-Book.

Edwards, P. (2002) Bolus Preparation in Children with Cerebral Palsy using Chewing Gum: A Comparison with Normal Children. UCL: unpublished project

Forest, K. (2002) Are Oral–Motor Exercises Useful in the Treatment of Phonological/Articulatory Disorders? Seminars in Speech and Language, 23, 15 – 25

Gerstner, G.E. & Parekh, V.V. (1995) Evidence of Sex-specific Differences in Masticatory Jaw Movement Patterns. Journal of Dental Research, 76, 796 - 806

Gisel, E.G. (1994) Oral-Motor Skills Following Sensorimotor Intervention in the Moderately Eating Impaired Child with Cerebral Palsy. Dysphagia, 9, 180-192

Gisel, E.G. (1996) Effect of Oral Sensorimotor Treatment on Measures of Growth and Efficiency of Eating in the Moderately Eating-Impaired Child with Cerebral Palsy. Dysphagia, 11, 48 – 58

Gisel, E.G., Alphonse, E. & Ramsay, M. (2000) Assessment of Ingestive and Oral Praxis Skills: Children with Cerebral Palsy vs. Controls. Dysphagia, 15, 236 – 244

Green, J.R., Moore, C.A. & Reilly, K.J. (2002) The Sequential Development of Jaw and Lip Control for Speech. Journal of Speech, Language and Hearing Research, 45, 66 – 79

Jelm, J.M. (1990) Oral-Motor Feeding Rating Scale. Tucson: Therapy Skill Builders

Kenny, D.J., Koheil, R.M., Greenberg, J., Reid, D., Milner, M., Moran, R. & Judd, P.L. (1989) Development of a Multidisciplinary Feeding Profile for Children who are Dependent Feeders. Dysphagia, 4, 16 - 28

Kohyama, K., Mioche, L. & Martin, JF. (2002) Chewing Patterns of Various Texture Foods Studied by Electromyography in Young and Elderly Populations. Journal of Texture Studies, 33, 269 – 283

Lancaster, G. & Pope, L. (1989) Working with children's phonology. UK: Speechmark

Liedberg, B. & Owall, B. (1995) Oral Bolus Kneading and Shaping Measured with Chewing Gum. Dysphagia, 10, 101 – 106

Lof, G. (2006) Logic, Theory and Evidence against the Use of Non-speech Oral Motor Exercises to Change Speech Sound Productions. Workshop Handout at the ASHA Convention, Miami Beach. Http://health.groups.yahoo.com/group/phonologicaltherapy/files (Accessed 20/11/06)

Logemann, J.A. (1998). Evaluation and Treatment of Swallowing Disorders (2nd Ed). ProEd: USA

Moore, C.A. (1993) Symmetry of Mandibular Muscle Activity as an Index of Coordinative Strategy. Journal of Speech and Hearing Research, 36, 1145 – 1157

Moore, C.A & Ruark, J.L. (1996) Does Speech Emerge from Earlier Appearing Oral Motor Behaviours? Journal of Speech and Hearing Research, 39, 1034 - 1047

Morris, S. (1985) Developmental Implications for the Management of Feeding Problems in Neurologically Impaired Infants. Seminars in Speech and Language, 6, 293 - 315

Morris, S.E. & Klein, M.D. (1987) Pre-feeding skills. Tucson, AZ: Therapy Skill Builders

Newman, L.A. & Peterson, M. (1999) Swallowing disorders in the pediatric population. In R.L. Carrau and T. Murry. (Eds). Comprehensive management of swallowing disorders. London: Singular

Onozuka, M., Fujita, M., Watanabe, K., Hirano, Y., Niwa, M., Nishiyama, K. & Saito, S. (2002) Mapping Brain Region Activity during Chewing: A Functional Magnetic Resonance Imaging Study. Journal of Dental Research, 81, 743-746

Peyron, M.A., Lassauzay, C. & Woda, A. (2002) Effects of Increased Hardness on Jaw Movement and Muscle Activity During Chewing of Visco-elastic Model Foods. Experimental Brain Research, 142, 41 - 51

Purslow, P.P (1991) Measuring Meat Texture and Understanding its Structural Basis. In J. Vincent and P. Lilleford. (Eds) Feeding and the Texture of Foods. Cambridge: Cambridge University Press

Reilly, S.M., Skuse, D.H. & Wolke, D. (2000) SOMA: Schedule for Oral Motor Assessment . London: Whurr

Reilly, S.M., Skuse, D.H., Wolke, D. & Stevenson, J. (1999) Oral-motor Dysfunction in Children who Fail to Thrive: Organic or Non-organic? Developmental Medicine & Child Neurology, 41,115 - 122

Rosenfeld-Johnson, S. (1993) A three part treatment plan for muscle-based oral-motor therapy. USA: Talktools/Innovative Therapists International.

Rosenfeld-Johnson, S. (2005) Assessment and treatment of the jaw. Putting it all together: sensory, feeding and speech. USA: Talktools/Innovative Therapists International

Sanders, E.K. (1972) When are Speech Sounds Learned? Journal of Speech and Hearing Disorders, 37, 55 - 63

Stolovitz, P. & Gisel, E.G. (1991) Circumoral Movements in Response to Three Different Food Textures in Children 6 Months to 2 Years of Age. Dysphagia, 6, 17-25

Thommessen, M., Heiberg, A., Kase, B.F., Larsen, S. & Riis, G. (1991) Feeding Problems, Height and Weight in Different Groups of Disabled Children. Acta Paediatrica Scandinavica, 80, 527 – 533

Tortora, G.J. & Grawbowski, S.R. (1993) Principles of anatomy and physiology (7th Ed). NY: HarperCollins College Publishers

