Clinical Forum

Nonspeech Oral Motor Treatment Issues Related to Children With Developmental Speech Sound Disorders

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Children with developmental speech sound disorders[1] account for a significant number of clients who require services from speech-language pathologists (SLPs) (Bernthal & Bankson, 2004; Janota, 2001; Shriberg & Kwiatkowski, 1994). There are a number of different treatments for developmental speech sound disorders, and there is a body of research that examines the efficacy of the various treatments (Bowen, 2005; Gierut, 1998; Kamhi, 2005). Gierut pointed out that the major difference among treatments is in respect to their underlying theory,

but that they can be categorized broadly into phonetic or sensory motor-based treatments (Bernthal & Bankson, 2004), phonemic or conceptual-based treatments (Gierut, 1998), and hybrid treatments that incorporate both phonetic and phonemic components (Rvachew, 2005). Sensory motor approaches may also target speech perception in addition to sound production.

The goal of sensory motor treatment is to improve the accuracy of articulatory movements for a speech sound or sounds and incorporate those movements in contextual speech through different levels of practice that range from syllables to conversational speech. Phonemic treatments target the underlying cognitive–linguistic problems of the child through different types of contrastive practice and/or metalinguistic awareness. For example, the use of minimal pairs creates a contrast between the error sound and the target sound. Treatment confronts the client with semantic problems that are

[1]Developmental speech sound disorder is a collective term that refers to clinical differences in the development of a child's sound system. A child may exhibit sensory motor-based phonetic errors, linguistic-based phonemic errors, or a combination of these two types of errors. The etiology of most developmental speech sound disorders is unknown.

ABSTRACT: **Purpose:** This article examines nonspeech oral motor treatments (NSOMTs) in the population of clients with developmental speech sound disorders. NSOMTs are a collection of nonspeech methods and procedures that claim to influence tongue, lip, and jaw resting postures; increase strength; improve muscle tone; facilitate range of motion; and develop muscle control. In the case of developmental speech sound disorders, NSOMTs are employed before or simultaneous with actual speech production treatment.
Method: First, NSOMTs are defined for the reader, and there is a discussion of NSOMTs under the categories of active muscle exercise, passive muscle exercise, and sensory stimulation. Second, different theories underlying NSOMTs along with the implications of the theories are discussed. Finally, a review of pertinent investigations is presented.

Results: The application of NSOMTs is questionable due to a number of reservations that include (a) the implied cause of developmental speech sound disorders, (b) neurophysiologic differences between the limbs and oral musculature, (c) the development of new theories of movement and movement control, and (d) the paucity of research literature concerning NSOMTs.
Clinical Implication: There is no substantive evidence to support NSOMTs as interventions for children with developmental speech sound disorders.

KEY WORDS: nonspeech oral motor treatments (NSOMTs), developmental speech sound disorders, therapeutic exercise

solved through contrastive practice. Hybrid approaches employ both phonetic practice and phonemic contrast and encompass both the motoric and linguistic aspects of speech.

Nonspeech oral motor treatments (NSOMTs) diverge from phonetic and/or phonemic treatments because they target nonspeech motor movements and oral postures with the aim of developing motor patterns requisite for speech sound production (Strode & Chamberlain, 1997). NSOMTs employ various exercise movements, instruments such as horns and whistles, and stimulatory techniques. In sum, NSOMTs are used by some SLPs as a facilitating agent before or concurrent with treatment for speech sound disorders (Marshalla, 2001; Williams, Stephens, & Connery, 2006).

The speech-language pathology literature, along with anecdotal reports from practitioners, indicates that NSOMTs have a significant, controversial, and continuing history in the treatment of communication disorders (Clark, 2003, 2005; Hodge, 2002; Morley, 1967; Ruscello, 2004; Ward, 1931; Weismer, 2006; Yorkston et al., 2001), oral myofunctional disorders (Gommerman & Hodge, 1995; Hanson, 1994; Ruscello, 2005; Umberger & Johnston, 1997), and dysphagia (Clark, 2003; Logemann, 1998; Morris & Klein, 1987). Currently, there are numerous workshops and published materials that provide a plethora of NSOMT information for practitioners (Chapman Bahr, 2001; Landis, 1994; Marshalla, 2001; Strode & Chamberlain, 1997), particularly for children with developmental speech sound disorders. Strode and Chamberlin wrote the following about NSOMTs in their publication materials for children with developmental speech sound disorders:

> [Nonspeech oral motor treatment] is designed to facilitate development of the motor skills needed for speech sound production through sensorimotor and oral-motor intervention. This enables the child to develop motor skills for speech and motor memory of speech sound productions so he can acquire appropriate movement and placement of the articulators for the target sounds. (p. 5)

The authors indicated that their NSOMT materials were designed for children who present with different etiologies, degrees of impairment, and chronological age range.

SLPs need to be cognizant of the fact that the application of any treatment is based on a set of underlying theoretical assumptions (Schwartz, 1992), and there are several assumptions implicit in the use of NSOMTs. The first assumption is that the use of NSOMTs implies that a muscle deficit is the causal factor of developmental sound system disorders. The second assumption fundamental to NSOMTs is that the neurophysiology of the limbs and oral musculature is similar, which suggests that therapeutic principles of limb rehabilitation apply to oral rehabilitation. The third assumption is that there is a transfer of training from the practice of NSOMT tasks to speech tasks. Readers should be aware that there are data contrary to the above assumptions, and these data are the major focus of this article.

