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# Aquatic Physical Therapy for Children with Developmental Coordination Disorder: A Pilot Randomized Controlled Trial

Susan Hillier
Auburn McIntyre
Leanne Plummer



**ABSTRACT.** Aquatic therapy is an intervention for children with Developmental Coordination Disorder (DCD) that has not been investigated formally. This was a pilot randomized controlled trial to investigate the feasibility and preliminary effectiveness of an aquatic therapy program to improve motor skills of children with DCD. Thirteen children (mean age 7 years 1 month; 10 males) with DCD were randomly allocated to receive either six sessions of aquatic therapy (once weekly session of 30 min for 6–8 weeks) or to a wait-list (control group). The intervention and measures were demonstrated to be feasible, but barriers, such as limited appointment times and accessibility, were encountered. Analysis of covariance indicated that at posttest, mean scores on the Movement Assessment Battery were higher for children who received aquatic therapy compared to those on the wait-list ($p = .057$). Similar trends were noted on the physical competence portion of the Pictorial Scale of Perceived Competence and Social Acceptance ($p = .058$). Participation levels, as measured by a parent questionnaire, showed improvement for both groups. Potential facilitators and barriers to implementation of an aquatic therapy for children with DCD are discussed.

**KEYWORDS.** Aquatic therapy, children, developmental coordination disorder, motor skills

Susan Hillier, PhD, is a senior lecturer, Centre for Allied Health Evidence, University of South Australia, Adelaide, Australia.

Auburn McIntyre, BSc, MSc, Grad Dip, Churchill Fellowship, is a senior clinician at the Women's and Children's Hospital, Adelaide, Australia.

Leanne Plummer is an honours candidate at the School of Health Sciences, University of South Australia, Adelaide, Australia.

Address correspondence to: Dr. Susan Hillier, Centre for Allied Health Evidence, School of Health Sciences, University of South Australia, City East, North Tce, Adelaide, SA 5000 Australia (E-mail: susan.hillier@unisa.edu.au).

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Developmental Coordination Disorder (DCD) is a term used to describe children who exhibit motor coordination skills below that expected for their chronological age and intellect and which are not attributable to medical disorders (American Psychiatric Association (APA), 2000). The reported prevalence of DCD is variable, with estimates generally being between 5% and 9% of children (Barnhart, Davenport, Epps, & Nordquist, 2003; Zoia, Barnett, Wilson, & Hills, 2006). Children with DCD form a highly heterogenous group and may display below average-for-age difficulties in a variety of areas including: gross motor skills (e.g., running, skipping, galloping, jumping); fine motor skills (e.g., dexterity tasks); and reduced kinaesthetic acuity, visual motor integration, visual–perception, balance, and agility (Macnab, Miller, & Polatajko, 2001). As a consequence of the movement difficulties, these children can experience problems with activities of daily living, academic performance, and social skills such as slowness, dependence, or avoidance of tasks (Chen & Cohn, 2003; Missiuna, Moll, King, King, & Law, 2007).

No specific pathological processes have been identified for DCD, and by definition there are no hard neurological signs (APA, 2000). However, a number of theories have been proposed, which form the basis of many assessment and/or intervention approaches. Common intervention strategies associated with bottom-up and top-down approaches are summarized in Table 1. Bottom-up approaches were developed from neuromaturational theories. Treatments are primarily aimed at changing underlying impairments that theoretically contribute to poor motor performances, i.e., decreased vision/perception, kinaesthesis, proprioception, and/or balance and strength (Mandich, Polatajko, Macnab, & Miller, 2001; Missiuna, Rivard, & Bartlett, 2006; Wilson, 2005). Targeting these components is thought to facilitate integration of sensory

TABLE 1. Approaches to DCD Intervention

| Approach | Examples | Approaches to treatment |
|---|---|---|
| Bottom-up | Sensory integration intervention | Child is provided with carefully targeted sensory input aimed at promoting motor adaption and higher cortical learning, i.e., sensory integration therapy (SIT) (Mandich et al., 2001). |
| | Perceptual motor training (PMT) | Provides a child with a broad range of experiences with sensory and motor tasks, with opportunity to practice (Barnhart et al., 2003; Mandich et al., 2001). |
| | Process-orientated treatment | Theorizes that children with DCD have kinaesthetic problems thus uses specific kinaesthetic training activities and positive reinforcement aimed at improving motor performance (Mandich et al., 2001). |
| Top-down | Cognitive approaches | Combines cognitive learning, maturational, and motor-control theory. The approach emphasizes participant problem-solving. Involves developing a movement goal, making a plan to accomplish the goal, attempting the goal, and then reevaluating how the plan went to learn how the movement will be attempted in the future, e.g., mastery of concepts (Barnhart et al., 2003; Wilson, 2005). |
| | Task-specific intervention | Based on dynamical systems theory. Concentrates on training a target task, with the premise that optimal performance comes with practice of the task to be learnt. The task is broken up into its components, taught separately, and then as a whole (Barnhart et al., 2003; Pless & Carlsson, 2000). |

