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Children with Down syndrome improved in motor functioning and muscle tone following massage therapy

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Twenty-one moderate to high functioning young children (mean age, two years) with Down syndrome receiving early intervention (physical therapy, occupational therapy and speech therapy) were randomly assigned to additionally receive two 0.5-hour massage therapy or reading sessions (control group) per week for two months. On the first and last day of the study, the children's functioning levels were assessed using the Developmental Programming for Infants and Young Children scale, and muscle tone was assessed using a new preliminary scale (the Arms, Legs and Trunk Muscle Tone Score). Children in the massage therapy group revealed greater gains in fine and gross motor functioning and less severe limb hypotonicity when compared with the children in the reading/control group. These findings suggest that the addition of massage therapy to an early intervention program may enhance motor functioning and increase muscle tone for children with Down syndrome.

Keywords: *Down syndrome; Massage therapy; Early intervention; Muscle tone; Fine motor; Gross motor; Motor functioning; Hypotonic*

Introduction

Down syndrome, a genetic condition affecting one in about 800 children born in the United States (National Institutes of Child Health and Human Development, 1997), is characterized by cognitive deficits (Nichols *et al.*, 2003; Seung & Chapman, 2004),

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speech problems (Kennedy & Flynn, 2002; Laws & Bishop, 2003), and motor and perceptual developmental problems (John *et al.*, 2004; Kearney & Gentile, 2003). Children with Down syndrome also frequently present with decreased muscle tone or hypotonia (Bodensteiner *et al.*, 2003; Martin, 2004).

The focus of this paper is on massage therapy, a treatment that is not typically prescribed for children with motor problems but based on recent research findings for other children may enhance development for children with Down syndrome, such as improve muscle tone and motor development. Physical exercise and activity have been shown to increase muscle strength and motor skills in typically developing children (Faigenbaum *et al.*, 2002) and children with physical disabilities (Wang & Ju, 2002; Dodd *et al.*, 2003). One possible explanation for the benefits is that exercise provides atypically developing children with the experience of normal movement, which might lead to quicker attainment of milestone skills (Horn *et al.*, 1995; Ulrich *et al.*, 2001). In one study, for example, motor training that focused on stimulating trunk rotation, increasing muscle tone, reducing atypical movement and increasing typical movement patterns improved gross and fine motor skills, kinesthetic and tactile perception (Bjornhage *et al.*, 1990). However, because the measures were not well defined in that study nor were precautions taken against experimenter bias, the internal validity of the study and their interpretations are questionable (Spiker & Hopmann, 1997). A randomized controlled trial that examined strength-training of young children and adolescents with cerebral palsy, however, revealed increased lower limb strength and improved scores on gross motor function for children with cerebral palsy (Dodd *et al.*, 2003).

Although studies have shown that physical therapy (PT), occupational therapy (OT) and developmental stimulation programs (or early interventions) attenuate symptoms for children with disabilities (Baumrind, 1993; Jackson, 1993), the results are not consistently supported (Roizen, 2001). For example, in a review of 21 studies on children with Down syndrome, Gibson and Harris (1988) reported that data were insufficient to conclude that providing early interventions led to better outcomes than having children receiving good caregiving at home. However, other meta-analyses have revealed small (Ottenbacher *et al.*, 1986; Turnbull, 1993) to moderate (Shonkoff & Hauser-Cram, 1987) treatment effects from early intervention programs. A more recent study reported improvements in children with Down syndrome following three months of sensory integrative therapy (puzzles, block design, body awareness, tactile perception, visual-motor coordination) with and without vestibular stimulation (linear swinging, therapy ball activities, balance on stairs and ramps) or following three months of neurodevelopmental therapy (scooter board games, obstacle crawl, walking activities and fine motor activities) (Uyanik *et al.*, 2003). However, in that study, no control group was included to examine maturation effects that might have occurred over the span of the three-month study.

In an excellent review of early intervention for children with motor disabilities, Harris (1997) reveals the importance of therapeutic exercise for developing normal movement patterns. Although parents may be trained to deliver therapeutic exercises, it is difficult to monitor their consistent delivery of interventions at home. Moreover,

although physical exercise is important for motor development, it is not well tolerated by children with Down syndrome, perhaps because of their low muscle tone (Pastore *et al.*, 2000) and, more importantly, may pose health risks for some individuals (Guerra *et al.*, 2003).

Because massage therapy is a passive treatment that requires little, if any, physical demands on the individual receiving the therapy, and because massage therapy has been shown to develop muscle tone for other children (see Field, 1998), massage therapy might enhance physical development for children with Down syndrome. If increasing muscle tone facilitates motor functioning, then children with Down syndrome receiving massage therapy would also be expected to show improved motor functioning.

Massage therapy involves skin-to-skin contact and includes stretching, pressing, rubbing, flexing and extending extremities at levels tolerant to children (never painful). Although no controlled studies were found on massage therapy effects for children with Down syndrome, one pilot massage study with 13 children with Down syndrome between one and four years of age revealed increased muscle activation and less severe hypotonicity (Linkous & Stutts, 1990) suggesting positive massage effects. However, no comparison group was included in the Linkous and Stutts study.

