Are Oral-Motor Exercises Useful in the Treatment of Phonological/Articulatory Disorders?

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ABSTRACT

The utility of oral-motor exercises in the remediation of children's speech acquisition delays continues to be a controversial issue. There are few empirical evaluations of the efficacy of these nonspeech activities in effecting speech changes, although much can be learned from investigations in related fields. The purpose of this article is to review the extant studies of the relation between oral-motor exercises and speech production in children as well as to examine the motor learning literature to gain a broader perspective on the issue. Results of this examination lead to questions about the procedures that are currently applied as well as to suggestions for future development of nonspeech activities in the treatment of children's phonological/articulatory disorders.

KEYWORDS: Oral-motor exercises, phonological disorders, treatment

Learning Outcome: As a result of this activity, the reader will be able to (1) describe the similarities and differences between speech production and oral-motor exercises and (2) describe basic principles of motor learning and how they apply to treatment of children with PAD.

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Phonological/articulatory disorders[1] (PADs)* in children are defined by the presence of speech acquisition delays or disorders that are not associated with neurological deficits or organic impairments.[2,3] Whereas these exclusionary criteria are generally accepted, the underlying cause of the disorder remains at the center of debate. The presumed cause of the speech impairment is important because it tends to dictate the assessment protocol as well as the ensuing treatment. One such treatment procedure, oral-motor exercises, is based on the premise that motor deficits are central to PADs and, therefore, improvements in oral-motor accuracy and consistency will advance speech development.[4,5]

In the current review, the empirical evidence of a relationship between oral-motor exercises and articulation changes in children will be investigated. A ubiquitous definition of what constitutes an oral-motor exercise does not exist; the term has been used to designate a variety of oral, lingual, and mandibular movements that range from articulator "wags" or "push-ups"[6] to activities that include blowing bubbles or on horns.[7] The limited published evidence of the relationship of oral-motor proficiency and PAD remediation will be reviewed first, but because of the paucity of such information possible rationales for using these nonspeech assessments and treatments will also be derived from studies on motor learning.

The most obvious reason for using oral-motor exercises is that speech is an extremely complex motor behavior and principles of motor learning suggest that learning is facilitated when a complex behavior is decomposed into smaller units.[8] The hypothesis that needs to be addressed, then, is whether practice on a part of the task (e.g., subunits of the target phone such as movement of a single articulator) increases the rate and accuracy of learning of the whole (e.g., accurate production of the target phone).

Other reasons, specific to motor development, have also been suggested to support the utility of oral-motor exercise in speech articulation treatment. Based on work with neurologically impaired children,[9] it has been hypothesized that children with PADs have limited tone to the speech musculature.[10] In an effort to increase the tone of the oral-facial muscles, strengthening exercises are proposed. This hypothesized utility of oral-motor exercises leads to two questions: (1) what is the strength that is needed for articulatory gestures? and (2) do oral-motor exercises increase articulator muscle strength?

Patterns of normal development also provide a useful background for understanding the utility of oral-motor exercises. Normal development, as outlined by Piaget,[11] includes a sensorimotor period in which neural pathways relating movement and the resulting percept are developed. A child who is not producing speech correctly may have limited access to this relationship. One hypothesis is that oral-motor exercises will provide this linkage by reconstructing the hierarchy of articulator movement normally experienced during development.[12]

Finally, it has been hypothesized that speech develops from earlier occurring behaviors such as sucking, chewing, or oral-motor reflexes.[13] Because oral-motor exercises may incorporate movement patterns that are similar to these primitive behaviors, these exercises may serve as a foundation for the development of the more complex movement patterns of speech.

In the following review, each of these hypotheses will be investigated. Although there have been many reports on the utility of oral-motor exercises in PADs, only articles that include experimental controls are included in this review.[14] The application of these controls is essential to the establishment of a relationship between the variables under investigation and serves as a foundation for evidence-based treatment.[15]

ORAL-MOTOR EXERCISES AND ARTICULATION FUNCTION IN CHILDREN

As has been noted earlier, there are few controlled investigations of the facilitative effect of nonspeech training on articulatory changes.