information in cortical regions of the brain to develop a more organized body schema (Willoughby & Polatajko, 1995). The approach has been criticized for ignoring more current concepts and for lacking empirical evidence supporting its theories (Wilson, 2005).

Top-down approaches, derived from more recently developed theories, propose that both internal (i.e., motor planning) and external factors (i.e., environment, specific task/task context) influence a child's motor development (Barnhart et al., 2003). This approach aims to improve cognitive or problem-solving skills as strategies to overcome difficulties (Barnhart et al., 2003; Wilson, 2005). Top-down approaches appear promising; however, the quality and quantity of investigations into their effects on children with DCD are limited (Hillier, 2007).

The effectiveness of one approach over another for treating children with DCD is not well established. Numerous reviews on DCD interventions have been published; the most recent and the only systematic review was by Hillier (2007). This review was of high quality, as assessed by the Critical Appraisal Skills Programme (CASP) (Public Health Resource Unit, 2006), and thus can be considered trustworthy. The review concluded that there was strong evidence to verify that intervention per se for a child with DCD is better than no intervention (Hillier, 2007).

A literature search using Medline, Pubmed, and CINAHL databases did not identify any research on the effect of aquatic physiotherapy for children with DCD. Aquatic physiotherapy is thought to assist children with DCD by using water to create multisensory stimuli, slow movement, enable children to safely experiment with postural changes/strategies, provide resistance for improving endurance/strength, and improve confidence (Arnheim & Sinclair, 1979; Campion, 1997). These potential attributes are considered to address many of the difficulties reported by children with DCD. Therefore it can be postulated that aquatic therapy may be of benefit for this population. It also may be postulated that such therapy falls into both bottom-up and top-down approaches in that there is emphasis on both afferent input and practice of tasks in a problem-solving manner. Benefits of aquatic therapy have been reported for children with (non-DCD) movement disorders in a systematic review by Getz, Hutzler, and Vermeer (2006), which also scored as a low risk of bias on the CASP tool.

The aims of this pilot study were to

1. determine whether aquatic therapy is feasible for children with DCD, and
2. provide preliminary data regarding the effectiveness of aquatic therapy in improving the motor skills, self-concept, and participation of children with DCD.

## *METHODS*

### *Design*

A pilot investigation using a single-blinded, randomized controlled trial (RCT) was conducted. There was one treatment group, receiving aquatic physiotherapy and one "wait-list" control group receiving no intervention. Ethics approval was obtained from the Human Research Ethics Committees of the University of South Australia and the Children's, Youth and Women's Health Service. In all instances written consent was gained from the potential participant's parent/s.

### *Participants*

Inclusion and exclusion criteria were based on the specific requirements of the recruiting site and on the criteria for DCD diagnosis as specified in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV; APA, 2000). Children included in the study were

- referred to the Minimal Motor Disorder Unit (MMDU) of the Women's and Children's Hospital (WCH) with suspected DCD (had significant problems that affected activities related to home and/or school life—DSM-IV, criterion 2);
- 5–8 years of age;
- below the 15th percentile on the M-ABC (Henderson & Sugden, 1992) (criterion 1, DSM-IV);
- not diagnosed as having an intellectual disability (criterion 4, DSM-IV);
- able to attend assessments and interventions.

Children were excluded from the study if they

- currently or recently (last 6 months) attended swimming lessons;
- had a swimming pool at home or were frequently using a pool;
- displayed evidence of comorbidities (including intellectual disabilities, neurological disorders (evidenced by impairments, such as hyperreflexia, hypertonia, paraesthesia, central weakness) or lower limb musculoskeletal problems that would affect motor skills) (criterion 3, DSM-IV);
- had hydrophobia or other hydrotherapy contraindications.