Williams, P. & Stephens, H. (Eds) (2004) Nuffield Centre Dyspraxia Programme (3rd Ed). UK: The Miracle Factory

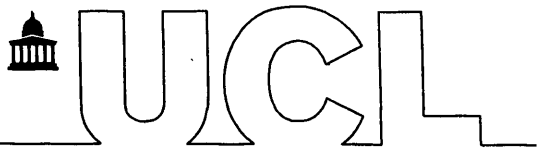
Woods, E.K. (1995) The Influence of Posture and Position on Oral Motor Development and Dysphagia. In S.R. Rosenthal, J.J. Sheppard and M. Lotze. (Eds) Dysphagia and the Child with Developmental Disabilities. San Diego, USA: Singular

Zemlin, W.R. (1988) Speech and hearing science: anatomy and physiology (3rd Ed). New Jersey: Prentice-Hall

APPENDIX I

Letter of ethical approval from UCL Research Ethics Committee

UCL GRADUATE SCHOOL
UCL RESEARCH ETHICS COMMITTEE



Dr Christina Smith
Department of Human Communication Science, UCL

22 March 2007

Dear Dr Smith

Notification of Ethical Approval

Project ID/Title: 0983/001: The effect of oral-motor therapy on chewing and articulation in 4-5yr olds

I am pleased to confirm that your research proposal has been approved by the UCL Research Ethics Committee for the duration of the project. However, members made one minor comment. It was suggested that the Informed Consent Form for participants should contain an additional statement regarding the dissemination of the research data collected.

Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'. The Request Form can be accessed by logging on to the ethics website http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Responsibilities Following Approval'.

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events.
   For non-serious adverse events you will need to inform Ms Helen Dougal, Ethics Committee Administrator within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

Yours sincerely

Sir John Birch
Chair of the UCL Research Ethics Committee

Cc: Fiona Cowman

APPENDIX II

Letter from SLT Manager, Galway PCCC, HSE- West, Ireland

dhmeannacht na Seirbhíse Sláinte
Health Service Executive

From the Speech & Language Therapy Dept,
Primary, Community & Continuing Care
Health Service Executive West
Shantalla Health Centre
25 Newcastle Road
Galway

Ón Rannóg Teiripé agus Urlabhra,
Cúram Príomhúil, Pobail agus Leanúnach
Feidhmeannacht na Seirbhíse Sláinte- an tIarthar

CF/ch/ltrs/FC-EC

The Ethics Committee
University College London

20th February, 2007

To Whom It May Concern:

Ms. Fiona Cowman, Speech and Language Therapist is a permanent employee of the Health Service Executive, West. She is currently on a career break to pursue a post graduate Master's degree in UCL.

As is the requirement with all HSE employees who work directly with children, Fiona received Garda Clearance prior to taking up her post. She continues to be covered by this.

I understand that Fiona will be conducting research with children who are engaged with the Speech and Language Therapy Services, HSE West. We do not have an Ethics Board here and our guidelines are that ethical approval should be sought for all studies from the Ethics Committee in the University over seeing the research being undertaken. It is a requirement that clients engaged in the research receive a full briefing and individual written permission is sought from each potential participant and/or their carer.

Clients attending this department are covered by the Data Protection Act 1988 and 2003. Therefore potential participants in Ms Cowman's study are covered by this legislation.

The Speech and Language Department is committed to engaging fully with this research proposal as we hope that it will inform and improve our clinical practice.

Yours faithfully,

APPENDIX III

Parent letter, information sheet and consent letter

Date:

Parents/Carer of:

_____

_____

_____

_____

Invitation to participate in a SLT research study

Dear Parents / Carer

Your child is being invited to participate in a research study being conducted by Ms Fiona Cowman, Speech and Language Therapist, as part of her MSc in Human Communication at the University College London under the supervision of Dr Christina Smith, Lecturer, Department of Human Communication, University College London. The study will be conducted in the Speech and Language Therapy Department, Community Care, Shantalla, Galway.

Please find enclosed an information sheet providing detailed information regarding the purpose of the research, what would be required of you and your child and potential benefits/risks to your child. Please read this sheet carefully and if you agree to your child's participation in this study, please sign the attached consent form and return in the stamped addressed envelope enclosed, before the . Parents / Carers will be contacted to arrange exact appointment dates and times once your signed consent form has been received.

Please do not hesitate to contact me if you have any queries. (See attached information sheet for contact details)

Yours sincerely

_____

Fiona Cowman
Speech and Language Therapist

Information Sheet for Parents

You can keep this information sheet.

The Effect of Oral-Motor Therapy on Chewing and Articulation in Children
(This study has been approved by the UCL Research Ethics Committee [Project ID Number]: **0983/001)**

We would like to invite your child to participate in the above research project. Before you decide whether or not you would like your child to participate, it is important for you to read the following information carefully. Please discuss it with others if you wish and ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This study is intended to investigate the potential benefits of a Speech and Language Therapy treatment programme focussed on chewing. This programme uses a child-friendly, safe, non-toxic toy that has a chewable surface. All parents will also be given advice for their child for chewing foods at home while taking his/her food preferences into consideration.

Who can take part in the study?

The treatment programme is aimed at children who have delayed oral-motor skills (i.e. weak muscles of the jaw, tongue and lips) who may also have a delay in their speech sounds and/or prefer to eat soft foods (fussy eaters). Your child has been identified with delayed oral-motor skills on a previous attendance at his/her Speech and Language Therapy Clinic and was put on a waiting list for a Speech and Language therapy group. Because of the difficulties your child is reported to have, he/she is being invited to participate in this study.

Where will the study take place?