Because children with developmental speech sound disorders constitute a large group of clients receiving speech-language services (Janota, 2001), SLPs need to use treatment programs and materials that will assist them in providing efficient and appropriate services. Proponents of NSOMTs argue for their employ as part of the treatment regimen (Beckman, 2003; Boshart, 1998) and express the position that coursework related to NSOMTs should be taught at the graduate level (Pierce & Taylor, 2001). Commercial NSOMT materials are very attractive to young children (Marshalla, 2001; Rosenfeld-Johnson, 1999), and activities can be implemented

without extensive preparation (Marshalla, 2004). However, practitioners are faced with an ethical dilemma because NSOMTs are not supported by empirical research (Forrest, 2002; Golding-Kushner, 2001; Hodge, 2002; Lof, 2003; Lof & Watson, 2008; Moore & Ruark, 1996; Tyler, 2005; Yorkston et al., 2001). That is, they lack a sufficient evidence base to warrant implementation for children with developmental speech sound disorders (Lass & Pannbacker, 2008; Lass, Ruscello, & Pannbacker, 2004).

Despite the lack of research in support of NSOMTs, it is very clear that NSOMTs are used quite extensively, particularly with clients who have been diagnosed with developmental speech sound disorders (Bowen, 2005; Hodge, Salonka, & Kollias, 2005). The use of NSOMTs is an abiding issue within the profession, and practitioners must be mindful of the fact that they are responsible for implementing intervention approaches that meet the needs of the client within a process of evidence-based practice (Baker & McLeod, 2004; Clark, 2005; Justice & Fey, 2004; Mullen, 2005) and ethical responsibility (Bowen, 2005; Lass et al., 2004). The purpose of this article is to provide a discussion of three specific topics. First, a definition of NSOMTs and a description of NSOMT techniques and their intended purposes are presented. Second, the theoretical underpinnings of NSOMTs along with the implications of the theories on professional practice are discussed. Finally, a literature review of relevant NSOMT studies is presented.

DEFINITION OF NSOMTs

Early speech texts describe NSOMT methods such as blowing small objects to develop an oral breath stream and engaging in other nonspeech activities to improve muscle strength and coordination for the development of correct sound production skills (Morley, 1967; Ward, 1931). However, contemporary NSOMT methods encompass a more extensive range of activities than initially conceptualized. Hodge (2002) indicated that NSOMTs are a collection of stimulation techniques and procedures that are designed to influence the resting posture and/or movement of the lips, jaw, and tongue. Other researchers assert that NSOMTs include specific nonspeech exercises to (a) increase strength and improve muscle tone and range of motion (ROM) (Boshart, 1998; Clark, 2005; Marshalla, 2004); (b) modify tongue, lip, and jaw resting postures (Hanson, 1994); and (c) improve muscular control and function through sensory stimulation (Clark, 2003). NSOMT techniques and procedures available to practitioners consist of activities such as blowing, blowing horns, repetitive exercise of different muscle groups such as spreading and rounding the lips, resistance exercises like opening and closing the jaw under tension, clinician-assisted movement of articulators, and sensory stimulation such as applying vibration to the lips or tongue. Proponents of NSOMTs indicate that the different techniques and procedures are effective change agents for speech (Ray, 2003), oral myofunctional (Hanson, 1994), and feeding disorders (Gisel, Applegate-Ferrante, Benson, & Bosma, 1996; Morris & Klein, 1987); however, our discussion is directed to children with developmental speech sound disorders.

NSOMT Techniques and Their Purposes

Clark (2003) indicated that NSOMTs consist of a broad range of therapeutic activities that can be categorized as (a) active muscle

exercise, (b) passive muscle exercise, and (c) sensory stimulation (see Table 1). The foundation of the therapeutic activities is based on principles of muscle facilitation and inhibition proposed by physical and occupational therapists such as Bobath, Brunnstrom, and Rood, and Knott and Voss, as cited in Prentice (2002). For instance, some professionals use techniques known as proprioceptive neuromuscular facilitation (PNF), which is based on a theory of muscle movement and control that was proposed by Knott and Voss (1968).

Active exercise. Active muscle exercise is probably the most commonly used intervention technique, and one that most practitioners of NSOMTs employ for children with developmental speech sound disorders. The two major categories of active exercise are strength training and stretching. Strength is the capacity of a muscle to produce adequate tension for both posture and movement (Smidt & Rogers, 1982). It is a composite of the properties of the muscle, the appropriate firing of motor units, and the timing of motor unit activation (Shumway-Cook & Woollacott, 1995). Strength training is employed in cases of muscle weakness and would presumably be a preparatory activity that is used before the introduction of specific motor skill-learning activities (Frontera & Lexell, 2005). That is, the muscle or muscle group needs to reach a certain level of functional performance before a skill-learning activity such as sound placement is introduced.

Strength training. Strength training programs may use isotonic or isometric muscle exercises. *Isotonic* exercise movements result in changes of muscle length with muscle tension remaining relatively constant; *isometric* exercise movements are designed to create muscular tension without changing muscle length appreciably (Clark, 2005). For example, an isotonic exercise such as *lip pops* might be used to improve lip strength. In this exercise, the client is instructed to bring the lips together and then open the lips forcefully while making a popping sound. The purpose is to overload the muscles beyond their normal operating levels, just as an individual engages in weight training through the application of progressive resistance (Tomes, Kuehn, & Peterson-Falzone, 2004). The exercise is practiced under a designated number of training trials across a specified period of treatment while increasing resistance to movement (Pinet, 1998). An example of an isometric exercise is having the client hold a tongue depressor between the lips for a specified period of time with both time and number of trials manipulated. The exercise creates muscular tension without altering muscle length significantly.