**This term will be used to refer to children with multiple articulatory errors that are not secondary to neurological or organic impairments. Because the source of the problem remains unclear, neither a cognitive (i.e., phonological) nor motoric (i.e., articulatory) basis is being assumed.*

The studies that have been published focus on the efficacy of oral-myofunctional therapy for tongue thrust on the correction of distorted /s/ production. For example, Overstake[16] monitored changes in /s/ production in two groups of children with tongue thrust. In this treatment study, 76 children were divided into two groups; one group received treatment on swallowing for 15 minutes per week and the second group of children received treatment on swallowing and /s/ production. The study was conducted over a 9-month period and attrition was fairly high, with only 48 subjects remaining at the study's termination. Of these 48 subjects, 24 of 28 (85%) children who had received swallowing treatment only produced undistorted /s/ in conversational speech. Fifteen of 20 subjects (75%) who received both swallowing and speech therapy demonstrated correct production of /s/ in conversation. Overstake concluded that in remediating /s/ articulation swallowing treatment alone was as effective as—if not more effective than—treatment that included both swallowing and speech. Although the data support this assertion, there are many aspects of the research that remain unclear. For example, no information is given on the specifics of either the swallowing or speech treatment, thereby limiting clinical application of this research. Further, the reason for the high rate of subject attrition is not provided. Finally, no explanation is given for the better performance of the group of children treated only on swallowing; specifically, why did 85% of the children treated on swallowing alone produce correct /s/ in conversation when only 75% of the children treated on both swallowing and speech were able to make this correction?

Perhaps because of these ambiguities, Christensen and Hanson[17] used a controlled procedure to investigate whether oral myofunctional therapy has a facilitative effect on subsequent articulation therapy. Ten children between the ages of 5;8 and 6;9 who had completed kindergarten were included in the study. All children demonstrated anterior tongue thrust and severe frontal lisps but were developing normally in all other domains. Children were divided into two groups with one group of children receiving articulation therapy only for 14 weeks and the second group of children receiving 6 weeks of myofunctional therapy for tongue thrust and 8 weeks of articulation therapy. Articulation therapy was the same for children in both groups and progressed from auditory identification of correct sibilants through production of the sound in isolation and in syllables, words, phrases, and spontaneous conversation. Comparison of pretreatment and posttreatment production of sibilants and performance on an articulation test indicated that children in both groups made improvements in articulation; however, there were no differences in the amount of speech change made for children in the two groups. Although the investigators suggest intervening variables, the results of the study indicate no facilitative effect of tongue-thrust treatment on speech articulation. These results are similar to those reported by Dworkin et al[18] for adult speakers with acquired apraxia of speech; their findings indicated no facilitative effect of nonspeech oral-motor exercises on speech production.

Clearly, there is a need for more experimental studies of the effect of nonspeech oral-motor treatment on changes in speech production. Not only would these data have clinical utility, they would provide benefits to theoretical models of speech acquisition by elucidating the components of this complex behavior. These types of data are available in other areas of motor learning and may serve as a basis for future studies of the transfer of training from nonspeech movements to articulatory changes.

TRANSFER OF TRAINING AND PART-WHOLE LEARNING

Transfer of training occurs when learning of a response in one situation or domain facilitates learning of a response in a different, novel situation.[19] Research in this area has identified two major issues that affect learning efficiency: (1) characteristics of the task that might influence transfer of training[20] and (2) methods of decomposing the task into its parts.[21]

Naylor and Briggs[20] identified two task variables, task complexity and task organization, that influence the transfer of training. Task complexity was defined as "the demands placed on the S's information-processing and/or memory-storage capacities by each of the task dimensions independently, while task organization refers to the demands imposed on [the subject] due to the nature of the interrelationship existing among the several task dimensions"[20] (p 217). Naylor and Briggs demonstrated that learning of complex tasks with independent parts will be facilitated by training on individual parts of the behavior. By contrast, tasks that comprise highly organized or integrated parts will not be enhanced by learning of the constituent parts; rather, training on parts of these organized behaviors will diminish learning, particularly when task complexity increases. These results have been replicated many times in studies of complex skill acquisition.[19] As noted by Naylor and Briggs,[20] highly organized tasks require learning of the information processing demands as well as learning of "time-sharing and other intercomponent skills" (p 223).