The study will take place in your child's Speech and Language Therapy clinic in Galway Community Care, Galway, Ireland.

What does participation in the study mean for you and your child?

Children who do participate in the study will initially be required to attend an assessment session (this will take approximately 45 minutes), which will assess chewing skills and speech sounds, and will also identify your child's food preferences. He/she will then receive 2 therapy sessions per week for 4 weeks focusing on his/her chewing (each session will take approximately 30 minutes). This should be a fun experience for your child! Exercises for practise at home will also be given. These exercises will only take a few minutes, and are done 3 times per day by the parent with the child. However it is essential that both children and parents commit to carrying out the homework in order for the programme to be beneficial and effective. You will be asked to complete a homework diary. At the end of the treatment programme there will be a final assessment session similar to the first one, where parents can also give feedback to the researcher if they wish (this will take approximately 1 hour). To ensure reliable analysis, some of the assessment sessions will be videotaped with your permission.

What are the possible benefits/risks to your child?

It is anticipated that this treatment will improve jaw strength. This may be seen as improved chewing ability in your child's assessment and also when he/she is chewing harder foods at mealtimes with a potential increase in the variety of foods eaten. Another possible benefit is an improvement in your child's speech sounds. I do not anticipate that your child will experience any discomfort with this programme, however if he/she becomes unhappy, assessment/treatment will be immediately stopped.

Whether or not your child participates in this study will in no way affect his/her place on current waiting lists for Speech and Language Therapy. He/she will remain in the Speech and Language Therapy service and if your child is on the waiting list for therapy, his/her position on that list will remain unchanged. However by his/her participation in this study he/she may benefit from receiving this treatment programme while waiting to attend therapy.

What will happen to the collected data?

All data will be collected and stored in accordance with the Irish Data Protection Act 1988. Your child's personal information will not be made available to others. The collected data from the assessments will be anonymously included within my Masters thesis and in any publications arising from this study.

Also as an employee of the Health Services Executive, the researcher has been subject to a satisfactory criminal record check.

What should you do now?

It is up to you to decide whether or not your child will take part. If you decide he/she will take part please keep this information sheet, sign the enclosed consent form and return in the stamped addressed envelope. You have the right to withdraw your child from this study at any time with giving a reason.

If you have any further questions regarding this research study, please contact me, Fiona Cowman, using the details at the bottom of the page. If you have any complaints or concerns please contact me or my supervisor at the University College London using the contacts below.

Thank you for taking the time to read this information sheet!

Yours sincerely

Fiona Cowman
Speech and Language Therapist
SLT Dept. Galway Community Care, Shantalla, Galway, Ireland.

Dr Christina Smith,
Lecturer
Dept Human Communication Science, University College London,
Remax House, 31/32 Alfred House, London, WC1E 7DP.

Or alternatively:
Catherine Flynn
Speech and Language Therapy Manager
SLT Dept, Galway Community Care, Shantalla, Galway, Ireland

Informed Consent Form for Participants in Research Studies

The Effect of Oral-Motor Therapy on Chewing and Articulation in 4-5 year old Children

(This study has been approved by the UCL Research Ethics Committee [Project ID number]: 0983/001)

Participant's Statement:

I _____

agree that I have

- ☐ read the information sheet and/or the project has been explained to me orally;
- ☐ had the opportunity to ask questions and discuss the study;
- ☐ received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my child's rights as a participant and whom to contact in the event of a research-related injury.

I understand that I am free to withdraw my child from the study without penalty if I so wish. I consent to the processing of my child's personal information for the purposes of this study only and I understand that the collected data from the assessments will be anonymously included within the researchers Masters thesis and in any publications arising from this study. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Irish Data Protection Act 1988. I understand that I will be given a brief copy of the results arising from the assessments upon my request.

Signed:_____ Date: _____

Signed:_____ Date: _____

Investigator's Statement:

I, Fiona Cowman

confirm that I have carefully explained the purpose of the study to the participant's parents and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: _____ Date: _____

APPENDIX IV

Video taping consent letter

CONSENT TO BE VIDEOTAPED

CHILD'S NAME: _____

- I agree for my child to be videotaped as part of his/her participation in the research project –

The Effect of Oral-Motor Therapy on Chewing and Articulation in 4-5 year old Children

(This study has been approved by the UCL Research Ethics Committee [Project ID number]: 0983/001)

- I understand that the videotapes will only be accessed by the researcher and will be stored in a locked filing cabinet in the clinic until analysis is complete. They will then be destroyed.

Signed: _____

Relationship to child: _____

Date: _____

APPENDIX V

Assessment forms:

- Oral Motor/Feeding Rating Scale (Jelm, 1990)
- Edinburgh Articulation Scale (Anthony et al, 1971)
- Paediatric Oral Skills Package (Brindley et al, 1996)

by Judy Michels Jelm, M.S., CCC-SLP

I. IDENTIFYING INFORMATION

CLIENT'S NAME _____

BIRTHDATE _____ C.A. _____

DIAGNOSIS _____

MEDICATIONS _____

FOOD ALLERGIES _____

DATE(S) OF EVALUATION _____

FEEDER'S NAME _____

EVALUATOR'S NAME _____

REPORTED TIME TAKEN FOR A TYPICAL MEAL (Report in Minutes) _____

II. ORAL-MOTOR/FEEDING PATTERNS							III. RELATED AREAS OF FEEDING FUNCTION							
							SELF-FEEDING	ADAPTIVE FEEDING EQUIPMENT	DIET ADAPTATIONS	POSITION	SENSITIVITY	FOOD RETENTION	SWALLOWING	OROFACIAL STRUCTURES
BREAST	0	1	2	3	4	5								
LIP/CHEEK MOVEMENT														
TONGUE MOVEMENT														
JAW MOVEMENT														
BOTTLE	0	1	2	3	4	5								
LIP/CHEEK MOVEMENT														
TONGUE MOVEMENT														
JAW MOVEMENT														
SPOON FEEDING	0	1	2	3	4	5								
LIP/CHEEK MOVEMENT														
TONGUE MOVEMENT														
JAW MOVEMENT														
CUP DRINKING	0	1	2	3	4	5								
LIP/CHEEK MOVEMENT														

IV.