Pinet pointed out that a majority of functional activities necessitate a combination of different muscle contractions, so strength training should incorporate a variety of activities that target a specific muscle or muscle group in relation to the target or desired motor skill function. That is, exercise activities should be specific to the goal of the strength training program (Barnes, Roberts, Mirrett, Sideris, & Misenheimer, 2006; Clark, 2003; Weismer, 1997, 2006). Accordingly, if we wished to strengthen an articulator for speech production, the strength training should be in conjunction with a speech task, not just in building strength with activities that are only tangentially related to the desired outcome (Kuehn, 1991, 1997).

At a physiological level, strength training targets force, endurance, and power (Shumway-Cook & Woollacott, 1995). When a muscle contracts, it generates force or tension, and strength training is designed to increase muscle tension. Kisner and Colby (1990) pointed out that active exercise also targets endurance, which is the amount of force that can be maintained over a period of time. Finally, active exercise is also conducted for the purpose of developing power, the speed with which force is generated. The active practice or exercise must be carried out at physiologic levels, which tax the muscle, so that it exceeds its typical operating levels. The neuromuscular result of a successful rehabilitation program is hypertrophy of muscle fibers and collective recruitment of additional motor units (Duffy, 2005; Hodge, 2002).

Stretching. Stretching is the movement of a muscle or muscle group outside of its typical operating range. A corollary to stretching is ROM, wherein a muscle or muscle group is moved through its complete range of expected movement, not beyond the range. Stretching exercises are employed to either increase or decrease muscle tone. Muscle tone is the stiffness of a muscle or its resistance to changes in length, and it is mediated by sensory receptors that are located in the muscles (Shumway-Cook & Woollacott, 1995). Important sensory receptors present in striated muscle are known as muscle spindles, and they are sensitive to both changes in muscle length and the speed of change (Shelton, 1989). The muscle spindle information is used at different levels of the peripheral and central nervous systems, which include reflexive behavior and higher level central nervous system functions that mediate motor control. Duffy (1995) wrote that tone is a sustained feature of normal muscles because they are continually in a ready state for movement. Muscle tone is the structural scaffold for the execution of skilled motor

Table 1. Nonspeech oral motor treatments (NSOMTs) used to treat speech, oral myofunctional, and feeding disorders.

Procedure	Problem	Type of NSOMT
Active exercise		
Strength training	Muscle weakness	Overload muscles above normal operating levels, generally using resistance exercises
Isotonic exercise		
Isometric exercise		
Stretching	Muscle tone	Quick stretching increases muscle tone; slow stretching decreases muscle tone
Passive exercise	Muscle tone, joint flexibility, circulation, sensory input	Assisted movement of muscle or muscle group
Sensory stimulation		
Massage	Relaxation of muscles, muscle tone	Stroking muscles; tapping muscles
Vibration	Stimulate or inhibit muscle activity	Low or high frequency vibration
Temperature	Muscle tone, muscle spasm, sensory deficits, edema, swelling	Apply heat or cold
Electrical stimulation	Muscle movement	Apply low-level electrical voltage

movement patterns. Disorders of muscle tone may range from flaccidity or complete loss of muscle tone to spasticity, which manifests in increased muscle tone. In either case, tone disorders result in weakness, which adversely affects the execution of skilled movement.

Clark (2003) pointed out that stretching can be carried out by either the client (active stretching) or the practitioner (passive stretching). During active stretch exercises, muscle fibers may be subject to quick stretching or slow stretching. Quick stretching results in an increase in muscle tone; slow stretching results in an inhibition of the stretch reflex and a corresponding decrease in muscle tone (O'Sullivan, 1988). Duffy (1995) suggested that active stretching may have some benefit in reducing spasticity of the articulators when engaging in exercises such as prolonging maximum tongue protrusion, lip retraction, or jaw opening. Clark (2005) cautioned that stretching activities are based on research regarding the limb muscles, not the oral musculature. It is to be noted that the muscle spindle density of the limbs and the distribution of spindles in the oral musculature differ with the exception of the jaw elevator muscles (Clark, 2003). The jaw elevator muscles show similar density patterns to the limb muscles and exhibit a stretch reflex. They could potentially be responsive to active stretching activities, but it is doubtful that the other articulators such as the lips and tongue would respond to a treatment program of active stretch.

Passive exercise. Passive exercise is the movement of a muscle or muscle group with assistance by a clinician or through the use of exercise machines (Pinet, 1998). Passive exercise includes passive range of motion (PROM) and passive stretch. The purpose of passive exercise is not to build muscle strength, but to maintain joint flexibility and soft tissue integrity, enhance vascular circulation, facilitate sensory input to a muscle or muscle group, and possibly modify tone (Pinet, 1998). The SLP may assist the client partially or provide complete assistance in executing the desired ROM. PROM exercises are typically employed with clients who cannot actively exercise because of severe hyper- or hypotonicity. It is hypothesized that a slow passive stretch acts to reduce the stretch reflex (Kisner & Colby, 1990). This would seemingly be appropriate in cases of hypertonicity because the goal is to reduce excessive muscle tone. Conversely, a passive quick stretch is designed to stimulate muscle spindles, thereby increasing muscle tone. The caveat in this discussion is the same as that presented for active stretching. That is, the distribution of muscle spindles in the oral musculature differs from that of the limbs; consequently, the same treatment principles of muscle spindle activation or deactivation may only apply to the jaw elevator muscles (Clark, 2003).