In numerous randomized controlled studies for other children, massage therapy has been shown to improve performance for preterm infants on the Brazelton motor items (Field *et al.*, 1986, 1987; Scafidi *et al.*, 1990, 1993), suggesting that massage facilitates motor development. In one controlled-study with preterm infants, flexion and extension movements typical of preterm infant massage were shown to increase bone density and muscle strength (Moyer-Muleur *et al.*, 1995).

Massage therapy effects on improved motor skills may be attributed to improved muscle tone, although this hypothesis has not been tested. The primary objective of the present study was to examine whether massage therapy improved muscle tone in children with Down syndrome. If massage therapy develops muscle tone, then children receiving massage therapy might also show improved motor development. This was the second objective of the study. A third objective of this study was to examine whether enhancing muscle tone and motor functioning would also be associated with enhanced development of other areas since motor proficiency is believed to provide the basis for development of other areas (Jobling, 1998).

Young children with Down syndrome were recruited from two centers participating in providing early intervention services (PT, OT, speech therapy, etc.) to children with disabilities. Because we were interested in conducting a controlled-study, one-half of the children with Down syndrome were assigned to a massage therapy group and the other one-half to a reading/attention control group. The reading sessions consisted of a therapist holding and reading stories to the child for 0.5 hours on the same time schedule as the massage therapy group. Reading was chosen because it controlled for potential placebo effects that might be attributed to the massage therapist 'attending' to the children. At the beginning and end of a two-month program (two sessions per week for eight weeks), muscle tone, motor functioning and general development were assessed for the two groups of young children with Down

syndrome. Muscle tone was assessed using a newly designed scale (the Arms, Legs and Trunk Muscle Tone Scale [ALT]) that had been used in a previous study for children with cerebral palsy (Hernandez-Reif *et al*., 2005), and was being used in the current study to examine its validity on children with Down syndrome.

Method

Participants

Following Institutional Review Board approval, parents who had a young child with Down syndrome attending one of two early intervention programs received information about the study. The children were attending mainstreamed preschool programs whose policy included integrating typically and atypically developing children. The children were housed in preschool classrooms with an outdoor patio area and/or an outdoor playground area with a teacher:child ratio of 1:4. The two intervention programs were within four blocks of each other and the University's Medical Center. The children arrived in public transportation provided by the county and were in the center from 8:00 a.m. to 2:00 p.m.

After obtaining parental informed consent, the children's intervention charts were reviewed to verify the diagnosis of Down syndrome and level of physical or mental impairment. Children were not recruited if their chart reflected severe emotional or physical impairment. Twenty-three preschool children (mean age, 24.5 months; standard deviation, 9.5) diagnosed with Down syndrome were identified for the study. The children were from parents from lower to middle socioeconomic status based on the parents' education and occupation (Hollingshead mean = 3.6).

The children participating in the study were assessed on the Developmental Profile for Infants and Young Children (DPIYC) by a team of professionals who were familiar with the children and worked at the intervention centers (the children's special educator/teacher, speech therapist and physical therapist or occupational therapist). After obtaining baseline functioning measures, the children were randomly assigned to receive massage therapy (n = 12) or reading (control) sessions (n = 11). However, the data for two children were not used because the children missed more than three intervention sessions in a row and as a result were dropped from the study. The two children (one in the massage therapy group and the other in the reading group) had been kept out of school by their parents due to illness. The final sample consisted of 21 children (13 males) and the ethnic distribution was 1/3 Caucasian, 1/3 Hispanic and 1/3 African-American. The two groups did not differ on demographic variables (see Table 1). Because no main effects of intervention setting were found [$F(1, 18) = 0.07$, $p > 0.05$], the data were collapsed across settings.

Procedure

The teachers at the intervention centers had a minimum of a bachelors' degree (four-year college degree) in Special Education, Education or Psychology. Each teacher

Table 1. Demographic data by intervention group

Variable	Group		*P*	
	Massage therapy	Reading	*t*-test	X^2
Mean age (months)	24.4	25.1	0.86	
Ethnicity (number of children)				0.83
Caucasian	4	3		
Hispanic	3	4		
African-American	4	3		
Gender				0.39
Male	6	7		
Female	5	3		

headed a classroom and had two teacher assistants. Teaching assistants typically had the equivalence of a two-year college degree (Associate in Arts or Associate in Science). The teachers met State certification for teaching and standards for the state's Health and Rehabilitative Service Program. Besides the daily activities of a regular preschool program (finger painting, singing, listening to stories and playground time in the morning and afternoon), the Early Intervention program required one hour of nap time, lunch and provided the children with one hour per week of physical therapy, one hour per week of occupational therapy and between 30 and 60 minutes per week of speech therapy. These interventions occurred between 9:00 and 11:30 in the morning or between 12:30 and 2:00 in the afternoon in a special therapy room and were conducted by licensed physical, occupational and/or speech therapists. Intervention sessions were typically 0.5 hours long and occurred twice a week for physical and occupation therapies and one or two times a week for speech therapy. The children were not enrolled in extracurricular activities outside of the program (e.g. ballet, karate, etc.).

Setting and schedule. The massage therapy and reading sessions were integrated into the Early Intervention program and also occurred at the children's intervention/preschool center between 9:00 and 11:30 in the morning or between 12:30 and 2:00 in the afternoon. The massage or reading session was always conducted on the same two days of the week and time for each child (e.g. Monday at 10:00 and Wednesday at 1:00) in between the services the children were already receiving (PT, OT or speech). Because we wanted to conduct the study in the context of the children's Early Intervention/preschool program and because parents could not reliably miss work for eight weeks to participate in the study, we recruited and trained licensed massage therapists to conduct the massage sessions (see 'Massage therapy' later).