NOTES ON **RESPIRATION/PHONATION SOUND PRODUCTION**

NOTES ON **GROSS MOTOR FUNCTION FINE MOTOR FUNCTION**

	0	1	2	3	4	5										
BITING / SOFT COOKIE																
LIP/CHEEK MOVEMENT																
TONGUE MOVEMENT																
JAW MOVEMENT																
BITING / HARD COOKIE																
LIP/CHEEK MOVEMENT																
TONGUE MOVEMENT																
JAW MOVEMENT																
CHEWING																
LIP/CHEEK MOVEMENT																
TONGUE MOVEMENT																
JAW MOVEMENT																
STRAW DRINKING																
LIP/CHEEK MOVEMENT																
TONGUE MOVEMENT																
JAW MOVEMENT																

KEY:

+ = **NORMAL**
± = **PROBLEM AREA: INCONSISTENT**
- = **PROBLEM AREA: CONSISTENT**

0 — **NORMAL FUNCTION**
1 — **QUESTIONABLE DYSFUNCTION**
2 — **LESS THAN 25%**
3 — **25%-50%**
4 — **50%-75%**
5 — **MORE THAN 75%**

(Please use all Keys in conjunction with manual)

V. RATING SCALE SYNOPSIS OF ORAL-MOTOR IMPROVEMENT/FEEDING PATTERNS:

	BREAST	BOTTLE	SPOON FEEDING	CUP DRINKING	BITING/SOFT COOKIE	BITING/HARD COOKIE	CHEWING	STRAW DRINKING
LIP/CHEEK MOVEMENT								
TONGUE MOVEMENT								
JAW MOVEMENT								

616.
31
OMFRS
2802981787

EDINBURGH ARTICULATION TEST / QUANTITATIVE ASSESSMENT SHEET

Name _____ Sex _____ Test given by _____

Address _____ Place of Test _____

Date of Birth _____ Date of Test _____

monkey	ŋk	____ ____	sleeping	sl	____ ____	finger	f	____ ____
tent	t	____ ____		p	____ ____		ŋg	____ ____
	nt	____ ____	wings	ŋz	____ ____	thumb	θ	____ ____
fish	ʃ	____ ____	garage	g	____ ____	watch	w	____ ____
train	tr	____ ____		r	____ ____		tʃ	____ ____
umbrella	m	____ ____		dʒ	____ ____	string	str	____ ____
	b	____	aeroplane	pl	____ ____		ŋ	____ ____
	r	____	spoon	sp	____ ____	three	θr	____ ____
	l	____		n	____ ____	teeth	θ	____ ____
milk	m	____ ____	toothbrush	θbr	____ ____	pencil	p	____ ____
	lk	____ ____		ʃ	____ ____		ns	____ ____
stamps	st	____ ____	red	r	____ ____		l	____ ____
	mps	____ ____		d	____ ____	yellow	j	____ ____
queen	kw	____ ____	bottle	tl	____ ____		l	____ ____
clouds	kl	____ ____	birthday	rθd	____ ____	sugar	ʃ	____ ____
	dz	____ ____	horse(ie)	h	____ ____		g	____ ____
Christmas	kr	____ ____	feather	ð	____ ____	Indian	n	____ ____
	sm	____ ____	elephant	l	____ ____		d	____
	s	____ ____		f	____		j	____
bridge	br	____ ____		n	____		n	____
	dʒ	____ ____		t	____	matches	tʃ	____ ____
flower	fl	____ ____	soldier	s	____ ____		z	____ ____
chimney	tʃ	____ ____		ldʒ	____ ____	scissors	z	____ ____
	mn	____ ____		r	____ ____	desk	d	____ ____
smoke	sm	____ ____	glove	gl	____ ____		sk	____ ____
	k	____ ____		v	____ ____			

Sold in packs of 50 test forms. Re-order from Longman Group (UK) Ltd, Fourth Avenue, Harlow, Essex CM19 5AA, quoting ISBN 0 443 02308 5, and stating number of packs required.

Also available from Longman: *The Edinburgh Articulation Test* (complete set) and *E.A.T. Qualitative Assessment Forms* (pack of 50).

EDINBURGH ARTICULATION TEST / CONVERSION TABLE

(Sample of 510 Edinburgh children)

	Raw scores															
Age group	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61	65
3·0 < 3·25	43	64	71	81	84	89	95	101	107	112	117	122	129	137	149	164
3·25 < 3·5	39	61	67	77	80	85	91	97	103	108	113	118	125	133	145	161
3·5 < 3·75		57	64	73	76	81	88	93	99	104	109	115	121	129	141	157
3·75 < 4·0		53	60	69	73	77	84	89	95	100	105	111	117	125	137	153
4·0 < 4·25		49	56	65	69	74	80	85	91	96	101	107	113	121	133	149
4·25 < 4·5		45	52	61	65	70	76	82	87	93	98	103	109	117	129	145
4·5 < 4·75		41	48	57	61	66	72	78	83	89	94	99	105	114	125	141
4·75 < 5·0		37	44	54	57	62	68	74	79	85	90	95	101	110	122	137
5·0 < 5·25			40	50	53	58	64	70	76	81	86	91	97	106	118	133
5·25 < 5·5				46	49	54	60	66	72	77	82	87	94	102	114	130
5·5 < 5·75				42	45	50	56	62	68	73	78	84	90	98	110	126
5·75 < 6·0				38	41	46	53	58	64	69	74	80	86	94	106	122

Standardisation of scores based on total Right scores of 510 *children aged* 3·0 *but not yet* 6·0 *years*

This table shows the conversion of total Right scores (raw scores) into standard scores, i.e. into a score distribution with a mean of 100 and a standard deviation of 15. The age interval is 3 months, and raw scores are given at 4-point intervals.