Sensory stimulation. The final category of NSOMTs consists of different sensory stimulation agents that are applied to improve or stimulate muscle function. This form of NSOMT is employed with children who have developmental sound system disorders, but it has been used primarily with children with sound system disorders of known etiology such as structural-based disorders (Ruscello, 2004; Tomes et al., 2004) and motor speech disorders (Chapman-Bahr, 2001; Yorkston et al., 2001). Typically, sensory agents include the use of massage, vibration, temperature (hot/cold), and electrical stimulation. The different types of input are sensed by a variety of mechanoreceptors, proprioceptors, nociceptors, and thermoreceptors that are responsive to alterations in muscle length and accompanying rate of change in length, muscle tension, joint position, vibration, deep pressure stimulation, skin pressure, two-point discrimination, pain, temperature, and touch (Shelton,

1989). The incoming sensory or afferent information is processed at different levels of the nervous system, and there is a response by the efferent or motor system. The sensory agents have different effects on the muscle system such as relaxation, movement or increased range of movement, increased tone, and/or reduction in tone.

Massage. Clark (2003) indicated that massage may take the form of stroking muscles or tapping muscles. Stroking muscles is carried out for the purpose of reducing muscle tension and creating a state of emotional relaxation. Engel (1998) wrote that massage consists of stroking, kneading, and rubbing muscles in preparation for active exercise so that functional performance might be enhanced. The sensory stimulation facilitates muscle relaxation and improves local blood flow, pain relief, and muscle suppleness. Massage is not a strength-building technique, nor will it inhibit muscle wasting or hypotonicity (Clark, 2003).

Tapping muscles is conducted to stimulate the muscle spindle, thus increasing muscle tone (O'Sullivan, 1988). It is done by striking the belly of the intended muscle with the fingertips during active muscle contraction. Some express the position that tapping lacks specificity in targeting specific muscles and is not an effective procedure for improving muscle control (Dutton, 1998). Moreover, brisk tapping may conduct along adjoining bone and stimulate additional muscles that are not targeted. Tapping does not appear to be an appropriate technique for the oral musculature because of the neurophysiological difference between the limbs and the speech articulators with respect to muscle spindle distribution (Clark, 2003).

Vibration. Vibration is another form of sensory stimulation that is employed in muscular rehabilitation. The frequency of vibration will either facilitate or inhibit muscle activity (Bishop, 1974, 1975): High-frequency vibration stimulates muscle activity; low-frequency vibration inhibits muscle activity. Clark (2003) pointed out that high-frequency vibration is used to elicit a tonic vibratory response, a reflex contraction that is the result of muscle spindle stimulation. In addition, there is an accompanying decrease in muscle tone of the antagonist muscle through reciprocal inhibition. Thus, vibration acts to enhance the tone of the agonist and reduce the tone of the antagonist. Its use as a treatment for speech sound disorders is subject to the same reservations as other NSOMTs that attempt to stimulate muscle spindles. In addition, there are a number of reservations regarding placement site, age of client, and type of client diagnosis that contraindicate the use of vibration (Clark, 2003).

Temperature. Superficial heat is applied to muscles to reduce muscle spasm and spasticity. It is also used in cases of bursitis and tendonitis, but should be avoided when there is edema, swelling, or damage to tissue (Lee, Itoh, Yang, & Eason, 1990). The application of heat has not been used extensively with the speech musculature; however, cold has been used quite frequently in the treatment of persons with neuromuscular disorders (Hall, 2001). Johnson and Scott (1993) reported that icing procedures may be used with different populations that include persons with cerebral palsy, acquired neurological insult such as stroke, and progressive neurological disease like multiple sclerosis. It has been reported that cold acts to reduce spasticity in muscles because it decreases nerve conduction speeds (Clark, 2003). Shumway-Cook and Woollacott (1995) stated that quick icing of a muscle can facilitate muscle activity, and it may also reduce muscle spasm. Cold is also used to reduce edema, swelling, and damage to tissue (Engel, 1998). Cold in combination with tactile stimulation has been used regularly in speech-language pathology as a stimulating agent to improve the speed in triggering

the pharyngeal swallow (see Logemann, 1998; Sciortino, Liss, Case, Gerritsen, & Katz, 2003).

Electrical stimulation. Electrical stimulation is used in a number of applications for muscular problems, but this type of stimulation does not have an extensive history in the speech pathology literature (Clark, 2003). Humbert and Ludlow (2004) indicated that electrical stimulation can be applied to the skin or directly to muscles via electrodes that are inserted into muscle fibers. When applied to the skin with surface electrodes, electrical stimulation will activate sensory receptors and muscles just below the skin tissue. Most applications of electrical stimulation involve intramuscular stimulation, with the stimulation controlled by the client or automatically delivered. Electrical stimulation is used frequently in combination with other muscle rehabilitation techniques (Pape & Chipman, 2005).