Each session (massage or reading) was conducted on an individual basis in a separate, quiet matted area (without other children around) in the children's intervention

center. The children were brought to the quiet area for their session by their therapist and then returned by the same therapist to their classroom activity after the session. The procedure was easy to implement since the children were used to this procedure for their other interventions (PT, speech therapy, etc.).

A licensed massage therapist who was also certified in Infant Massage and had experience working with children with Down syndrome developed a massage therapy routine. Volunteer massage therapists with interests in pediatric massage were trained to follow the written protocol. The control group reading sessions were also delivered by the massage therapists and consisted of reading Dr Seuss books for 0.5 hours to the children assigned to this group. The children in the massage therapy and reading groups were provided with two warm-up sessions to become acquainted with their therapist. If the child cried during a session, the therapist was instructed to stop and simply hold the child to reassure him/her. All of the children tolerated and liked their sessions and none of the children were dropped because of intolerance. Although state changes were not recorded, some therapists reported that on occasion a child would fall asleep during the massage session. Because massage therapists only volunteered one day per week, all of the children in the intervention had a minimal of two different massage therapists providing the reading or massage sessions.

Massage therapy. Massage therapists from two nearby massage therapy schools administered the 0.5-hour sessions twice a week for two months. The therapists were licensed in the State of Florida and had 600 hours of anatomy, kinesiology and physiology course work in addition to the state's requirement of clinical hours of bodywork. All of the therapists had taken courses on infant massage and/or had experience massaging infants and/or children (e.g. preterm infant massage). The therapists received written and verbal training on the following protocol used for the study.

The 30-minute massage therapy session started with the child lying on a small mat on the floor. The therapist conducted the following sequence three times with the child in a supine position: *Legs and feet*—(a) while forming hands like a letter 'C' and wrapping the fingers around the child's leg, long, milking and twisting strokes from the thigh to the ankles; (b) massaging foot by gliding thumbs across bottom of foot followed by squeezing and tugging each toe; (c) massaging across top of foot by gliding thumbs from ankle to toes; (d) flexing and extending the foot; (e) massaging from ankle to foot and back to ankle; (f) stroking from the ankle up towards the thigh; and (g) back and forth rolling movements (as if making a rope from dough) from the ankle to the thigh. *Stomach*—(a) slow, circular, rubbing movements to stomach area with one hand; (b) using the palms, hand over hand down the stomach in a paddle-wheel fashion; (c) starting with thumbs together at the umbilicus, stroking horizontally to sides of body and then twice above and twice below the umbilicus; (d) using fingertips and starting below the umbilicus on the child's right side, small circular upward movements until even with the umbilicus, then continuing across to the left side, and then down on the left side to below the umbilicus; (e) with one hand following the other, short upward stroking from right side below the umbilicus, then

across the umbilicus to the left side of the body, and then down on the left side to below the umbilicus; and (f) cupping or holding sides of knees, bending both knees simultaneously towards the stomach and holding for three to five seconds. *Chest*—(a) with palms of hands on child's sternum, stroking outward across chest; (b) starting at sternum, stroking upwards and over tops of shoulders and down the sides of the ribs; and (c) starting at the right thigh, stroking diagonally through the chest to the opposite shoulder and back down to the same thigh; repeat starting at the left thigh; *Arms and hands*—same as legs and feet (i.e. replace 'legs' with 'arms' and 'feet' with 'hands'). *Face*—(a) making small circles to entire scalp (as if shampooing hair); (b) with flats of thumbs together on midline of forehead, stroking outward towards the temples; (c) stroking gently over the eyes and brows; (d) starting at the bridge of the nose, stroking across the cheekbones to the ears; and (e) making circular movements under the chin, around the jaw line, around the ears, to the back of the neck and the rest of the scalp.

The following sequences were done after placing the children on their stomach (in a prone position). *Back*—applying oil to the hands: (a) starting at the top of the spine, alternating hand strokes across the back working down towards the tail bone (never pressing the spine) and reaching over to include the sides; (b) hand over hand movements from upper back to hips with flats of hands and then continuing to feet; (c) using circular motion with fingertips, from neck to hips stroking over the long muscles next to the spine and retracing on the other side of the spine; (d) making circular strokes with the palm of the hand to rub the tops of the shoulders; and (e) ending with long gliding strokes from the neck to the feet.

Reading attention control. The reading sessions were conducted on the same time schedule as the massage therapy sessions; that is, for 0.5 hours twice a week for two months. The reading sessions consisted of a massage therapist holding the child and reading books to the child from the Dr Seuss series for 0.5 hours on a mat. The children in the reading group received individual attention from the therapist, without the structured 'touch' of massage therapy.

Assessments

Prior to the start of the study, and after completing two months of massage therapy or reading sessions, each child was assessed using the DPIYC scale by the intervention professionals who worked at the center. The intervention professionals who administered the DPIYC were unaware of the child's group assignment and included the child's special education teacher, physical or occupational therapist and speech therapist. In addition, an observer unaware of the child's group assignment rated the child on muscle tone (the ALT).

