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Effects of Teaching Methods on Swimming Skill Acquisition in Children with Developmental Coordination Disorder

Susan Oh
University of Western Australia, ohh_susan@yahoo.com

Melissa Licari
University of Western Australia

Brendan Lay
University of Western Australia

Brian Blanksby
University of Western Australia

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This study compared the delivery of "verbal and visual" with "verbal, visual, and tactile" swimming instruction to small groups of DCD pupils for front crawl and backstroke performance across 10 lessons × 30 min/week. The interaction and main effects for group and time on front crawl performances were not significant, indicating no differences were found between the two teaching methods. In addition, the front crawl performances of the DCD swimmers did not change over the intervention period. The interaction and main effect for group on backstroke performances over the 10 weekly lessons were not significant. However, a significant main effect of time was found with backstroke changes found between Weeks 1 and 10 and Weeks 6 and 10. Subcomponent analyses for horizontal body position, head position and breathing, and use of the lower limbs revealed significant time effect improvements, but only between Weeks 1 and 10. Hence, both DCD groups improved their backstroke performances at the same rate across the 10 week intervention, despite being exposed to different instructional methods.

The Diagnostic and Statistical Manual of Mental Disorders describes Developmental Coordination Disorder (DCD) as a marked impairment in developing motor coordination that usually interferes with daily tasks at home, school, and in play environments (APA, 1994; 2000; Larkin & Hoare, 1991). Advances in technology have suggested that DCD could result from neural disturbances linked to abnormalities of motor development (Henderson, 1992). Neurological research has speculated that children with DCD present abnormalities in neurotransmitter or receptor systems (Hadders-Algra, 2002). Functional magnetic resonance imaging of attentional brain networks in DCD children has reported less ability to easily, and/or promptly, switch between motor responses (Querne et al., 2008).

DCD occurs in ~6% of children (APA, 1994; 2000) and more boys are diagnosed than girls (~3:1 ratio). Gender variations might be due to higher referrals of boys who are expected to be more active (Hay & Donnelly, 1996; Henderson & Hall, 1982). But, DCD children form a heterogeneous group (Hamilton, 2002; Miyahara & Register, 2000) and they can experience highly individual motor development

The authors are with the School of Sport Science, Exercise, and Health at the University of Western Australia in Crawley.

delays (Ayres, 1972; 2005; Ayres, Mailloux, & Wendler, 1987; Ayyash & Preece, 2003; Dewey & Wilson, 2001; Larkin & Hoare, 1991).

The disorder usually is assessed by examining children's general movement proficiencies, such as fine and gross motor skills and activities of daily living. Tests used to measure general movement proficiency include the Movement Assessment Battery for Children (MABC; Henderson & Sugden, 1992; MABC 2; Henderson, Sugden, & Barnett, 2007), the Bruininks—Oseretsky Test for Motor Proficiency (BOTMP; Bruininks, 1978), and the McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1982). The MAND (McCarron, 1982) assesses motor proficiency on both fine and gross motor skills that apply to 4–17 yr olds in the general population. Assessment standards should always bear in mind that there is no one gold standard to identify DCD in children (Crawford, Wilson & Dewey, 2001; Dewey & Wilson, 2001; Henderson & Barnett, 1998; Mandich, Polatajko, Macnab, & Miller, 2001a; Mandich, Polatajko, Missiuna, & Miller, 2001b; Missiuna, Moll, King, King, & Law, 2006; Missiuna & Pollock, 1995; Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). The MAND, however, has found better reliability and concurrent validity than the BOMTP for identifying differences in motor proficiency (Tan, Parker, & Larkin, 2001).

Despite it being difficult to distinguish whether skill deficits are due to DCD or other conditions, early identification and intervention are important. Detrimental effects on progress in school (Cantell, Smyth, & Ahonen, 1994; Losse et al., 1991; Sugden & Wright, 1998) can have a negative emotional impact on DCD children as they are not readily accepted by their peers (Larkin & Hoare, 1991) and become more introverted (Schoemaker & Kalverboer, 1994); judge themselves as less competent, both physically and socially (Schoemaker & Kalverboer, 1994); and usually experience higher levels of anxiety and have a lower sense of self-worth (Piek, Baynam & Barrett, 2006; Skinner & Piek, 2001). Negativity in psychosocial domains can result in children and adolescents with DCD being less content with their lives and place less value on themselves in areas of scholastic domain, social acceptance, physical appearance, and athletic competence than their better coordinated peers (Cantell et al., 1994; Losse et al., 1991; Piek et al., 2006; Skinner & Piek, 2001; Summers, Larkin, & Dewey, 2008).