In her seminal work on NSOMTs, Clark (2003) indicated that low-level electrical voltage is applied to muscles for the purpose of stimulating muscle contractions. She pointed out that the physiological effect of electrical stimulation on various muscle fibers differs from the activation pattern that is found during purposeful exercise. Furthermore, literature is cited that shows that electrical stimulation is most effective when it is used in combination with strength training and/or functional muscular activities. Current application of electrical stimulation is being used for the treatment of dysphagia (Freed, Freed, Chatburn, & Christian, 2001; Park, O'Neill & Martin, 1997), but the effectiveness of the procedure has not been established at this time (Humbert & Ludlow, 2004).

THEORETICAL MODELS OF NSOMTs

Batavia (2001) wrote that a theory is an explanation of how something functions, and it enables us to make future predictions that can be tested. For example, if a clinician develops a treatment, the underlying theoretical explanation of the treatment will be used to predict individuals who might respond to future applications of the treatment. Collecting performance data from clients enables the clinician to support, refute, or modify the theory (Lum, 2002). Schultz (1972) pointed out that any mainstream treatment is based on a theory that provides both direction and limits, despite the fact that in some cases, practitioners are unaware of the underlying theory. Nevertheless, when a practitioner employs a specific treatment, there is an implicit acceptance of the theory underlying the treatment (Friel-Patti, 1994; Schwartz, 1992; Shuster, 2005). Proponents of NSOMTs espouse two different theoretical rationales to explain their treatment programs. One rationale is from the occupational and physical therapy literature (Marshalla, 1985; Ottenbacher, Bundy, & Short, 1983); the other is from the speech literature (Forrest, 2002).

Some SLPs employ NSOMTs from the occupational and physical therapy literature that are based on the theoretical concepts of Rood (Rood approach), Bobath (neurodevelopmental treatment), Brunnstrom (movement therapy), and Voss (proprioceptive neuromuscular facilitation) (Levit, 1995; Myers, 1995; Trombly, 1995a, 1995b), whereas others use sensory integration therapy as a theoretical model (Baloueff, 1998; Bigsby, 1998; Chapman Bahr, 2001; Griffer, 1999; Mauer, 1999). For example, neurodevelopmental treatment was developed by Berta and Karel Bobath, who were occupational therapists and worked primarily with children who had cerebral palsy or cerebral vascular accidents (Levit, 1995).

According to their theory, individuals have programs or templates for normal movement patterns that are programmed in the central nervous system. When there is neurological damage, the programmed movement patterns are inhibited by abnormal patterns of tone or reflex behavior. Neurodevelopmental treatment aims to reduce the reflex and tone disorders in order to facilitate emergence of the normal movement pattern templates.

Current research and theory development in occupational and physical therapy questions many of the assumptions that underlie NSOMTs ("Remediating Motor Control," 1995). One central assumption of the theories is that incoming sensory information is a major component in facilitating motor movement patterns; however, contemporary research indicates that movement is a more complex process than simply afferent input and efferent output to achieve an intended muscle movement. Experiments have shown that when a person is instructed to execute a movement activity goal, cortical activity often begins before the movement and any sensory information that is generated from the movement. In addition, it has been found that muscle contractions sometimes occur before the initiation of a movement and that different muscles and muscle groups show diverse activation patterns for achieving the same goal under different response conditions. These data cannot be explained by any of the theories that were discussed earlier. In fairness to the theories, it should be pointed out that they were based on earlier study methods, and the resultant data were obtained without modern technology that now allows movement study with conscious, alert humans and animals.

Another limitation is that the theories are based on a hierarchical model of child development (Neistadt & Crepeau,1998; "Remediating Motor Control," 1995). That is, development is a sequential, predictable process that evolves as a function of central nervous system maturation. Cortical structures control lower level brain centers, which in turn control other lower centers. Current research, however, suggests that motor development is a complex process that is dependent on interactions among the child's biology, environment, and culture. Movement and the development of movement are influenced by a number of variables, not just neural maturation that was purported to evolve in a specific sequence for all humans. It is now known that motor development is much more varied among individuals (Neistadt & Crepeau, 1998; "Remediating Motor Control," 1995). For example, some children do not creep but begin to walk without ever creeping, which suggests that creeping is not a requisite motor behavior that must be achieved before walking.

Some practitioners in the speech literature suggest that there is a strong link between speech and nonspeech functions. That is, researchers speculate that speech and vegetative nonspeech functions share coordinative components (Chapman Bahr, 2001). Consequently, nonspeech activities such as chewing and sucking form a foundation for the emergence of speech skills (Moore & Ruark, 1996; Ruark & Moore, 1997). A number of well-controlled studies have been conducted, and the research does not support the hypothesis that the two systems share coordinative motor control strategies when individual articulators and the coordinated activity of articulators are studied (Bunton & Weismer, 1994; Connaghan, Moore, & Higashakawa, 2004; Moore, 1993; Moore, Caulfield, & Green, 2001; Moore & Ruark, 1996; Moore, Smith, & Ringel, 1988; Ruark & Moore, 1997; Wohlert & Goffman, 1994). For example, Ruark and Moore studied the lip movements of toddlers who engaged in both speech and nonspeech tasks. Electromyographic data from the upper and lower lips were obtained from a group of 7 normally

developing toddlers with a mean age of 26 months. Analysis of the data showed different patterns of lip muscle activity for the speech and nonspeech tasks. Ruark and Moore indicated that there does not appear to be a coordinative sharing of motor control. That is, the results suggest that different motor control mechanisms underlie speech and nonspeech behavior.