DPIYC (Rogers & D'Eugenio, 1977). The DPIYC is a criterion-referenced test with a normative test score. This instrument provides developmental norms in the

following areas: perceptual/fine motor, gross motor, self-care (feeding, toileting, dressing/hygiene skills), social/emotional, language and cognition. The DPIYC was originally designed to help identify children's relative strengths and weaknesses, and to indicate which developmental skills were emerging so that appropriate activities or interventions could be planned. The DPIYC can be administered in less than one hour and contains 299 items.

The DPIYC was used in the present study because of convenience since this instrument was familiar and/or routinely administered by the professionals (special educators, physical therapist, occupational therapist, speech therapist) working with the children at the centers. Each child was individually administered the DPIYC at the start of the study and again at the end of the two-month program.

Each child's range of functioning was determined following brief observations with and without objects in open-ended activities to determine the developmental status of the child in the 0–36 month age range. Ceiling and basal levels were assessed for each developmental area. The ceiling level consisted of presenting the more difficult items until the child had failed either six consecutive items or all items in two consecutive age ranges. The basal level was the age range, preceding the child's earliest failure, where the child passed all items in two consecutive age ranges or passed six consecutive items. The highest item number of a sequence of passes represented the child's relative strengths and was interpreted as representing the child's present developmental age in months. Because the DPIYC provides a developmental range (e.g. 12–15 months) for each subscale, and the manual does not provide instructions for computing individual scores, the multidisciplinary team computed one age for each subscale (e.g. 12 months) based on the number of items the child passed. For example, if the child passed all the items on the 12–15 month age range, then the child would receive a 15. If the child passed less than 25% of the items on the 12–15 age range, then the child would receive a score of 12 months, and so on. That the validity of the developmental age scores is unknown is a limitation of this instrument. However, as already mentioned, the DPIYC was considered for this study because of its convenience in that it was being used by the intervention centers and was familiar to the professional team. To its credit, the DPIYC is correlated with the Bayley Mental (R = 0.80–0.96) and Motor Scales (R = 0.62–095) and the Vineland Social Maturity Scale (R = 0.77–0.93) (Rogers & D'Eugenio, 1977). Inter-rater reliability among therapists on the DPIYC has been reported at 82% across children and varying developmental domains (Dunn, 1990). Changes were expected in most areas for all children due to maturation effects. However, greater changes were expected beyond maturation effects for the fine and gross motor subscales for the children receiving massage therapy based on our hypothesis that massage therapy would lead to improved motor functioning.

The ALT (Hernandez-Reif & Field). The ALT was designed during the pilot phase of this study by two authors of this paper (M.H.R. and T.F.) in conjunction with feedback from two senior physical therapists with numerous years of experience

working with children with disabilities. After failing to find a sensitive pediatric muscle tone scale, the ALT was constructed to examine whether more modest muscle tone changes could be detected in the arms, legs and trunk of children with disabilities following the massage therapy intervention. The authors of the ALT are developmental psychologists with Ph.D.s and the second author also has a background in occupational therapy. The ALT was modeled after the five-point adult Modified Ashworth Scale (Bohannon & Smith, 1987), but with a wider range of tone intensity, and using descriptions from the General Tone item of the Neonatal Behavioral Assessment Scale (Brazelton & Nugent, 1995). The ALT ranges along a continuum anchored at one end with a Likert scale for assessing hypotonicity (–4.00 to –1.00), a midscore of 0 to depict normal tone, and anchored at the other end with another Likert scale for assessing hypertonicity (1.00 to 4.00). Operational definitions for each muscle tone level of the ALT are depicted in Figure 1.

The scale was first piloted with three children with Down syndrome and three children with cerebral palsy, and first reported in a study that examined massage therapy for 20 children with cerebral palsy (Hernandez-Reif *et al*., 2005). Reliability analysis on the ALT conducted on the baseline ALT measures for the children with Down syndrome who participated in the current study revealed high internal consistency (Cronbach alpha = 0.9043; Split-half alpha for Part 1 = 0.9070 and alpha for Part 2 = 1.000).

TONE	SCORE	
Hypertonicity	4 (severe)	Limb rigid at rest and greater than 50% of the time during passive flexion or extension. Passive movement of the trunk is almost impossible due to immobility
	3 (moderate)	Limb rigid at rest and about 50% of the time during passive flexion or extension. Although difficult, passive movement of the trunk is possible.
	2 (mild)	Limb tone variable at rest and rigid approximately 25% of the time during passive flexion or extension. Passive movement of the trunk is possible with mild difficulty about 25% of the time.
	1 (slight)	Limb tone may appear average at rest. However, slight observable or palpable rigidity (catch and release) in passive flexion or extension and/or trunk movement.
NORMAL	0	No palpable or observable muscle rigidity. Lies with relaxed tone during rest. Average tone and smooth movement during passive flexion or extension or trunk movement.
Hypotonicity	-1 (slight)	Limb tone appears average at rest. However, slight observable or palpable limp or flaccid muscle tone during passive flexion or extension and/or trunk movement.
	-2 (mild)	Limb tone somewhat flaccid at rest and limp approximately 25% of the time during flexion or extension. Passive movement of the trunk occurs with flaccid tone about 25% of the time.
	-3 (moderate)	Limb tone is flaccid or limp at rest about 50% of the time and during flexion or extension or ROM. Passive movement of the trunk is always possible with little response felt in muscle tone as limb or trunk is moved.
	-4 (severe)	Limb completely flaccid or limp and for all or most of the time during passive flexion or extension. No resistance or muscle tone when limbs are moved. Complete trunk flexion occurs without resistance.