The suggested 'danger level' score is mean less one standard deviation i.e. if a child has a standard score in the region of 85 or less, his errors should be analysed in phonetic detail to see whether they show signs of speech retardation which call for therapy.

To obtain a standard score, take the nearest raw score (i.e. to total Right score) and age interval:

e.g. 1. score of 40 at 5 years 2 months:
reading from raw score 41 and age interval 5·0 but under 5·25, the standard score is 81. This is below the danger level and errors should be investigated in detail.

2. score of 58 at 4 years 5 months:
reading from raw score 57 and age interval 4·25 but under 4·5, the standard score is 117. This is well above average and no further investigation should be needed.

This same information can be looked at from a different angle and the Table used to give an indication of the 'articulation age' of a child. Again take the nearest raw score, look down this column to score 100 to nearest thereto, and read appropriate age group. Take examples above:

1. score of 40 at 5 years 2 months:
for raw score 41, a score of 100 is the mean for age 3·75 but under 4·0 years. In other words the child is articulating at a level of over one year below his physical age.

2. score of 58 at 4 years 5 months:
for raw score 57, a score of 100 is the mean for 5·5 years (102 for 5·25 < 5·5 and 98 for 5·5 < 5·75). This child is articulating at a level of one year above his physical age.

As a rough guide, 15 points on the standard score approximates to one year, and the 'danger level' can be thought of as a score of 85 or as one year behind in articulation age.

Paediatric Oral Skills Package: client details

1. Personal details

Name	Date of birth	Number
Address		

2. Assessment details

Date(s) of examination				
Age(s) at examination				
Examiner(s)				
Location(s)				

3. Relevant information/investigations

Referred by
Other professionals involved
Other assessment/test results
Case history information
Hearing
Vision
Family history/details

4. Medical history:

Diagnosis
Previous illnesses
Medication
Details of previous surgery if relevant

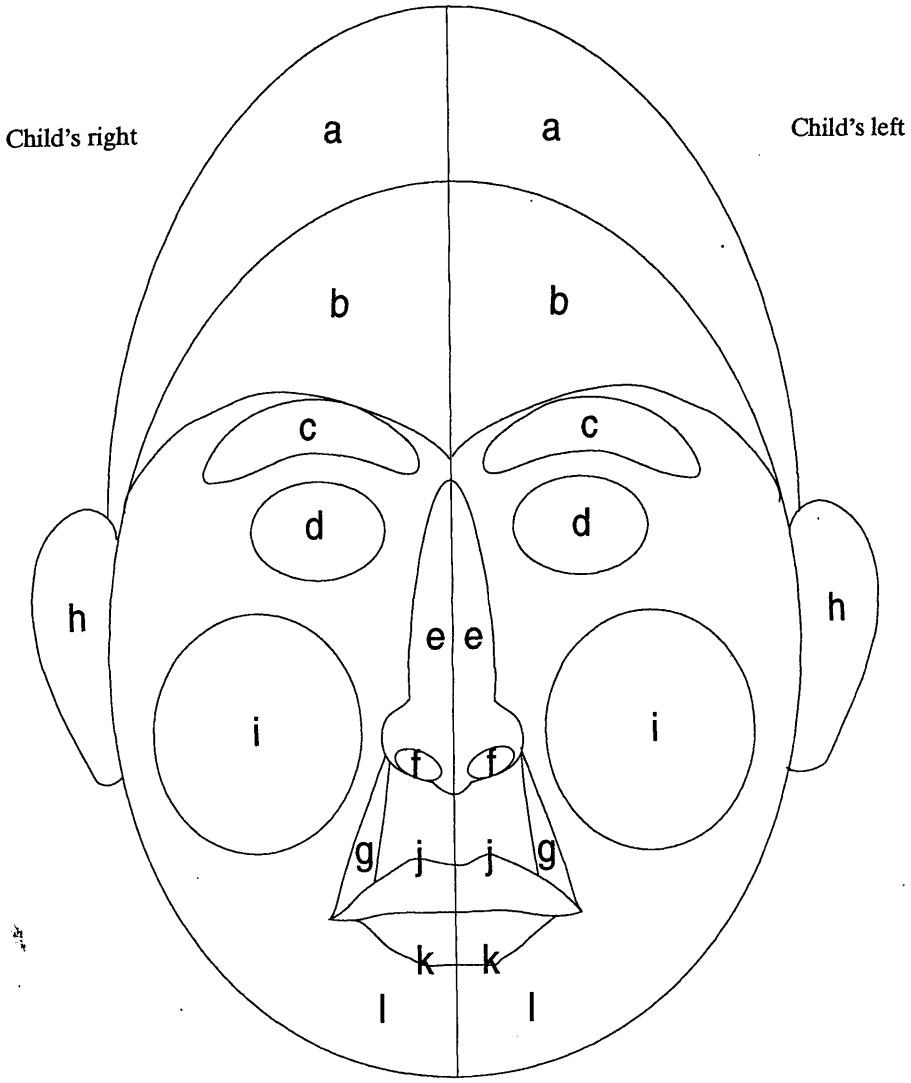
POSP Bradley et al

Orofacial structure and function

Face

O1 1 2 3 Observe structure and symmetry of the face

Errors	1 → 5		Comments
	R	L	
(a) Scalp			
(b) Forehead			
(c) Eyebrows			
(d) Eyes			
(e) Bridge of nose			
(f) Nostrils			
(g) Nasal groove			
(h) Ears			
(i) Cheeks			
(j) Upper lip			
(k) Lower lip			
(l) Jaw/chin			
Other			



Smile

O2 1 2 3 Is the spontaneous smile symmetrical?