In a sense, organization and complexity are relative in that end points of their continua probably cannot be defined; a highly complex task probably cannot have completely independent dimensions. In speech, for example, production of [bʌ] may be considered to have relatively little interrelated dimensions because the jaw moves only in an inferior direction and the tongue can ride on the jaw. Intercomponent organization is relatively greater for a sequence such as [bu] wherein the lips are rounded and the jaw movement may follow a vector composed of inferior-anterior rotation. Still greater organization would be required to produce a syllable such as [strænd] wherein movement of the tongue, lips, jaw, and velum must be coordinated within a limited temporal window.

Wightman and Lintern[21] expanded on the results of Naylor and Briggs by elucidating the interaction between task complexity, organization, and the type of part-task training that is used. On the basis of previous studies, Wightman and Lintern identified three ways in which a whole task can be decomposed during training—segmentation, fractionation, and simplification. Segmentation divides the task into a series of spatial or temporal subcomponents with identifiable start and end points. In speech treatment, an isolated phone may be segmented from a conversational environment so that the sound can be produced and practiced prior to its presentation in a syllable context. Once the child has mastered production of the isolated sound, it is recombined into a more speechlike sequence.

Fractionation decomposes simultaneously produced elements of a task into independent subcomponents. In speech treatment, fractionation would allow practice on independent movement of articulators that combine to produce a phone. For example, if a child was having difficulty with the production of lingua-alveolar consonants, fractionated practice might begin with isolated superior movement of the tongue tip with fixed positions of the tongue body, vocal folds, respiratory system, jaw, and lips. As the child mastered this isolated gesture, a second component of phonetic production, for example, jaw depression, would be practiced independently. Fractionation, then, takes the form of nonspeech activities that may approximate components of speech production.

The final means to decompose a complex task for training purposes is simplification. Simplification is a procedure in which various aspects of the target skill are made easier by adjusting characteristics of the task. A possible application to speech treatment might include initiating treatment for /s/ with the homorganic stop, [t]. Because stops require only a ballistic movement, they are considered easier to produce than fricatives[22,23]; beginning treatment for /s/ acquisition with the placement of [t] may simplify the movement pattern and give the child some reference for production.

Of the methods reviewed by Wightman and Lintern, only segmentation appears to provide a significant advantage over whole-task training and then only under restricted conditions. Wightman and Lintern found that fractionation methods resulted in reduced efficiency of learning compared with training on the whole task. These empirical results are consistent with theoretical models provided by dynamic systems[24] in that relevant sensory-motor correspondences are prerequisite for motor learning (e.g., auditory perceptual consequences of articulatory movement are needed for the typical development of speech). Fractionating a behavior that is composed of interrelated parts is not likely to provide this relevant information for the appropriate development of neural substrates. Finally, Wightman and Lintern demonstrated that simplification of a task yielded learning that was comparable to that of whole-task training. Again, this is consistent with empirical data from studies of generalization of knowledge obtained by phonologically disordered children due to treatment.[25]

In summary, part training is an effective means to enhance learning of a complex behavior under a limited set of conditions. Part training is not facilitative of acquisition of the whole behavior if the target activity comprises highly interdependent parts or, as Naylor and Briggs term it, a highly organized behavior. Further, the means by which a behavior is decomposed also influences the efficacy of training individual components of that behavior. Only segmentation of the whole task into temporally or spatially independent components provides an advantage to part training compared with teaching of the behavioral whole, and this is true only if the parts represent independent components of the behavior. Therefore, if subcomponents of speech are to be used in therapy, it is essential that the task is determined to meet the demands of part-whole training. Otherwise, part training is not a cost-effective or time-effective means of enhancing the development of speech. Similar conclusions were reached by Bunton and Weismer[26] in their comparison of speech and nonspeech tasks in adults.