SCORE:	ARMS:	LEGS:	TRUNK:
	Right _____	Right _____	Right _____
	Left _____	Left _____	Left _____
	Overall _____	Overall _____	Overall _____

Figure 1. The Arms, Legs and Trunk Muscle Tone Scale

A graduate student with a background in anatomy and physiology, kinesiology, trigger point and 125 hours of neuromuscular therapy and a massage therapy license was trained by one of the author's of the scale to conduct the ALT assessments for the children in the present study. The ALT was conducted twice for each child, once prior to the first massage therapy or reading session (day 1 or baseline) and again immediately after the last massage or reading session (final day). Inter-rater agreement assessed for 25% of the sample using Cohen kappa values ranged between 0.82 and 0.94 (mean, 88) between the graduate student and an author of the ALT scale. Greater changes in muscle tone approximating less hypotonicity were expected for the children receiving massage therapy.

Results

A one-way analysis of variance revealed no baseline group differences for the DPIYC areas (all $p > 0.05$). Because maturation effects were expected from the first to the last days of the two-month study, change scores were computed for the developmental areas of the DPIYC by subtracting the last day's score from the first day's scores. The change scores were then subjected to one-tailed independent sample *t*-tests to examine massage effects beyond the expected maturation effects. One-tailed *t*-tests were justified because the massage therapy group was expected to show greater gains (unidirectional) than the reading control group, and because of the small sample size of this pilot study.

The DPIYC

As expected, the independent sample *t*-tests revealed greater gains from the first to the last days of the study for the massage therapy group on: (1) fine motor functioning [$t(19) = 1.80$, $p < 0.05$], and (2) gross motor functioning [$t(19) = 1.74$, $p < 0.05$]. Marginal effects were also revealed in favor of the massage therapy group for language development [$t(19) = 1.62$, $p < 0.055$] (see Table 2).

The ALT

Because the ALT scores reflect ordinal data, non-parametric analyses were conducted. Mann–Whitney U-tests on arms, legs and trunk muscle tone change scores between groups revealed an improvement in arm muscle tone [$U = 8.5$, $p \leq 0.05$] and leg muscle tone [$U = 8.5$, $p \leq 0.05$] for the massage therapy group (see Table 3).

Discussion and implications for intervention

In addition to receiving Early Intervention services (PT, OT, speech therapy, etc.), 21 young preschool children (mean age, two years) with Down syndrome were assigned to receive two 0.5-hour massage therapy or reading (attention/control

Table 2. Mean (standard deviation) functioning months for massage therapy and reading/control groups on first-day and last-day measures

Variable	Massage therapy group	Reading/control group
Age (months)	24.36 (10.57)	25.10 (7.95)
Development (DPIYC)		
Fine motor	13.1 (6.0) / 18.9 (5.2)	13.1 (6.5) / 15.4 (7.3)
	R = (4–22) / (9–25)	*R* = (7–25) / (7–27)
Gross motor	13.7 (5.9) / 24.3 (8.8)	12.3 (6.0) / 17.6 (8.8)
	R = (4–22) / (9–37)	*R* = (7–23) / (9–34)
Feeding	14.0 (6.2) / 19.7 (5.7)	12.2 (5.7) / 15.5 (5.9)
	R = (3–23) / (10–29)	*R* = (5–23) / (8–25)
Toileting	14.5 (7.4) / 17.8 (7.4)	14.9 (6.1) / 17.3 (5.2)
	R = (3–24) / (12–35)	*R* = (7–24) / (12–24)
Dressing	12.9 (6.3) / 20.8 (3.8)	13.1 (3.6) / 18.9 (8.4)
	R = (3–23) / (12–33)	*R* = (7–20) / (12–33)
Social	18.2 (9.2) / 26.5 (8.8)	15.6 (7.7) / 20.6 (8.7)
	R = (5–31) / (7–36)	*R* = (9–30) / (9–33)
Language	13.1 (5.0) / 16.9 (3.5)	11.1 (4.6) / 12.5 (4.4)
	R = (3–19) / (10–20)	*R* = (5–18) / (6–20)
Cognition	13.8 (5.6) / 17.9 (6.2)	12.3 (5.4) / 15.7 (7.2)
	R = (4–23) / (9–27)	*R* = (5–23) / (5–30)

The first mean (standard deviation) in each column represents the baseline developmental age for the group / the second mean (standard deviation) in each column represents the developmental age at the end of the study. Respective age range scores (*R*) are presented on the second line of each subscale heading.

group) sessions each week for two months. As expected, all the children showed developmental gains in all areas across the two-month period (gross motor, self-care [feeding, toileting, dressing/hygiene skills], social/emotional, language and cognition). However, children in the massage therapy group showed greater fine motor and gross motor functioning than those in the control group, suggesting that massage therapy might enhance motor development beyond maturation effects expected for children with Down syndrome. The improved gross motor, feeding, social and cognition scores for both groups were probably attributed to the effects of the Early Intervention program (see Fewell & Glick, 1996; Harris, 1997). However, the observed changes might also have been attributed to maturation effects. To examine maturation versus intervention effects, future research should include a true 'control group' (e.g. a wait-list group), comprised of children with Down syndrome not receiving interventions. However, withholding Early Intervention services for research purposes might not be justified because of ethical issues. Alternatively, a sham massage group that receives stroking to the same body areas as the massage therapy group but without pressure might provide a good control for the massage therapy group and resolve the ethical issue of withholding intervention from the children. A sham massage group would also control for attention and for attention to