The long-term outcomes of poor motor coordination are of concern because almost 50% of affected individuals carry aspects of these movement difficulties and related emotional issues into adulthood (Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010; Skinner & Piek, 2001; Smyth, 1992; Sugden & Wright, 1998). Hence, without intervention, children may not outgrow their movement difficulties and skills will not improve. For instance, Losse et al. (1991) found children who had movement difficulties at 6 still had problems at 16 years of age. Thus, early identification and intervention could help improve movement proficiency and reduce associated emotional and social problems.

To date, various interventions have assisted children with DCD to develop movement skills, but little evidence exists as to the best approach (Ayyash & Preece, 2003). The task-oriented approach is commonly used with skills taught at a suitable pace from simple to complex. The personal teaching is adapted to suit each child's functional difficulties with day-to-day living tasks such as self-care activities of buttoning a shirt or gross motor movement difficulties, including running or riding a bicycle (Mannisto, Cantell, Huovinen, Kooistra, & Larkin, 2006; Sugden & Wright, 1998).

Often, these techniques involve a combination of verbal, visual, and/or tactile/physical guidance (Revie & Larkin, 1993; Wulf, Shea & Whitacre, 1999). Verbal guidance involves short, concise cues directing the learner through a key movement pattern (Magill, 2010). Teachers, coaches, and therapists often implement verbal guidance with visual guidance that involves demonstrating the skill (Magill, 2010). Tactile or kinaesthetic instruction involves physically handling the learner's body parts when performing the skill to reinforce the required movements (Holding, 1965) and provide a clearer sense of the movement goal by reducing errors (Wulf et al., 1999). Tactile instruction occurs less frequently in coaching settings as it takes more time to implement. Wulf et al. (1999) studied physical guidance for practicing slalom-type movements on a ski-simulator, with or without poles. Tactile guidance with the poles on a ski-simulator was more effective in terms of movement amplitude and efficient coordination during practice. In addition, both conditions led to similar amplitudes in immediate and delayed retention (Wulf et al., 1999).

Children often learn to swim by first building water confidence in orientation, entering and exiting the water. Then, they aim for a horizontal body position in flotation skills to help with safe submersion and recovery. In addition, teachers might introduce stroke specific skills on land before practicing them in the water (Bradley, Parker, & Blanksby, 1996; Gelinas & Reid, 2000). Swimming is a complex skill as it requires a neuromuscular readiness to achieve the high levels of intralimb and interlimb coordination of arms and legs, plus a horizontal body position and breathing restrictions (Blanksby & Blanksby, 1995; Blanksby, Parker, Bradley, & Ong, 1995).

Swimming is often recommended for children with DCD due to its individual, inclusive, and noncompetitive nature (Larkin & Hoare, 1991; Missiuna et al., 2006) that occurs in predictable and stable environments. Once familiar with the water, swimming could be an ideal sport enabling DCD children to safely experiment with postural changes and use the water as a resistive medium to improve muscular endurance and strength (Arnheim & Sinclair, 1979). It has been noted that children with DCD aged 5–12 years commonly displayed persistent problems in front crawl, including difficulty in breathing, lack of rhythm and timing, and combining arm stroking and leg kicking simultaneously (Larkin & Hoare, 1991; Whiting, 1970). Arm entries and extension were inefficient, leg kicking was initiated from the knees rather than the hips, and similar findings occurred for backstroke (Larkin & Hoare, 1991). Children with DCD generally found it harder to overcome inefficient motor techniques when acquiring swimming proficiency, which could constrain learning.