STRENGTH

Evaluation of articulator strength and procedures to increase strength in children diagnosed with functional articulation and/or phonological disorders is a complicated issue for several reasons. First, by definition, children with PADs should not exhibit muscle weakness[5,27]; children with phonological or functional articulation disorders are so classified because there is no evidence of an organic basis for the speech deficit. The existence of muscle weakness would imply dysarthria that results from an identifiable neurological deficit.[28] Therefore, children who exhibit such deficits need a more thorough medical evaluation to determine the site of lesion and associated deficits.

A second complication in discussing muscle strength as a factor in articulatory accuracy is the lack of knowledge of a target value; that is, few data exist regarding the strength needed for articulation. Estimates of lip muscle forces in speech production (i.e., muscle tension produced by active and passive, recoil elements), based on lip simulation and controlled activation, range from 0.5 to 0.6 Newtons,[29] which is about 20% of maximal forces that can be generated by neurologically intact adults. No comparable estimates are available for young children. Interlabial pressures (i.e., force/unit area) similarly are low with measured values of about 0.4–2.4 KiloPascals in conversational speech.[30] Depending on the dynamics of the jaw, it is estimated that these pressures are between 11 and 15% of available maxima of interlabial pressures. Again, these values are for adult speakers because no such data are available on interlabial pressure generation by children. Pressures associated with lingua-alveolar contact have been shown to vary by sex, position of the sound in a word, and measurement point within the oral cavity,[31] although precise estimates of these pressures within an individual's physiological range are not known. Initial attempts have been made in this direction by use of the Iowa Oral Pressure Instrument (Breakthrough, Inc.). Robin et al[32] report that maximum lingual pressure generation is equivalent in normally articulating children and adults. Their investigation of children with developmental apraxia of speech (DAS) indicated no significant differences in pressure generation between these articulation-impaired children and children with normal articulation.

A number of early studies investigated the relation of tongue strength, as measured by protrusive force, and articulatory competence in children and young adults. Results of these analyses do not lead to consistent conclusions about the existence of a relationship between speech proficiency and protrusive strength. For example, a number of studies suggest a relation between protrusive tongue force or pressure and articulatory accuracy,[31,33,34] whereas other investigations find no significant relation between articulator strength, including the tongue and lips, and articulation proficiency.[32,35–37] The reason for these different results is not clear in that similar methodologies and subject groups were used across studies with contradictory results.

In summary, the use of oral-motor exercises to increase articulator strength needs to be questioned on a number of grounds. Neither experimental investigations nor nosological description of articulation disorders provide consistent evidence for a strength deficit in children with PADs.

REPLICATING SENSORIMOTOR DEVELOPMENT

It has been proposed that early sensorimotor experience (e.g., from imitation of facial expressions, hand-to-mouth object manipulation, or free vocalizing) serves as a foundation for speech development.[12] Therefore, sensory deficits may contribute to articulatory disorders by limiting kinesthetic and tactile reinforcement of movement sequences, thereby limiting learning of the complex movements associated with speech.[38] In addition, investigations of individuals with neurological disorders (e.g., cerebral palsy) suggest that sensorimotor deficits affect motor learning.[39–41] The inference from these studies is that movement deficits can be reduced by improving coordination patterns through the use of afferent pathways.[40] The appeal of such a perspective led to many empirical investigations of the relation between sensory acuity and articulatory proficiency. In general, these studies do not reveal a clear relation between articulatory skill and kinesthetic sensitivity; some investigators indicate a significant correlation,[38,42,43] some studies reveal no relationship,[44,45] and still others suggest that the relationship is phoneme specific.[46]

Differences in results may be attributable to methodological variations across studies. In some investigations, oral stereognosis was used to determine whether children with articulation disorders were limited in their ability to recognize the form of objects placed in the oral cavity.[38,42,44,45] Vibrotactile thresholds and suprathreshold sensitivity were also investigated to determine kinesthetic and tactile acuity of the tongue.[43,47] Threshold differences between normal and articulation-disordered groups of subjects were not subjected to statistical testing, so the results are difficult to interpret.[43] Suprathreshold stimulation in which the vibrotactile stimulus intensity was varied indicated differences in perception between the subject groups that "approached significance" when a liberal probability level ($p \leq .10$) was used. A final test was conducted to determine whether suprathreshold stimulation increased threshold levels (i.e., caused a threshold shift) as has been shown for other sensory systems.[47] Again, between-group differences approached significance ($p \leq .10$), leading Fucci et al to conclude that sensory processing differences separate children with normal and disordered articulation.