Table 3. Means (standard deviations) for the ALT for the massage therapy and reading/control groups

	Massage therapy		Reading/control		
	First day	Last day	First day	Last day	Mann–Whitney U test on change scores, *P* values
Arms	−2.0 (1.4)	−0.9 (1.0)	−2.5 (1.2)	−3.0 (0.2)	0.05
Legs	−2.1 (.8)	−0.9 (0.6)	−2.3 (1.0)	−2.2 (1.2)	0.05
Trunk	−1.8 (1.7)	−0.8 (1.3)	−2.4 (1.1)	−1.3 (2.2)	0.28

ALT, muscle tone: 4 (hypertonic) to 0 (normal) to −4 (hypotonic).

the specific body parts that were massaged in the current study and would test the effects of moderate versus light pressure massage effects.

The developmental gains in motor functioning and muscle tone for the massage therapy group corroborates previously reported massage benefits for other groups of children (see Field, 1998). In preterm infants, massage therapy techniques have been shown to improve motor functioning (Field *et al.*, 1986, 1987), bone mass and bone mineralization (Moyer-Muleur *et al.*, 1995). Although in the present study the mechanism underlying the improved motor functioning is unknown, massage therapy might have led to increased bone density and muscle strength. A future study might examine massage versus sham massage (stroking the same body parts but without pressure) to determine the effects of pressure massage on motor development and muscle strength.

One study reported that young men with Down syndrome have decreased arm and leg muscle strength (Angelopoulou *et al.*, 2000). In the current study involving children with Down syndrome, increased muscle strength might have contributed to better muscle tone for the massage therapy group from the pressure stimulation. Increasing muscle strength has also been associated with increased functional activity, movement and coordination (Harris, 1997) and may explain the improved fine motor and gross functioning scores in the current study for the massage therapy group. An alternate explanation might be that massage therapy improved postural control and this might have facilitated the greater gains observed for the massage therapy group. Future studies might also examine massage therapy versus sham massage effects on posture, muscle strength (e.g. by grasp dynamometer testing), gait and/or stance recorded from videotaping or gait analyses.

One limitation of the present study was that the DPIYC (i.e. the measure used to assess motor and developmental gains) profiles a child's age range (e.g. 12–15 months) as opposed to a developmental age in months. In our study, the multidisciplinary team computed a developmental age for each subscale of the DPIYC based on the number of items the child passed. The validity of these scores is unknown, although we would expect that any error derived from computing the summary scores would be randomly distributed across the massage and control groups. Future studies might use other measures whose test manual describes procedures for converting raw

scores into age equivalent scores, such as the Peabody Developmental Motor Scales (Folio & Fewell, 1983) for gross and fine motor assessments.

The ALT was used in this study as an exploratory tool because a literature review failed to yield a pediatric scale that was sensitive to less than major changes in muscle tone. Although in the present study the ALT yielded acceptable interobserver reliability scores and high internal consistency, the ALT has not been widely tested and this is a major limitation of this study. Thus, the muscle tone findings from the massage therapy group should be interpreted with caution until further testing of the ALT is concluded. Another limitation is that several researchers have reported that muscle tone scales yield inconsistent and unreliable data; however, most of these studies have been conducted with adult stroke or spinal cord injury patients (Haas *et al.*, 1996) or using scales with little or vague definitions of muscle tone (hypotonia/ normal/ hypertonia) or wide ranges (e.g. from 0 to 100) (Pomeroy *et al.*, 2000). At least one study reported that tone assessment scales for passive movement that provide more detailed descriptors show good to very good reliability scores (Gregson *et al.*, 1999). The ALT attempted to improve on the more commonly used Ashworth Scale (Ashworth, 1964) and Modified Ashworth Scale (Bohannon & Smith, 1987) by including more descriptors. The ALT, in addition to including a greater number of descriptors, also includes more specific descriptors to measure different levels or degrees of muscle tone. Future research is necessary to assess the validity of the ALT scale with other children that experience muscle tone impairment (e.g. cerebral palsy, muscular dystrophy). Although this study involved a small sample size, the improved muscle tone for the massage therapy children, coupled with their improved motor functioning, is encouraging in that hypotonia (or decreased muscle tone) is common to Down syndrome and has been related to difficulty in regulating muscle control and stiffness, motor delays and movement patterns (Block, 1991).

Another finding from the present study was that although the mental age of older children with Down syndrome rarely increases with intervention (Crombie *et al.*, 1991; Rynders & Horrobin, 1990), improved scores in many areas, including cognition and social development, were recorded for both the reading and the massage therapy group. These changes may highlight the effectiveness of improved Early Intervention programs for higher functioning children with Down syndrome (Dykens *et al.*, 1994).