It remains unclear if children with physical disabilities should follow the same progressions used with typically developing children (Davies & Tucker, 2010; Gelinas & Reid, 2000; Langendorfer & Bruya, 1995; Leopore, Gayle, & Stevens, 1998). Gelinas & Reid (2000) found that 5–12 year old children with physical disabilities could display precursor skills such as rhythmic breathing, front and back floats, and front and back glides while progressing to swim 10m each of front crawl and backstroke. Such atypical progressions occur in 80% of children for skills on the front and 55% in skills on the back. This suggests that failure to achieve precursor skills should not constrain teaching more advanced, formal front crawl in children with motor difficulties (Gelinas & Reid, 2000). But, others recommend that children should achieve a repertoire of precursor skills before formal stroking (Langendorfer & Bruya, 1995).

Although there are studies on how children learn to swim (Blanksby & Blanksby, 1995; Blanksby & Parker, 1997; Erbaugh, 1978, 1980, 1986; Langendorfer & Bruya, 1995), less research has examined the rate of learning in children with DCD, relative to typically developing children. Donaldson, Blanksby, and Heard (2010) examined progress in precursor skills and front crawl swimming in children with and without DCD. Children with DCD performed at a significantly lower level than age-matched controls for all the water competency tasks and front crawl. Both groups did improve significantly in water competency and front crawl over the 10 lessons. However, children with DCD revealed difficulties with technique problems such as a cycling leg action, lifting the head to breathe, and poor interlimb coordination in front crawl.

Many learn-to-swim programs use verbal/visual/feedback instructions, but few have studied swimming skill development by children with DCD, especially whether tactile guidance with the skills might provide a clearer image to the learner of the movement goal. Thus, this study examined the rate at which children with DCD learned front crawl and backstroke using different instructional strategies. A verbal/visual/feedback method was compared with a verbal/visual/feedback + tactile method. Verbal/visual/feedback teaching was provided with the teacher standing on the pool deck with the tactile group teachers entering the water to provide the physical correction/feedback. It was considered that the DCD children exposed to the tactile strategy would improve their swimming at a greater rate across the 10-week intervention than the DCD group not receiving tactile instruction.

Methods

Participants

Males ($N = 22$) aged 5–9 years were examined to control for potential gender differences in rates of learning. The DCD subjects were recruited from the Unigym program for children with movement difficulties at The University of Western Australia (UWA). Subjects had been referred by at least one health professional—family doctor, pediatrician, child psychiatrist, psychologist, occupational therapist, or physiotherapist, thus satisfying the DSM-IV criteria (APA, 1994, 2000). The Human Research Ethics Committee at UWA approved the study and parents provided written consent before commencement.

Selection of subjects was based on McCarron's Assessment of Neuromuscular Development scores for five fine and five gross motor tasks (MAND; McCarron, 1982). The total scores were summed and converted into a Neuromuscular Developmental Index score (NDI; McCarron, 1982). Children were included if they recorded NDI scores of < 85 or gross motor scores < 45, as these scores showed low motor proficiency in this domain. In addition, borderline NDI scores of > 85 were considered if their gross motor scores were < 45.

Before the lessons, participants were assessed to ensure they were sufficiently water confident but not proficient at front crawl and backstroke. Competence was required in submerging, unilateral breathing, and self-propulsion through the water on the front and back without a flotation device; however, no subjects were able to combine arm strokes, leg actions, and breathing for front crawl or backstroke.

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Procedures

After determining baseline ability levels, subjects were randomly assigned into two groups matched for swimming proficiency and age. Then, classes of three students per teacher were formed for 10 lessons, which they attended once per week for 30 min. Attendance at eight lessons was required for results to be included. Three DCD and two DCD-t (t = tactile) pupils were omitted for insufficient attendance, leaving a total of 17 swimmers (DCD, $n = 8$; DCD-t, $n = 9$). Progress was evaluated in weeks 1, 6, and 10. All teachers had a minimum of two years aquatics teaching experience using the UWA teaching methodology. Consistent teaching delivery was reinforced during an in-service workshop to clarify strategies, lesson goals and progressions, class management, and the amount and type of feedback provided.

Lessons were held in a 25 × 11m heated (28–29 °C), covered pool in which pupils could stand on the bottom. The part-part-whole teaching method (Blanksby & Blanksby, 1995) was used with the motor tasks broken down into sequential steps. Each step is taught independently before being combined. For example, flutter kick was practiced first in front crawl before bubbles and breathing were each added. Then, the whole stroke was practiced by combining the arms, breathing, and kicking actions. Aids such as kick-boards of various sizes were used to enhance the learning process but no other flotation devices (Mandich et al., 2001a, 2001b).