Errors	1 → 5		Comments
	R	L	
Asymmetrical			
Retracted upper lip			
Retracted lower lip			
Other			

Orofacial structure and function

Jaw

O3 1 2 3 Note habitual posture of jaw

Errors	1 → 5	Comments
Wide open		
Partial closure/slightly open		
Deviation to R or L		
Retracted		
Protrusion		
Clenched		
Thrusting		
Writhing		
Other		

Jaw

O4 1 2 3 Observe ability to open mouth

(note actual ability, not habitual posture/state)

Errors	1 → 5	Comments
Habitually open		
Fully opened with jaw drop		
Jaw thrust to fully open		
Jaw thrust forward on opening		
Jaw retracted on opening		
Limitation		
Deviation to R or L		
Other		

Jaw

O5 1 2 3 Observe ability to close mouth

Errors	1 → 5	Comments
Tonic bite		
Occlusal anomaly		
Partial closure/slightly open		
Closure attempted – no attempt		
Deviation to R or L		
Other		

Orofacial structure and function

Lips

O6 1 2 3 Note habitual posture of lips

Errors	1 → 5	Comments
Open wide		
Partial closure		
Labiodental closure		
Labiolingual closure		
Closure with rounding		
Other		

Lips

O7 1 2 3 Note tone of upper lip

Errors	1 → 5	Comments
Increased tone with lip retraction		
Increased tone with lip rounding		
Increased tone with lips thin and tight		
Decreased tone, floppy, flaccid, broad		
Dyskinetic tone, writhing		
Fluctuating tone		
Other		

Lips

O8 1 2 3 Note tone of lower lip

Errors	1 → 5	Comments
Increased tone with lip retraction		
Increased tone with lip rounding		
Decreased tone, floppy, flaccid, broad and drooping		
Dyskinetic tone, writhing		
Fluctuating tone		
Other		

Tongue

O9 1 2 3 Note habitual position of tongue in mouth

Errors	1 → 5	Comments
Protruding beyond lips		
Resting on lower lip		
Interdental		
Deviated to R or L		
Other		

Tongue

O10 1 2 3 Note state of the tongue at rest

Errors	1 → 5		Comments
	R	L	
Fasciculation			
Hypertonic			
Hypotonic			
Wasting			
Large			
Small			
Short frenum/frenulum			
Rigid and centrally grooved			
Other			

Tongue

O11 1 2 3 Note habitual posture of tongue

Errors	1 → 5	Comments
Humped to back		
Tongue tip elevated to roof of mouth		
Deviated to R or L		
Habitual or periodic suckling tongue		
Writhing		
Floppy, broad on floor of mouth, flat		
Grooving, side elevation of tongue		
Pointing, thrusting		
Broad, thrusting		
Tight on floor of mouth		
Other		

Palate

O12 1 2 3 Note the structure of the hard palate

Errors	1 → 5		Comments
	R	L	
Cleft			
Fistula			
Submucous			
Narrow			
High and arched			
Broad			
Thickened alveolar ridge			
Other			

Palate

O13 1 2 3 Note the structure of the soft palate

Errors	1 → 5		Comments
	R	L	
Cleft			
Fistula			
Submucous			
Abnormal uvula			
Other			

Palate

O14 1 2 3 Observe movement of soft palate on /a/ cry or /ah/

Can be a performance item

Errors	1 → 5		Comments
	R	L	
Observation			
No movement			
Abnormal movement			
Deviated to R or L			
Other			
Performance			
Poor comprehension			
No attempt			
Refusal			
Delayed movement			
Unsustained			

Movement

M1 **1 2 3** Opening the mouth

Items (a)–(e) are on a continuum from voluntary control to involuntary reflex reaction

	(a) Instruction 'Open your mouth as wide as you can' 1 2 3	**(b) Imitation** 'Do this!' 1 2 3	**(c) Functional imitation** 'Yawn like this' 1 2 3	**(d) Functional label** 'Show me how you yawn' 1 2 3	**(e) Spontaneous/ reactive/prompt** Move spoon/cup towards mouth 1 2 3
Errors	1 → 5	1 → 5	1 → 5	1 → 5	1 → 5
Poor comprehension					
No attempt/no movement					
Refusal					
Associated/compensatory movement					
Delayed opening					
Partial opening					
Unsustained opening					
Jaw deviated R or L					
Jaw thrust (locked)					
Habitually open					
Other					

Comments

M2 1 2 3 Closing the mouth

Items (a)–(e) are on a continuum from voluntary control to involuntary reflex reaction

Errors	**(a) Instruction** 'Close your mouth' 1 2 **3** → 1→5	**(b) Imitation** 'Do this!' 1 2 **3** → 1→5	**(c) Functional imitation** 'Bite like this' 1 2 **3** → 1→5	**(d) Functional label** 'Show me how you bite' 1 2 **3** → 1→5	**(e) Spontaneous/ reactive/prompt** Move spatula or nasty object towards mouth 1 2 **3** → 1→5
Poor comprehension					
No attempt/no movement					
Refusal					
Associated/compensatory movement					
Closed teeth, not lips					
Lips closed, rounding					
Lips closed, writhing					
Closed asymmetrically					
Habitually open					
Tonic bite reflex					
Other					