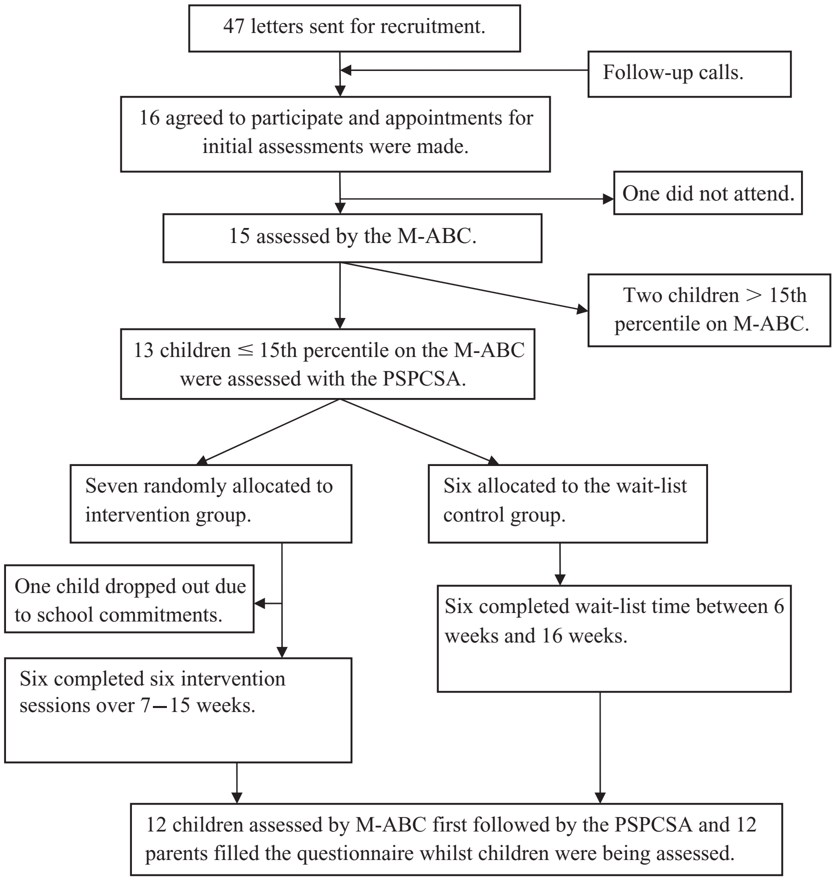
Power calculations indicated that a sample size of 19 subjects per group would be required to achieve 90% power with an alpha level of 0.05. Power was estimated for the Movement Assessment Battery for Children (M-ABC) with expected scores of 5 and 10.5 for the intervention and control groups respectively, and a standard deviation (SD) of 4.5 (Piek, Dworkin, Barrett, & Coleman, 2000).

A total of 12 children participated in the trial with recruitment and numbers detailed in the flow chart (Figure 1). Time constraints for the trial and limited referrals prevented the attainment of the desired sample size. The randomization process was completed by a person independent to the study, using a computer program, which randomly allocated intervention or control to each participant (concealed envelope method). One child (intervention group) dropped out after randomization due to school commitments at the scheduled time for sessions. Both groups consisted of one female and five males; in the intervention group the median age was 7 years 3 months (range 5 years 8 months to 8 years) and for the control group the median age was 6 years 10 months (range 5 years 5 months to 8 years 9 months). Both groups were comparable for all parameters at preintervention.

### *Measures*

*Movement Assessment Battery for Children* is a test of motor ability that uses a series of functional skills and can be used both to identify children with motor difficulties and to assess/monitor changes in the participant's motor ability (Henderson & Sugden, 1992). At the time of the trial, the second edition of the M-ABC (Henderson & Sugden, 2007) had just been published and we did not receive the measure prior to data

FIGURE 1. Flowchart of recruitment and group assignment. M-ABC: Movement Assessment Battery for Children; PSPCSA: Pictorial Scale of Perceived Competence and Social Acceptance.




collection. The M-ABC consists of eight movement tasks in three subtests: manual dexterity (three items), ball skills (two items), and static and dynamic equilibrium (three items) (Henderson & Sugden, 1992). Total impairment scores range from 0 to 40 with lower scores representing better performances (Sugden & Chambers, 2003). The authors conducted a systematic review of the psychometric properties of the M-ABC and confirmed acceptable levels of reliability, validity, and utility for children with DCD in the target age groups (Plummer, Hillier, & Civetta, 2010). The M-ABC test was carried out with a parent present and according to the standard protocol in the M-ABC manual (Henderson & Sugden, 1992).