Tactile instruction and feedback only was given before and at the end of each lap completed by the participants. This was to maintain similar time in providing feedback and instruction for both groups. The time was divided into verbal and visual only or verbal, visual, and tactile modes. For consistent instruction, teachers also were briefed on the tactile instructions to direct swimmers into an optimal position for performing the skill accurately by helping them to feel the movement. For example, teachers would physically manipulate a subject's head to the side for taking a breath and extend the subjects' arms and legs in front crawl to assist kicking from the hips, rather than the knees in a bicycling action.

Assessment Instruments For Swimming

It can be difficult to precisely evaluate changes in swimming skill levels. Assessing elements of smoothness, timing, quality—and degrees thereof—introduce a level of subjectivity, and qualitative evaluations are typically used. There is only a small amount of literature available on how to report qualitative performance changes during the developmental sequences or the rates of progress through the acquisition of separate swimming skills (Bradley et al., 1996; Erbaugh, 1986; Langendorfer, 2007; Larkin & Hoare, 1991). Langendorfer (2007) commented that for quite some time, most swimming programs have lacked valid, reliable, and objective assessment tools for measuring and evaluating swimming achievement.

Swimming Proficiency Assessments

To objectively evaluate changes in the swimming skill levels, front crawl, and backstroke, checklists were created (see Figures 1 and 2) from a list of efficiency and technique swimming problems set out by Larkin and Hoare (1991) and merged with swim teaching progressions used in the UWA-Uniswim program. For each stroke,

UWA UNISWIM
Swimming Club inc.

Figure 1: Checklist of Front Crawl

Name of Pupil: ________________ **Age:** ________________

Teacher: ______________________ **Tester:** ______________

Date Tested: __________________ **Assessment: 1 / 2 / 3**

Ratings System

0 = Not at all	1 = Sometimes	2 = Most of the time	3 = All the time

Components	Scores Achieved
1. Body Position	6
2. Head Position and Breathing	12
3. Upper Limbs	12
4. Lower Limbs	12
5. Total Score	42

1. Body Position	*0*	1	2	3
				
▪ Horizontal alignment of the trunk in water				
▪ Minimal body rotation				

Figure 1 — Checklist of front crawl. *(continued)*

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2. Head positioning and breathing				
				
▪ Head remains horizontal in water, with chin on the chest				
▪ Head turning to either side to inhale with ear in the water				
▪ Bubbles are blown out slowly in the water				
▪ Regular breathing pattern linked to arm action				
3. Upper Limbs				
				
▪ Fingers are closed together				
▪ Slow, straight arm freestyle				
▪ Long pull with back of the hand catching raindrops				
▪ Hand enters the water near to the top catching the imaginary board				
4. Lower Limbs				
				
▪ *Kick is initiated at hips*				
▪ *Knees extended with straight legs kicking action*				
▪ *Relaxed feet with ankles pointed*				
▪ *Kicking feet just break surface*				

Figure 1 *(continued)* — Checklist of front crawl.

UWA UNISWIM
Swimming Club inc.

Figure 2: Checklist of Backstroke

Name of Pupil: ________________ **Age:** __________________

Teacher: ______________________ **Date Tested:** ___________

Tester: _______________________ **Assessment: 1 / 2 / 3**

Ratings System

0 = Not at all	1 = Sometimes	2 = Most of the time	3 = All the time

Components	Scores Achieved
1. Body Position	/ **9**
2. Head Position and Breathing	/ **3**
3. Upper Limbs	/ **12**
4. Lower Limbs	/ **12**
5. Total Score	/ **36**

6. Body Position	***0***	**1**	**2**	**3**
				
▪ Horizontal alignment of the trunk in water				
▪ Tummy pushed up				
▪ Minimal body rotation				

Figure 2 — Checklist of backstroke *(continued)*

7. Head positioning and breathing				
				
▪ Head remains horizontal in water, with eyes looking up to the top				
8. Upper Limbs				
				
▪ Fingers are closed together				
▪ Slow, straight arm backstroke				
▪ Little finger leads and enters water first				
▪ Hand pulls through and exits water at upper thigh level				
9. Lower Limbs				
				