In summary, studies of lingual sensitivity do not present a clear picture of the relation of this parameter to articulatory accuracy in children. It remains plausible that these tests did not measure the relevant variables of sensorimotor function; if this is true, additional research is needed to verify the presence or absence of a relation. Based on the conflicting data that are currently available, it is difficult to make a strong case for using oral-motor exercises for children with PAD; however, theoretical models[24] continue to make this an enticing line of inquiry.

Theoretical models of movement development have diverged from Piaget's general perspective of discrete stages[24] and posit that development evolves from the organism's interaction with the environment and the pairing of sensory traces with the contributing movement.[45] These interactions form the basis of neural pathways within the nervous system that are preferentially reinforced by movement patterns and their sensory representations. This model provides a sound theoretical basis for the utility of nonspeech oral-motor exercises in the development of neural control of articulation. But, as with the conclusions about partitioning a behavior into its component tasks, the exact nature of the sensorimotor sequence is critical to the development of relevant neural control. As Thelen and Smith[24] state, "context makes, selects, and adapts knowledge . . . because knowledge is only made manifest in a real-time task" (p 216). Therefore, if sensorimotor stimulation is to foster speech, more speechlike activities, such as sound play and stimulability training,[48] would be more reasonable approximations to the target behavior. If nonspeech activities are to be used, we are faced again with the need for more information about the relevant components of those behaviors. The lack of empirical data on the requirements of a nonspeech action pattern as an analog to articulatory performance suggests that there are many obstacles to developing such a counterpart to speech.

DEVELOPMENT OF SPEECH FROM OTHER BEHAVIORS

As noted earlier, speech acquisition has been modeled as a dynamic process by which the articulatory system self-organizes from a variety of independent components into ordered configurations of action.[24,49,50] A dynamic systems model of speech acquisition posits that rhythmic behaviors (e.g., chewing, sucking) are modified to form diverse behaviors. If this hypothesis is correct, then a program that follows the typical course of development, such as a program of oral-motor exercises, may facilitate speech acquisition in children with PADs.

As with the issues discussed previously, there are few controlled studies of orofacial action patterns during the earliest stages of speech acquisition. The data that have been reported[49,51–53] reveal significant differences in movement, masticatory-muscle activity, and coordination for speech compared with primitive behaviors of the perioral region (i.e., chewing). Consistent with findings from other studies,[54] Moore and colleagues[55] demonstrated that in the adult, muscle activity for speech is characterized by cocontraction of agonist and antagonist muscles, that is, simultaneous activity in muscles that effect the movement (agonist) and muscles that oppose the movement (antagonist). This pattern of muscle activation was also evidenced in children as young as 15 months of age, the youngest age group investigated.[52] By contrast, chewing in both children and adults was marked by reciprocal (i.e., alternating) activation of agonist-antagonist muscles. For example, during jaw depression the anterior digastric muscles were active followed by activity of antagonist muscles, such as temporalis, for jaw elevation. Therefore, at relatively early stages of speech production, muscle activation patterns for speech are distinct from chewing but similar to speech muscle activation patterns seen in adults. If chewing does serve as a precursor to speech, there is considerable divergence in the muscle activity for these behaviors at the very earliest stages of development.

The similarities of speech muscle activity between adults and young children are particularly interesting given that movement patterns show developmental trends that parallel phonological acquisition. In a study by Green et al,[49] kinematic analyses of the upper lip, lower lip, and jaw were completed for three groups of children (1-year-old children, 2-year-old children, 6-year-old children) and adults. As predicted by phonological models,[50,56] differences in coordination of the articulators was found across the age groups. One-year-old children used jaw movement as the primary contributor to mouth closure for the bilabial consonant and demonstrated a lack of spatial and temporal coupling between the lips and/or the jaw during the oral-closing gesture. Movement patterns for the 2-year-old children revealed a tight coupling between the upper and lower lip but no such linkage with the jaw. The oral-closing gestures produced by the 6-year-old children were similar to those produced by adults, although children's movements were more variable.