Comments

Movements

M3 1 2 3 Lip spreading

Items (a)–(e) are on a continuum from voluntary control to involuntary reflex reaction

	(a) Instruction 'Make your lips spread sideways' 1 2 3	**(b) Imitation** 'Do this!' 1 2 3	**(c) Functional imitation** 'Smile like this' 1 2 3	**(d)Functional label** 'Show me how you smile' 1 2 3	**(e) Spontaneous/ reactive/prompt** Tickle child/tell a joke! 1 2 3
Errors	1 → 5	1 → 5	1 → 5	1 → 5	1 → 5
Poor comprehension					
No attempt/no movement					
Refusal					
Associated/compensatory movement					
Lip writhing					
Asymmetrical					
Lip retraction/grimace					
Lip rounding					
Mouth open					
Other					

Comments

Movements

M4 **1 2 3** Lip rounding

Items (a)–(e) are on a continuum from voluntary control to involuntary reflex reaction

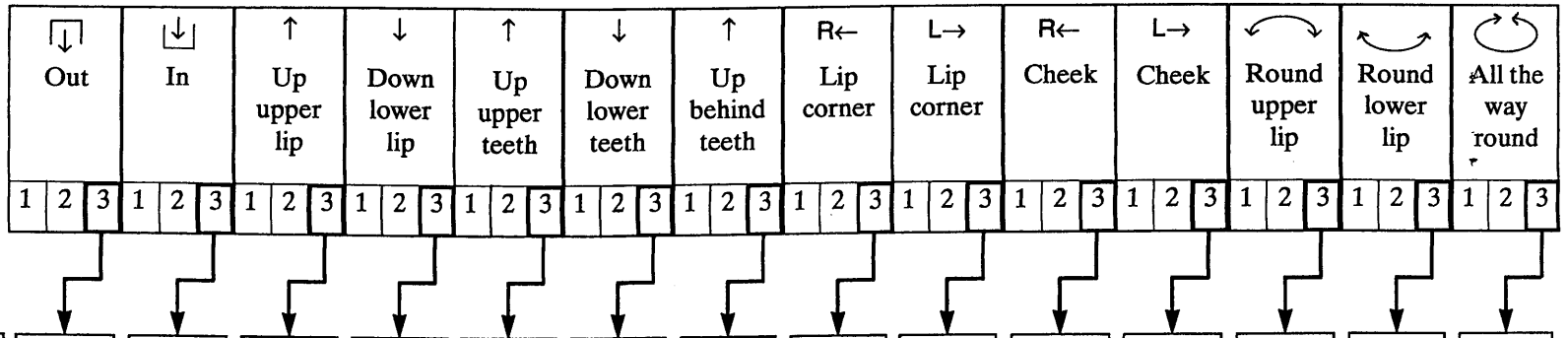
	(a) Instruction 'Make your lips make a little round hole' 1 2 **3** → 1→5	**(b) Imitation** 'Do this!' 1 2 **3** → 1→5	**(c) Functional imitation** 'Blow like this' 'Whistle/kiss' 1 2 **3** → 1→5	**(d) Functional label** 'Show me how you blow/ whistle/kiss' 1 2 **3** → 1→5	**(e) Spontaneous/ reactive/prompt** Straw/dummy/ teat/whistle/ candle 1 2 **3** → 1→5
Errors					
Poor comprehension					
No attempt/no movement					
Refusal					
Associated/compensatory movement					
Weak lip rounding					
Labiodental closure					
Tongue protrusion					
Voicing					
Other					

Comments

Movement

M9a 1 2 3 Voluntary tongue movements

Give verbal instructions, point out movement on your mouth if necessary



Voluntary /on instruction	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5	1→5
Poor comprehension														
No attempt/no movement														
Refusal														
Associated compensatory movement														
Jaw thrust/extension														
Jaw drop														
Weak movement														
Fasciculation														
No tongue tip														
Lip retraction														
Thick, bunching of tongue														
Grooving of tongue														
Incorrect movement														
Partially completed movement														
Perseveration, previous movement														
Other														

APPENDIX VI

Treatment record sheets:

- Group A
- Group B

Record sheet (Group A)

Child's name: _____

Activity	Session 1		Session 2		Session 3		Session 4		Session 5		Session 6		Session 7		Session 8	
Homework done																
	Right	Left	R	L	R	L	R	L	R	L	R	L	R	L	R	L
Chewy Tube - Red																
Chewy Tube - Yellow																
Ark Grabber - Purple																
Ark Grabber - Green																
Cube Placement																
Slow Feed																

Record sheet (Group B)

Child's name: _____

Activity	Session 1		Session 2		Session 3		Session 4		Session 5		Session 6		Session 7		Session 8	
Homework done																
	Right	Left	R	L	R	L	R	L	R	L	R	L	R	L	R	L
Cube Placement																
Slow Feed																

APPENDIX VII

List of foods used in treatment phase

LIST OF FOODS USED

Soft textures:

Processed cheese slices (folded over for cubes)

Cheerios

Crackers

Bananas

Soft apples without skin

White and whole-wheat bread (2 slices for cubes, crusts for slow feed)

Grapes

Strawberries

Medium textures:

Ham slices (folded over for cubes

Chicken

White and whole-wheat toast (2 slices for cubes, crusts for slow feed)

Harder apples (without the skin)

Cucumber

Breadstick

Beef slices (folded over for cubes)

Peaches (without the skin)

Harder textures:

Hard apple with skin

Raw carrot

Roast beef

Raw peppers (red)

Cheddar cheese

Roast pork

APPENDIX VIII

Homework information sheets:

- Group A
- Group B

Homework programme (Group A)

Child's Name: _____

To gain the maximum benefit from the therapy provided, it is essential that your child does his/her homework. I will be monitoring the children's progress by checking home practise.
Please practise each activity 5-10 times per day (this can be in one sitting or spread throughout the day). Minimum of 1 day between Monday and Thursday sessions and minimum of 2 days between Thursday and Monday sessions.