▪ *Kick is initiated at hips*				
▪ *Knees extended with straight legs kicking action*				
▪ *Relaxed feet with ankles pointed down*				
▪ *Kicking feet just break surface*				

Figure 2 *(continued)* — Checklist of backstroke.

the (a) body position, (b) head position and breathing, (c) use of upper limbs, and (d) use of lower limbs were evaluated. Each individual component in the checklist was rated on a four point scale: 0 = not at all; 1 = sometimes; 2 = most of the time; and 3 = all the time. This rating system helped to improve the sensitivity of measuring skill acquisition. Four swimming teachers, each with >5 years of teaching experience, completed the assessments independently. They observed the children swimming from the pool deck, and assessed skills in weeks 1, 6, and 10. The validity and reliability of this process was shown to be 0.90 (Bradley et al., 1996).

Data Analysis

Independent groups *t* tests were used to compare subject characteristics in Week 1. The body position, head position and breathing, and use of upper and lower limbs for each swimming skill were evaluated for each child. The maximal total score for each stroke was the summation of the scores of each individual component. In Week 1, group differences in swimming proficiency were compared using an independent groups *t* test. Mean scores for each stroke achieved following Week 1, 6, and 10 evaluations were entered into SPSS (Version 17.0) and compared using 2 (Groups) × 3 (Time) split-plot analyses of variance (SPANOVA). Individual components for each stroke also were analyzed using SPANOVA. Paired samples *t* tests were conducted to identify where the differences were in Weeks 1, 6, and 10. A significance level of $p < .05$ was adopted for all statistical tests (Steyn, 2000).

Results

General Descriptive Characteristics

The characteristics of the two DCD groups are presented in Table 1. No significant differences were found between the two groups for age, gross motor (< 45) and NDI scores. However, the verbal/visual/feedback group reported significantly higher MAND fine motor scores than their tactile counterparts.

Table 1 Characterisitics of the Two DCD Groups

	Verbal/Visual (n = 8)		Verbal/Visual/Tactile (n = 9)	
	Mean	SD	Mean	SD
Age	7.51	1.06	7.67	1.09
Gross Motor Score (MAND)	38.38	6.19	36.11	11.61
Fine motor score (MAND)	44.00	14.06*	30.22	11.74
NDI Score	86.38	13.90	74.56	15.22

Note. * = significantly different between the DCD groups, $p < .05$.

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Front Crawl Swimming Performance

Figure 3 illustrates the mean scores of front crawl for Weeks 1, 6, and 10 for the two groups. The interaction, $F(2, 30) = 1.08$, $p = 0.35$, and main effects for group, $F(1,15) = 0.01$, $p = 0.92$ and time, $F(2, 30) = .85$, $p = 0.44$ were not significant. Thus, neither teaching method improved the front crawl performance of DCD swimmers over the intervention period.

Backstroke Swimming Performance

Figure 4 illustrates the mean scores for backstroke achieved by both groups at Weeks 1, 6, and 10. The interaction, $F(2, 30) = 0.46$, $p = 0.63$, and main effect for group, $F(1, 15) = 1.13$, $p = 0.30$, were not significant. However, a significant main effect of time, $F(2, 30) = 6.14$, $p = 0.01$, was found. Paired samples *t*-tests showed changes between Weeks 1 and 10, $t(16) = –3.77$, $p = 0.01$, and Weeks 6 and 10, $t(16) = –2.50$, $p = 0.03$. Subcomponent analyses revealed time effects for body position, $F(2, 30) = 6.92$, $p = 0.01$; head position and breathing, $F(2, 30) = 4.42$, $p = 0.02$; and the use of lower limbs, $F(2, 30) = 3.49$, $p = 0.04$. These changes only occurred between Weeks 1 and 10 for body position, $t(16) = –3.62$, $p = 0.01$; head position and breathing, $t(16) = –3.39$, $p = 0.01$; and the use of lower limbs, $t(16) = –3.18$, $p = 0.01$. Despite finding a significant time effect between Weeks 6 and 10, none of the follow-up *t* tests were significant for body position, head position and breathing, and use of lower limbs. Hence, both DCD groups improved at the same rate across the 10 lessons despite exposure to different teaching methods.