Taken together, these studies suggest that speech movements may be distinctive from other nonspeech behaviors at an early stage of development. Muscle activation patterns that are unique to speech are demonstrated in infants, but the coordination between structures develops over the course of years. These results stress the importance of coordinated movement in speech production and question the utility of treatment protocols that do not encompass an organizational scheme that is comparable to that found in speech production.

WHY ARE ORAL-MOTOR EXERCISES USED IN TREATMENT OF PAD?

The preceding review provides a rather pessimistic view of the utility of oral-motor exercises in treatment of PAD. That leaves us with the question of why these procedures are used by clinicians. Two reasons have been presented by practicing clinicians. The first rationale focuses on the primary concern of clinicians, that is, "use whatever works." However, as the limited experimental data suggest, oral-motor exercises may not "work" in remediation of PAD. Further, based on principles of dynamic systems, oral-motor exercises may be harmful by laying a framework of movement patterns that are contrary to those used in speech. As Green et al[49] suggest, "the advancement to mature speech may require the young child to *overcome* [italics added] ingrained oromotor patterns" (p 252).

The second rationale that has been expressed is that "I don't know what to do and this is a start." As with the previous rationale for using nonspeech exercises, this emphasizes the frustration that is felt by clinicians when working with children with intractable PADs. Some of these disorders appear resistant to treatment, and oral-motor exercises may provide a mechanism for success. However, the underlying disorder is founded in speech, thereby making success in a nonspeech activity somewhat irrelevant to the diagnosed problem.

There are many procedures that have been shown to provide effective remediation for children with phonological disorders.[57] Other studies have shown that effective treatment exists for children with other forms of PAD.[58–60] To date, there are very few studies that have compared treatment efficacy for children with varying profiles of speech sound disorder.[61–63] More limited are the studies that have investigated the efficacy of nonspeech procedures as a foundation for speech-sound remediation.[16,17] As reviewed in this report, extant empirical studies do not support a facilitative relationship between nonspeech behaviors and speech production. However, the relevant studies may remain to be conducted.

CONCLUSIONS

Based on currently available resources, oral-motor exercises cannot be considered to be a legitimate treatment protocol for children with PADs. First, empirical studies on the impact of oral-motor exercises on speech remediation do not provide support for the utility of these procedures. More generally, information on transfer of training during motor learning does not support the use of simple behaviors as a means to master a complex activity. Within the context of a highly complex and highly organized task such as speech, research has shown that training on part of the task does not increase the rate or accuracy of learning the whole. One interpretation of this assertion is that decomposition of speech into its subcomponents does not facilitate acquisition of this complex behavior.[64] Alternatively, the proper exercises to promote phoneme acquisition may exist but are as yet undetermined.[65] There is reason to be optimistic that procedures can be developed that will induce changes in speech sound production; however, such a procedure will need to include the same level of complexity and organization that characterizes speech. Preliminary efforts that use nonspeech activities to improve respiratory and laryngeal control in dysarthria are promising.[66,67]

It has been suggested that oral-motor exercises can be used to improve articulatory muscle strength. Although it is not clear that this proposal is true, its accuracy may not be relevant; motivation to increase oral-muscle strength is predicated on preexisting weakness of these muscles in children with PADs. The existence of such weakness has not been ascertained from extant research publications. Further, children with speech disorders who exhibit muscle weakness are, by definition, dysarthric and therefore should be excluded from treatments designed to remediate PADs.

Similar conclusions can be drawn about the impact of oral-motor exercises on promoting sensory-motor linkages. A basic tenet of this approach is that children with PADs have perceptual deficits. At best, the research on this issue is equivocal. Finally, it is clear that oral-motor exercises cannot be used as a foundation for speech acquisition. Muscle activity patterns for early-occurring behaviors such as chewing are clearly distinct from the activation seen in speech. This divergence is evident by the age of 1 year. Until evidence from carefully controlled studies is presented to validate the utility of oral-motor exercises, the inclusion of nonspeech activities in treatment of children with PADs simply may deplete resources that could otherwise be used for effective intervention procedures.[68]

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