A REVIEW OF THE NSOMT LITERATURE

The claim of a relationship between speech and nonspeech behaviors has spurred a great deal of research into coexisting variables for more than 6 decades, but there is a limited number of experimental studies (Becky, 1942; Bilto, 1941; Shelton, Arndt, Krueger, & Huffman, 1966), as noted in current and past reviews of the literature (Bernthal & Bankson, 2004; Bosma, 1967; Winitz, 1969). For instance, Palmer and Osborn (1940) developed a ball-shaped device that inserts in the mouth and measures tongue pressure. In their experiment, participants pressed the ball with their tongues and exerted maximum pressure, which was displayed on a manometer. Their findings indicated that normal speakers generated slightly higher pressures than did speakers with speech sound disorders. Their interpretation of the results was that speakers with speech sound disorders have lingual muscle weakness, which needs to be remediated. Palmer and Osborn further stated that strength was a key factor in developing muscular speed and precision, which they indicated were requisites to normal speech production. A more contemporary study conducted by Dworkin and Culatta (1980) examined lingual strength in a group of normal speakers, a group of normal speakers with open bites and tongue thrust, and a group of lispers who also had open bites and tongue thrust. Measurement of static tongue strength did not differ significantly among groups, and the authors concluded that tongue strengthening exercises are not warranted to correct frontal lisping.

The previous studies reflect the explicit experimental search under the medical model for causal agents to explain developmental speech sound disorders. Our early literature is replete with references to NSOMTs as interventions for individuals with communication disorders, particularly speech sound disorders of known and unknown etiologies (Brown, 1947; Froeschels, 1943; Kanter, 1947; Ward, 1931). At that time, there was a major focus on identifying causal factors, and limited attention was directed to the conduct of treatment studies. Consequently, many treatments and treatment techniques that incorporated NSOMTs were based on rationale(s), which were intuitively appealing to practitioners but were generally authoritarian statements that lacked scientific rigor (Finn, Bothe, & Bramlett, 2005; Hixon & Hardy, 1964).

The first series of NSOMT studies to be summarized examined participants who had developmental speech sound disorders or residual errors and a coexisting oral myofunctional problem such as tongue thrust. For example, Overstake (1976) studied a group of 76 children who had tongue thrust, interdental lisps, and related problems with dental occlusion. Participants were assigned to one of two treatment groups. One group received treatment for tongue thrust; the other group received a combination of tongue thrust and speech sound treatment. A total of 48 participants completed the treatments, which were administered over a 9-month period. The data indicated that both groups improved their /s/ articulations; as a result, the author concluded that tongue thrust treatment was just as successful as a combination of tongue thrust and speech treatment for improving /s/ production.

Christensen and Hanson (1981) identified 10 children who had /s, z/ errors and concomitant tongue thrust. The children were randomly assigned to one of two treatment groups. One group received speech sound treatment; the other received a combination of tongue thrust therapy and speech treatment. The results indicated that both groups improved /s, z/ productions, but the group receiving both tongue thrust therapy and speech treatment also demonstrated improvement in swallowing. The findings support the position that different treatments are necessary for presenting speech sound and nonspeech oral myofunctional problems. Similarly, a single-subject study conducted by Gommerman and Hodge (1995) examined the effectiveness of tongue thrust therapy and speech therapy. The participant was a 16-year-old female who had a tongue thrust and minor sibilant distortion. The first treatment condition consisted exclusively of tongue thrust therapy, and probe measures indicated that the participant improved swallowing skills, but there was no corresponding improvement in sibilant production. Following the tongue thrust therapy, speech sound treatment was initiated, and improvement in sibilant production was found. Posttreatment measures taken 6 months after the treatments showed that correct swallowing pattern and sibilant production were maintained.

Ray (2003) provided tongue thrust treatment to 6 adults who also had residual speech sound errors. The residual errors appeared to be a function of different dental/occlusal problems presented by the adults. The investigator claimed that resting tongue and lip posture and articulation improved as a result of the tongue thrust therapy despite the dental/occlusal problems. Skinder-Meredith and Lentz (2004) examined the efficacy of an oral motor exercise device with a 7-year-old who had both speech sound errors and a tongue thrust. The device consisted of a plastic cylinder with three different diameter sizes and an extended holding piece. The cylinder was positioned against the client's incisors, and the client's lips were sealed around the cylinder while held in place by the client. The client sucked on the cylinder for a specified time and number of trials. The investigators studied the client in a single-subject design (ABA); there were two sessions per week for 8 weeks. Speech treatment for /r/ was carried out for the entire treatment period, and /s/ served as a control sound. Following the third treatment session, the client began to use the oral motor exerciser in supplement to the speech sound therapy and discontinued use on the 12th treatment session. Statistical analysis of probe measures showed that use of the device resulted in slight improvement of /r/ productions, but there was no change in the untreated /s/. There was no information regarding the status and measurement of tongue thrust.

The second series of articles examined the use of NSOMTs as a facilitating agent for treating children with speech sound disorders. Colone and Forrest (2000) studied 2 children who were monozygotic twins with similar residual error patterns. One of the twins received NSOMT; the other received direct treatment of speech sound errors. Each participant was administered the treatment over seven sessions. Evaluative data indicated a positive change in sound production skills for the twin who received speech treatment. The twin who received NSOMT did not show improvement in sound production skills. After the initial NSOMT, direct treatment of speech sound errors was instituted for the twin and a positive change in speech was found.