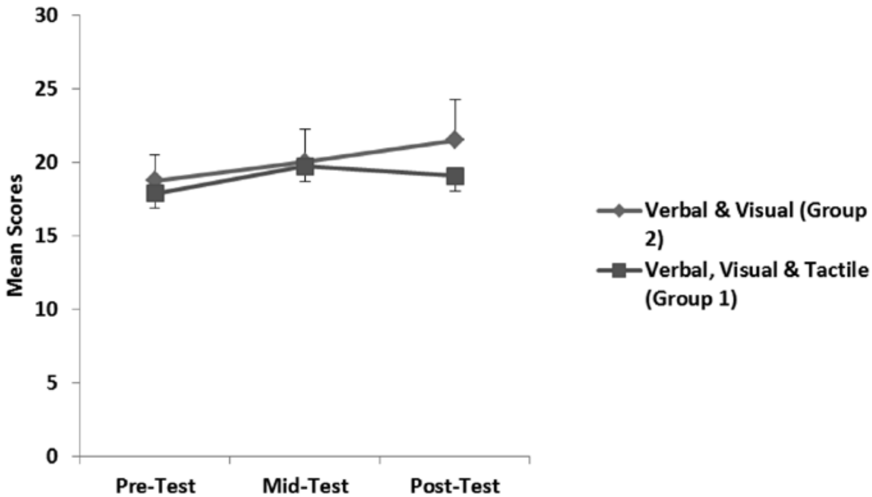

Figure 3 — Mean scores achieved in the acquisition of front crawl between the two DCD groups during the 10 week swimming program. The values shown represent Means ± *SEM*. No differences were found across the 10 week intervention.

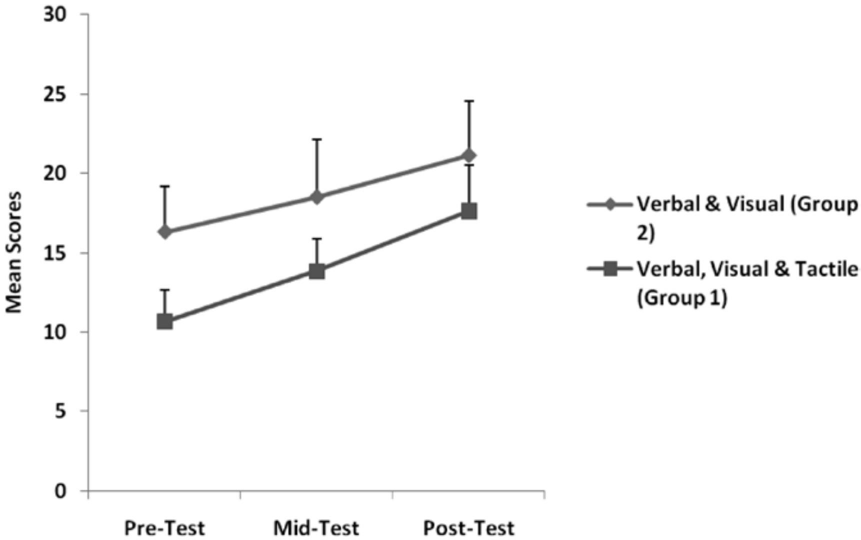

Figure 4 — Mean scores achieved in acquiring backstroke between the two DCD groups during the 10 week swimming program. The values show Means ± *SEM* * / ** = significant change between the time periods for both groups ($p < .05$).

Discussion

It was hypothesized that the swimming skills of the DCD-t pupils would improve faster using verbal/visual/tactile than verbal/visual strategies; however, both DCD groups progressed at the same rate with no group differences in front crawl and backstroke performance. It is unclear why the additional tactile assistance did not add any learning benefits. The tactile instructional methods used in front crawl and backstroke included physical manipulation of children's arms and legs to demonstrate the desired flexion/extension of limbs and manipulating the head to achieve the correct position in the breathing phase. Tactile instruction and feedback was specifically limited to before and at the conclusion of each lap when swimmers were resting. This procedure was deliberately adopted so that performance changes could not be attributed to one group simply receiving considerably more instruction and feedback. Although learning complex skills for children with DCD can be quite lengthy and challenging (Marchiori, Wall, & Bedingfield, 1987), simpler skills like throwing and hopping can be refined to age appropriate levels after as few as 8 × 20 mins sessions (Revie & Larkin, 1993). As swimming is more complex, it could take longer to achieve significant improvements. Perhaps the learning period (10 × 30 mins) was insufficient to effect sustained swimming improvement and using more lessons, longer instructional periods, and larger subject numbers would help to clarify the matter.