Activity	Session 1 - SLT	Session 1 -parent	Session 2 - SLT	Session 2 -parent	Session 3 -SLT	Session 3 - parent	Session 4 - SLT	Session 4 -parent
Chewy Tube - Red								
Chewy Tube - Yellow								
Ark Grabber - Purple								
Ark Grabber - Green								
Cube Placement								
Slow Feed								

Activity	Session 5 - SLT	Session 5 - Parent	Session 6 - SLT	Session 6 - parent	Session 7 -SLT	Session 7 -Parent	Session 8 - SLT	Session 8 - parent
Chewy Tube - Red								
Chewy Tube - Yellow								
Ark Grabber - Purple								
Ark Grabber - Green								
Cube Placement								
Slow Feed								

Child's Name: _____

The following gives the important information you need to help your child achieve the homework given by the Speech and Language Therapist.

CHEWY TUBE/ARK GRABBER:

Positioning:

For best results your child should be positioned in a stable body posture to allow for maximum mobility in the jaw. This may be on a chair or a bench which allows for a 90-degree angle in the pelvis, knee and ankle. His/her feet should be on the floor or a book/box can be placed under the feet. His/her head should be kept upright, looking straight ahead and with hands in his/her lap (you will always hold the oromotor equipment)

Place the tip of the chewy tube/ARK grabber on your child's lower back molars, extending out from the side of the mouth. Instruct your child to bite and demonstrate with your own mouth. Keep the chewy tube/ARK grabber in your child's mouth and continue to give the instruction to bite-bite-bite etc for as many repetitions as indicated for homework.

Equipment:

Please keep the equipment safe and return it each week in the bag supplied. Each child will have the use of their own designated equipment and will not be required to share in the sessions, for hygiene reasons. I will sterilise the equipment periodically, again for hygiene purposes. If you wish to do so yourself, the American Medical Association states that a solution of 4% bleach to 96% water can be used for sterilising the equipment. Please do not place in a dishwasher.

CUBE PLACEMENT/SLOW FEED:

Please use the same sitting posture as described above.

Cube Placement:

Choosing a food of your child's preference, cut it into a cube shape approximately $\frac{1}{2}$ inch per side. Place the cube on the surface of the left back molars using either your fingers or an up-side-down fork. Eventually your child will be able to place the cube themselves using their own fingers or a fork. Remove the fork and instruct your child to chew-chew-chew as you demonstrate

also, until the cube is completely chewed and ready for swallowing. Repeat on the right side or as directed in the homework sheet.

Slow Feed:

This is ideal for snacks. Choosing a food of your child's preference, cut it into a relatively thin julienne-stick shape i.e. about as long as your little finger! Place the tip of the food on the surface of your child's left back molar, with the rest sticking out of your child's mouth. Instruct your child to chew. As the tip is bitten off each time, move the food so that the new tip is positioned on the back molar again. Continue until the stick is all gone and then repeat on the right side or as directed in the homework sheet.

Finally many thanks again for agreeing to your child's participation in this research project.

If you have any questions, please contact me on

Fiona Cowman
Speech and Language Therapist

Homework programme (Group B)

Child's Name: _____

To gain the maximum benefit from the therapy provided, it is essential that your child does his/her homework. I will be monitoring the children's progress by checking home practise.
Please practise each activity 5-10 times per day (this can be in one sitting or spread throughout the day). Minimum of 1 day between Monday and Thursday sessions and minimum of 2 days between Thursday and Monday sessions.

Activity	Session 1 - SLT	Session 1 -parent	Session 2 - SLT	Session 2 -parent	Session 3 -SLT	Session 3 - parent	Session 4 - SLT	Session 4 -parent
Cube Placement								
Slow Feed								

Activity	Session 5 - SLT	Session 5 - Parent	Session 6 - SLT	Session 6 - parent	Session 7 -SLT	Session 7 -Parent	Session 8 - SLT	Session 8 - parent
Cube Placement								
Slow Feed								

Child's Name: _____

The following gives the important information you need to help your child achieve the homework given by the Speech and Language Therapist.

CUBE PLACEMENT/SLOW FEED:

Positioning:

For best results your child should be positioned in a stable body posture to allow for maximum mobility in the jaw. This may be on a chair or a bench which allows for a 90-degree angle in the pelvis, knee and ankle. His/her feet should be on the floor or a book/box can be placed under the feet. His/her head should be kept upright, looking straight ahead.

Cube Placement:

Choosing a food of your child's preference, cut it into a cube shape approximately ½ inch per side. Place the cube on the surface of the left back molars using either your fingers or an up-side-down fork. Eventually your child will be able to place the cube themselves using their own fingers or a fork. Remove the fork and instruct your child to chew-chew-chew as you demonstrate also, until the cube is completely chewed and ready for swallowing. Repeat on the right side or as directed in the homework sheet.

Slow Feed:

This is ideal for snacks. Choosing a food of your child's preference, cut it into a relatively thin julienne-stick shape i.e. about as long as your little finger! Place the tip of the food on the surface of your child's left back molar, with the rest sticking out of your child's mouth. Instruct your child to chew. As the tip is bitten off each time, move the food so that the new tip is positioned on the back molar again. Continue until the stick is all gone and then repeat on the right side or as directed in the homework sheet.

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Speech and Language Therapist