A study by Occhino and McCann (2001) examined the effects of oral motor exercises on the speech sound production skills of a

youngster who had been diagnosed with pervasive developmental disorder. NSOMTs were used exclusively during the initial phase of management, and then just before sound production treatment at the second phase of treatment. The results of the investigation indicated that NSOMTs did not influence speech sound production skills positively. In a similar vein, a case study conducted by Abrahamsen and Flack (2002) examined the merit of NSOMTs in modifying the speech sound skills of a preschool youngster with suspected childhood apraxia of speech (CAS). The child underwent a regimen of NSOMTs techniques such as blowing and oral sensory stimulation for a period of 10 hr. The results indicated that NSOMTs were not successful in changing the child's speech sound production skills.

An investigation conducted by Polmanteer and Fields (2002) compared a combination of NSOMTs and speech treatment with exclusive speech treatment. Eight participants were randomly assigned to one of two groups. One group of 4 participants received the combination treatment that included NSOMTs and treatment of different speech sound errors. The other group of 4 participants received speech treatment only. The speech treatment for participants in either group varied as a function of the clinician and was either phonetic or phonemic based. All participants were seen for 6 weeks and received two 30-min individual sessions per week. The authors reported that the participants who received the combination of NSOMTs and speech treatment demonstrated higher speech improvement scores at posttesting.

The final study was carried out by Guisti Braislin and Cascella (2005), who investigated the efficacy of oral motor exercises with a group of children who presented with mild speech sound disorders. The 4 participants received the treatment across 7 weeks. Each child was enrolled for two 30-min sessions per week and underwent a sequence of NSOMT exercises that were taken from the work of Strode and Chamberlain (1997). According to the researchers, the exercises were purported to improve the children's oral strength and muscle tone. There was no direct treatment of speech sound production skills. A comparison of participants' scores on a standardized test of speech sound production indicated no difference between pre- and posttreatment performance.

DISCUSSION

Consideration of Use of NSOMTs

NSOMT activities encompass active exercise, passive exercise, and sensory stimulation. They are employed to increase strength, improve muscle tone, facilitate muscle relaxation and contraction, reduce inflammation, increase joint flexibility, and improve circulation. Active exercise is used most frequently in the population of children with developmental speech sound disorders. Different exercise activities and devices (Boshart, 1998; Chapman Bahr, 2001; Marshalla, 2001) are used to build strength and/or improve muscle tone. For instance, Marshalla (2004) recommended a number of NSOMT exercises for improving muscle strength and tone before the introduction of speech sound treatment. One such lingual exercise is pushing against the tongue with a tongue depressor, holding the position for 1 to 5 s, and asking the client to "feel" introspectively the tension that is created by the pushing exercise. This particular activity has the elements of an isometric task coupled with having the

client consciously monitor the sensory information that is created by the tension of the tongue pushing against the depressor. However, there are certain reservations that the reader must keep in mind when considering the use of NSOMTs.

First and foremost is that employing NSOMTs with children who have developmental speech sound disorders implies that the children have underlying neuromuscular deficits such as weakness that require treatment before or concomitant with speech sound treatment (Bauman-Waengler, 2004; Gierut, 1998; Lowe, 1994; Ruscello, 1993; Rvachew, 2005; Smit, 2004; Williams, 2003). This notion of a muscle deficit hypothesis has spurred a great deal of research over the years in general motor skills, oral motor skills, and sensory processes thought to underlie general body and oral mechanism processes in children with developmental speech sound disorders (Bernthal & Bankson, 2004; Shriberg, Kwiatkowski, Best, Hengst, & Terselic-Weber, 1986; Williamson, McDade, & Montgomery, 2001; Winitz, 1969). However, overall research findings do not support a muscle deficit hypothesis in the population of children with developmental speech sound disorders (see Shriberg & Kwiatkowski, 1994).

It should be noted that childhood speech disorders caused by neuromuscular deficits by definition are diagnosed as dysarthria and need to be treated accordingly (Caruso & Strand, 1999; Crary, 1993). For example, a child who presents with muscle weakness of the soft palate might be a candidate for a strength training program if the clinician determines through assessment that muscle weakness is present. The goals of a therapeutic exercise program at the neurophysiologic level are muscle hypertrophy and recruitment of additional motor units so that palatal movement is enhanced. The desired perceptual result of such a program is a reduction or elimination of nasal emission (speech sound disorder) and hypernasality (resonance disorder). The child may benefit from the strength building program; however, the reader must be mindful of the fact that the client has a motor speech disorder, not a developmental speech sound disorder.

A second reservation and proviso to the discussion is that treatment tasks should be specific to the intended outcome. Weismer (1997) indicated that motor control principles are task specific, and treatment should be consistent with the intended outcome. If the goal is to improve speech production skills, as in the case cited above, the clinician needs to introduce a strength-building task that is specific to the intended goal (Haugen & Mathiowetz, 1995; Hoffman, Sheldahl, & Kraemer, 2005; Lof, 2003; Pehoski, 1995; Weismer, 2006). For instance, in the case of palatal weakness, continuous positive airway pressure (CPAP) is an example of a muscle exercise program that allows delivery of a resistance load to the palate while the client is practicing speech (Kuehn 1991, 1997). The resistance is provided by introducing increased air pressure to the nasal cavity via the CPAP instrumentation. The increased pressure forces the palate to work against a resistance that can be manipulated during speech practice to target muscle strength and endurance.