Lower NDI scores were found in the DCD-t group but were not significant. In addition, the verbal/visual/feedback group reported significantly higher MAND fine motor scores than their tactile counterparts at the beginning of the study. Perhaps the lower DCD-t, NDI scores ($p > .05$) and the higher DCD, MAND fine motor scores ($p < .05$) could have influenced the results in some counter-balancing way. For example, if there was some learning impact from the higher MAND scores helping the verbal/visual group to acquire swimming skill more rapidly, combined with the possibility of a learning benefit by adding a tactile teaching component in the other group, each cancelled the other out. Further research is required to clarify this issue.

Over the 10 lessons, significant improvements in backstroke skills were noted, possibly due to breathing being easier with the face out of the water at all times. Breathing in backstroke presents minor challenges to stroke timing relative to front crawl breathing and could explain the disparities when learning the two strokes. Further, when the subcomponents of front crawl were analyzed, body position, head position and breathing, and the use of upper limbs and lower limbs showed no significant improvement. Thus, greater coordination difficulties might arise in children with DCD trying to learn front crawl than backstroke. Despite the detailed checklists being valid and reliable, it's possible that more precise information of task complexity may be required for assessing front crawl performance (Donaldson et al., 2010).

The rating scores from the assessment checklists were qualitative, and each nominated skill component was allocated equal value. This ignores any "degree of difficulty" and greater specificity could fine tune the process. For example, if learning effective front crawl requires developmentally ordered sequences, the scoring of sequential learning lead-up drills/skills needs greater scrutiny. The ability to do flutter kick might equal 1 point, but adding other more "troublesome," higher "degree of difficulty" components such as "breathing bubbles out into the water" or breathing with kicking could equal 2 points—as that takes longer to learn. As the task complexity increases, the coordination of bubbles and breathing with kicking and arms might need to be allocated more points, say 3. This could help to recognize the stages where learners experience problems and where teachers need to spend extra time and attention for quality learning. It would also be useful to explain such details to learners and parents who are anxious about any phase(s) of slower progress. It was noted that learning how to get the feet off the bottom and float in water, encountering the more demanding learning stage of smoothly turning the head to breathe with the arm action while maintaining kicking, breathe air out into the water without over-breathing, or holding the breath were some of the more difficult aspects of smooth swimming (Blanksby & Blanksby, 1995). Hence, allocating equal points for each segment could be masking the more troublesome phases of learning front crawl. Hence, as well as including some subjectivity in the assessment process, the checklist scores could underestimate real progress.

The present study found that including tactile instruction did not elicit any improvement over verbal and visual instruction. However, due to the heterogeneity of children with DCD, they should be exposed to different sources of feedback tailored to their individual needs for optimal learning. It is also possible that other factors not assessed in the present research could have had a bearing on the findings.

Evaluations of motor imagery in children with DCD have revealed deficits in their internal representation of movement (Wilson et al., 2000). Possibly these deficits hinder swimming performances requiring mental imagery of the movement. For instance, children in learn-to-swim classes often receive verbal cues such as "keep your head down and look for the fish" then "turn your head to the side and listen for the fish," "reach your arms to the sky," "swim with long legs," or "kick your socks off" that relate to proprioceptive or kinaesthetic information. If children with DCD find it difficult to internally represent these movements, they could be hard to perform. The difficulty is exacerbated when performing skills in water with different tactile and sensory stimuli than encountered on land. Postural control might also hinder learning to swim, especially if dry land postural difficulties persist in the water (Geuze, 2003; Wann, Mon-Williams, & Rushtion, 1998; Williams & Woollacott, 1997). Finally, the retention ability of children with DCD could also have impacted upon their ability to hold the instructional feedback from one week to the next. Thus, retention tests could also be administered at regular periods of time, such as replicating typical school term breaks to examine skill retention after various periods away from swimming.

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