In summary, although future research is required using more established outcome measures and the current findings are preliminary, the results of this pilot study are nonetheless encouraging and suggest that, when added to an Early Intervention program, massage therapy may enhance motor functioning and limb muscle tone for young children with Down syndrome. Motor functioning and muscle strength are pivotal for achieving postural, manipulative and locomotor milestones (Block, 1991). Attenuating motor functioning delays may in turn contribute to increased self-esteem in school-aged children with Down syndrome (Jobling, 1998). If future research supports the massage benefits, then massage should be considered as an adjunct to Early Intervention services for therapists, teachers and parents to learn and incorporate in the daily routine of children with disabilities.

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References

Angelopoulou, N., Matziari, C., Tsimaras, V., Sakadamis, A., Souftas, V. & Mandroukas, K. (2000) Bone mineral density and muscle strength in young men with mental retardation (with and without Down syndrome, *Calcified Tissue International,* 66, 176–180.

Ashworth, B. (1964) Preliminary trial of Carisprodol in multiple sclerosis, *Practitioner,* 192, 540–542.

Baumrind, D. (1993) The average expectable environment is not enough: a reply to Scarr, *Child Development,* 64, 1299–1317.

Bjornhage, L., Lagerwall, B., Ericsson-Sagsjo, A. & Waldenstrom, E. (1990) Early motor training for children with Down syndrome, in: E. Chigier (Ed.) *Looking up at Down syndrome* (London, Freund Publishing), 163–171.

Block, M. (1991) Motor development in children with Down syndrome: a review of the literature, *Adapted Physical Activity Quarterly,* 8, 179–209.

Bodensteiner, J., Smith, S. & Schaefer, G. (2003) Hypotonia, congenital hearing loss, and hypoactive labyrinths, *Journal of Child Neurology,* 18, 171–173.

Bohannon, R. & Smith, M. (1987) Interrater reliability of a Modified Ashworth Scale of Muscle Spasticity, *Physical Therapy,* 67, 206–207.

Brazelton, T. B. & Nugent, J. K. (1995) *Neonatal Behavioral Assessment Scale* (London, MacKeith Press).

Crombie, M., Gunn, P. & Hayes, A. (1991) A longitudinal study of two cohorts of children with Down syndrome, in: C. J. Denholm (Ed.) *Adolescents with Down syndrome: international perspectives on research and programme development* (Victoria, University of Victoria Press), 3–13.

Dodd, K., Taylor, N. & Graham, H. (2003) A randomized clinical trial of strength training in young people with cerebral palsy, *Developmental Medicine and Child Neurology,* 45, 652–657.

Dunn, W. (1990) Establishing inter-rater reliability on a criterion-referenced developmental checklist, *Occupational Therapy Journal of Research,* 10, 377–380.

Dykens, E., Hodapp, R. & Evans, D. (1994) Profiles and development of adaptive behavior in children with Down syndrome, *American Journal on Mental Retardation,* 98, 580–587.

Faigenbaum, A., Milliken, L., Loud, R., Burak, B., Doherty, C. & Westcott, W. (2002) Comparison of 1 and 2 days per week of strength training in children, *Research Quarterly for Exercise and Sport,* 73, 416–424.

Fewell, R. & Glick, M. (1996) Program evaluation findings of an intensive early intervention program, *American Journal of Mental Retardation,* 101, 233–243.

Field, T. (1998) Massage therapy effects, *American Psychologist,* 53, 1270–1281.

Field, T., Scafidi, F. & Schanberg, S. (1987) Massage of preterm newborns to improve growth and development, *Pediatric Nursing,* 13, 385–387.

Field, T., Schanberg, S., Scafidi, F., Bauer, C., Vega-Lahr, N., Garcia, R., Nystrom, J. & Kuhn, C. (1986) Tactile/kinesthetic stimulation effects on preterm neonates, *Pediatrics,* 77, 654–658.

Folio, M. & Fewell, R. (1983) *Peabody developmental motor scales and programmed activities* (Chicago, IL, Riverside).

Gibson, D. & Harris, A. (1988) Aggregated early intervention effects for Down's syndrome persons: patterning and longevity of benefits, *Journal of Mental Deficiency Research,* 32, 1–17.

Gregson, J., Leathley, M., Moore, A., Sharma, A., Smith, T. & Watkins, C. (1999) Reliability of the Tone Assessment Scale and the modified Ashworth scale as clinical tools for assessing poststroke spasticity, *Archives of Physical Medicine and Rehabilitation,* 80, 1013–1016.

Guerra, M., Llorens, N. & Fernhall, B. (2003) Chronotropic incompetence in persons with Down Syndrome, *Archives of Physical Medicine and Rehabilitation,* 84, 1604–1608.

Haas, B., Bergstrom, E., Jamous, A. & Bennie, A. (1996) The inter rater reliability of the original and the modified Ashworth scale for the assessment of spasticity in patients with spinal cord injury, *Spinal Cord,* 34, 560–564.

Harris, S. (1997) The effectiveness of early intervention for children with cerebral palsy and related motor disabilities, in: M. J. Guralnick (Ed.) *The effectiveness of early intervention* (Baltimore, MD, Paul Brookes Publishing), 327–347.

Hernandez-Reif, M., Field, T., Largie, S., Diego, M., Manigat, N., Seoanes, J. & Bornstein, J. (2005) Cerebral palsy symptoms in children decreased following massage therapy, *Early Child Development and Care*, 175(5), 445–456.