A final concern is that the muscle spindle distribution of the articulators with the exception of the jaw elevator muscles (masseter, temporalis, and medial pterygoid muscles) differs from that of the limbs (Clark, 2003). The dissimilarity in spindle density suggests that there will be differences in response to therapeutic activities such as stretching and the use of various stimulation agents. Consequently, therapeutic techniques such as stretching muscles and applying stimulation such as massage, tapping, vibration, and cold

may not have the same results as those found in the limbs and jaw elevator muscles.

Theoretical Reservations of NSOMTs

Theoretical explanations of NSOMTs were developed in the occupational therapy, physical therapy, and speech-language pathology professions, and practitioners must realize that using a specific therapy approach implies acceptance of the theory underlying the treatment (Schultz, 1972). Levit (1995) pointed out that the different theories of limb control were not subject to rigorous study; consequently, there is limited empirical data to support any of them. Moreover, NSOMT theories formulated by researchers in occupational and physical therapy were based on the state-of-the-art research findings and clinical observations at that time; however, the theories have been challenged in light of new data ("Remediating Motor Control," 1995). Advances in technology allow researchers to investigate movement and movement control in ways that could not be done previously. Another important reservation is that the different theories embraced a hierarchical model of child development, which is not consistent with recent findings in motor development research (Neistadt & Crepeau, 1998).

It has also been advanced in the speech-language pathology literature that speech and nonspeech functions share coordinative components, and nonspeech movements form a basis for the development of speech production skills (Moore & Ruark, 1996). However, a series of investigations examined the physiology of speech and nonspeech movements, and the conclusion was that they do not share coordinative control strategies (Bunton & Weismer, 1994; Moore, 1993; Moore et al., 1988; Wohlert & Goffman, 1994); thereby rejecting the hypothesis that the two systems share motor control strategies. The limitations that were identified in the professional literatures of occupational therapy, physical therapy, and speech-language pathology contraindicate the use of NSOMTs to improve speech sound production skills.

NSOMT Literature

The NSOMT studies summarized herein are indicative of the limited literature base that supports NSOMTs as a valid mainstream treatment. Moreover, many of the investigations lack appropriate experimental control and have not been subject to rigorous peer review. Although NSOMTs have been a recommended treatment since the profession began to develop a knowledge base,

there is a very limited number of investigations that have studied the effectiveness of NSOMTs with children who present with developmental speech sound disorders (Kamhi, 2006). The results of a majority of the studies support the fact that NSOMTs do not facilitate the acquisition of speech sound skills.

The paucity of NSOMT studies is in contrast to the abundance of speech sound disorder treatment investigations, which include descriptive, clinical, and experimental manipulation of treatment variables. An exhaustive review by Gierut (1998) identified 64 different studies that were published in the American Speech-Language-Hearing Association (ASHA) journals between 1980 and 1995. The author concluded that treatment efficacy was indeed demonstrated across the studies. Dependent variable measures have consistently shown positive changes "in improving speech intelligibility and in bridging the gap between the sound system of the child and that of the target phonology" (Gierut, 1998, p. S89). It is quite clear that the preponderance of research evidence supports direct speech treatment, not NSOMTs, as an effective change agent for clients with developmental speech sound disorders.

SUMMARY AND CONCLUSIONS

An extensive review of the literature is presented, and the conclusion is that there is no credible evidence to support NSOMTs as therapies for developmental speech sound disorders (see Table 2). This conclusion is also consistent with reviews that were undertaken for other communication disorders (Shuster, 2001; Yorkston et al., 2001). SLPs need to select treatments for their clients that have been subject to empirical scrutiny (Finn et al., 2005). Evidence-based practice provides a methodology for this process because it encompasses the components that are requisite to selecting a treatment that is appropriate and grounded in some degree of scientific rigor (Baker & McLeod, 2004; Clark, 2005; Justice & Fey, 2004: Lass et al., 2004; Lass & Pannbacker, 2008; Mullen, 2005). It also provides a process for the SLP to collect client response data and make objective treatment decisions (see Baker & McLeod, 2004; Olswang & Bain, 1994).

Finally, the development of new technologies and study methods has enabled the profession to study and quantify important speech (Barlow & Bradford, 1992; Kuehn & Moon, 2000) and nonspeech muscle performance variables (Folkins et al., 1995; Luschei, 1991; Robbins et al., 2008; Robin, Somodi, & Luschei, 1991; Sapienza & Wheeler, 2006; Solomon, 2000; Solomon & Munson, 2004),

Table 2. A summary of factors that contraindicate the use of NSOMTs with children who have developmental speech sound disorders.

- Current research has not identified oral or general muscle deficits in the population of children with developmental speech sound disorders.
- The oral musculature (with the exception of the jaw-closing muscles) differs with respect to muscles of the limbs.
- NSOMTs violate the principal of task specificity. Treatment tasks should be related to the goal of the learning task.
- Theories adopted from other professions are not adequate explanatory models due to limitations in research technology, current knowledge of motor development, and limited supporting research.
- Researchers in the speech and hearing sciences have systematically studied speech and nonspeech behaviors and have not identified a direct motor control link.
- There is a limited amount of NSOMT treatment research and the results are equivocal.
- The speech-language pathology literature contains numerous studies that support phonetic/phonemic treatments for children with developmental speech sound disorders.

which have implications in both theoretical and applied research. These findings add to our knowledge base; provide evidence to accept, refute, or modify current theories of speech production and nonspeech behavior; and improve our ability to treat clients with communication and swallowing disorders. Although future research may dispute the current findings or cause them to be modified, contemporary theory and empirical data do not support NSOMTs as interventions for children with developmental speech sound disorders.

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