Horn, E., Warren, S. & Jones, H. (1995) An experimental analyses of neurobehavioral motor intervention, *Developmental Medicine and Child Neurology*, 37, 697–714.

Jackson, J. (1993) Human behavioral genetics, Scarr's theory, and her views on interventions: a critical review and commentary on their implications for African American Children, *Child Development,* 64, 1318–1332.

Jobling, A. (1998) Motor development in school-aged children with Down syndrome: a longitudinal perspective, *International Journal of Disability, Development and Education,* 45, 283–293.

John, F., Bromham, N., Woodhouse, J. & Candy, T. (2004) Spatial vision deficits in infants and children with Down syndrome, *Investigative Ophthalmology and Visual Science,* 45, 1566–1572.

Kearney, K. & Gentile, A. (2003) Prehension in young children with Down syndrome, *Acta-Psychologica,* 112, 3–16.

Kennedy, E. & Flynn, M. (2002) Early phonological awareness and reading skills in children with Down syndrome, *Down Syndrome: Research and Practice,* 8, 100–109.

Laws, G. & Bishop, D. (2003) The comparison of language abilities in adolescents with Down syndrome and children with specific language impairment, *Journal of Speech, Language and Hearing Research,* 46, 1324–1339.

Linkous, L. & Stutts, R. (1990) Passive tactile stimulation effects on the muscle tone of hypotonic, developmentally delayed young children, *Perceptual Motor Skills,* 71, 951–954.

Martin, K. (2004) Effects of supramalleolar orthoses on postural stability in children with Down syndrome, *Developmental Medicine and Child Neurology,* 46, 406–411.

Moyer-Mileur, L., Leutkemeier, M., Boomer, L. & Chan, G. (1995) Effect of physical activity on bone mineralization in premature infants, *Journal of Pediatrics,* 127, 620–625.

National Institutes of Child Health and Human Development (1997) *Facts about Down syndrome* (Washington DC, Health Information and Media Publications).

Nichols, S., Jones, W., Roman, M., Wulfeck, B., Delis, D., Reilly, J. & Bellugi, U. (2003) Mechanisms of verbal memory impairment in four neurodevelopmental disorders, *Brain and Language,* 88, 180–189.

Ottenbacher, K., Biocca, Z., DeCremer, G., Gevelinger, M., Jedovic, K. & Johnson, M. (1986) Quantitative analysis of the effectiveness of pediatric therapy: emphasis on neurodevelopmental treatment approach, *Physical Therapy,* 66, 1095–1101.

Pastore, E., Marino, B., Calzolari, A., Digilio, M., Giannotti, A. & Turchetta, A. (2000) Clinical and cardiorespiratory assessment in children with Down syndrome without congenital heart disease, *Archives of Pediatric Adolescent Medicine,* 154, 408–410.

Pomeroy, V., Dean, D., Sykes, L., Faragher, E., Yates, M., Tyrrell, P., Moss, S. & Tallis, R. (2000) The unreliability of clinical measures of muscle tone: implications for stroke therapy, *Age Ageing,* 29, 229–233.

Rogers, S. & D'Eugenio, D. (1977) *Developmental programming for infants and young children* (2nd rev. edn) (Ann Arbor, MI, University of Michigan Press).

Roizen, N. (2001) Down Syndrome: progress in research, *Mental Retardation and Developmental Disabilities Research Reviews,* 7, 38–44.

Rynders, J. & Horrobin, J. (1990) Always trainable? Never educable? Updating educational expectations concerning children with Down syndrome, *American Journal on Mental Retardation,* 95, 77–83.

Scafidi, F., Field, T. & Schanberg, S. (1993) Factors that predict which preterm infants benefit most from massage therapy, *Developmental and Behavioral Pediatrics,* 14, 176–180.

Scafidi, F., Field, T., Schanberg, S., Bauer, C., Tucci, K., Roberts, J., Morrow, C. & Kuhn, C. (1990) Massage stimulates growth in preterm infants: a replication, *Infant Behavior and Development,* 13, 167–188.

Seung, H. & Chapman, R. (2004) Sentence memory of individuals with Down's syndrome and typically developing children, *Journal of Intellectual Disability Research,* 48, 160–171.

Shonkoff, J. & Hauser-Cram, P. (1987) Early intervention for disabled infants and their families, *Pediatrics,* 69, 635–641.

Spiker, D. & Hopmann, M. (1997) The effectiveness of early intervention for children with Down Syndrome, in: M. E. Guralnick (Ed.) *The effectiveness of early intervention,* (Baltimore, MD, Brookes), 271–305.

Turnbull, J. (1993) Early intervention for children with or at risk for cerebral palsy, *American Journal of Diseases of Children,* 147, 54–59.

Ulrich, D., Ulrich, B., Angulo-Kinzler, R. & Yun, J. (2001) Treadmill training of infants with Down syndrome: evidence-based developmental outcomes, *Pediatrics,* 108, E84.

Uyanik, M., Bumin, G. & Kayihan, H. (2003) Comparison of different therapy approaches in children with Down Syndrome, *Pediatrics International,* 45, 68–73.

Wang, W. & Ju, Y. (2002) Promoting balance and jumping skills in children with Down syndrome, *Perceptual Motor Skills,* 94, 443–448.