Inter-rater and intra-rater reliability of the M-ABC were assessed prior to the commencement of data collection using prerecorded videos of children with DCD from a previous study. The trial assessor (LP) scored videos of children with DCD. Scores were then analyzed against the scores of an experienced pediatric physiotherapist, external to this study, for inter-rater reliability. The same trial assessor rescored five videotaped tests 6 weeks later for intra-rater reliability. The intra-class coefficients for inter-rater reliability (ICC (2,1) = 0.994) and intra-rater reliability (ICC (2,1) = 0.998) were excellent.

*Pictorial Scale of Perceived Competence and Social Acceptance* (PSPCSA) (Harter & Pike, 1984) is commonly used with children with DCD and is recommended as a self-concept measure (Willoughby, King, & Polatajko, 1996). It includes six items in each of the four subscales: cognitive competence, physical competence, peer acceptance, and maternal acceptance (Harter & Pike, 1984). The PSPCSA has good to excellent psychometric properties reported in the literature—including reliability, validity, and clinical utility (Harter & Pike, 1984; Klein & Magill-Evans, 1998; Mantzicopoulos, French, & Maller, 2004).

Questionnaire on Parent's Perception of Changes in their Child's Participation: Assessment of the participants' participation was included as children with DCD often withdraw from participating in recreation, social, and school roles (Mandich, Polatajko, & Rodger, 2003; Wilson, 2005). After an extensive review of the literature, a suitable, feasible, and standardized outcome measure for different aspects of participation of children as young as 5 years old could not be located. Those found were either prohibitively long (45 to 90 min), expensive, not appropriate for children as young as 5 years old, or not validated for use with children with DCD. It has been reported that there is a lack of adequate measures to sufficiently quantify children's global participation levels (King et al., 2007). We therefore devised a short questionnaire to evaluate parent's perception of the changes in their child's participation (four questions: school physical activities, self-care, sports and recreation, and social activities) and self-esteem (one question: self-esteem and confidence). This was quantified using a Likert type scale (scored 1–5) with "1" representing "a lot" of worsening of participation, "3" representing no change in participation, and "5" representing "a lot" of improvement in participation in a given component. Under each question, parents were also asked to comment on any additional activities that their child had started or stopped participating in since the first assessment. This questionnaire was tested on five parents and evaluated by an experienced physiotherapist and researcher for face validity. A review by Glascoe and Dworkin (1995) has shown that using parents as a subjective measure of their child's developmental and behavioral status is valid and reliable.

## ***Procedure***

### *Pre- and Posttest Measures*

An assessor blinded to participant group conducted all assessments in a quiet clinic room at Women's and Children's Hospital. Participants were assessed with the M-ABC and the PSPCSA, with a parent present, prior to randomization, and reassessed in the same room by the same blinded assessor after six sessions of intervention or the scheduled control (wait-list) period. While the participant was being assessed at the posttest session, the attending parents completed the questionnaire.

### *Aquatic Therapy Program*

As there were no existing trials outlining possible content and intensity of aquatic therapy for children with DCD, we devised a program based on the experience of the participating physiotherapist (AM), the principles of intervention confirmed in the literature for effective DCD intervention (Hillier, 2007), and on the principles of the Halliwick method and the concept of water specific therapy (WST) (Campion, 1997; Cole & Becker, 2004). Halliwick method and WST use scientific principles of hydrostatics, hydrodynamics, and body mechanics to progressively engage balance strategies and facilitate coordinated movement. Within this format, graded task-specific training was integrated into the program (ball skills, standing balance, and walking/running). Principles of motor learning and mastery were also incorporated within every exercise (Valentini & Rudisill, 2004). This approach enabled the child to experience graded success with clear feedback at all times so that they were aware of their performance, could monitor their progress, and build confidence (Valentini & Rudisill, 2004). The water and busy pool environment provided a multisensory environment and thus may encompass some of the sensory integration or bottom-up principles discussed earlier. A full manual of potential exercises and progressions was produced and each child's individual program was selected from this template. The treating therapist was a physiotherapist with over 10 years clinical experience in providing aquatic physiotherapy to children with DCD. Full details of the program are available from the authors.

The participants allocated to the aquatic therapy group received a total of six, 30-min aquatic physiotherapy sessions in a 1 to 1 format, as was the standard procedure at the WCH. There is an early indicative evidence to support the use of an individualized approach with clinical reasoning in the literature, based on the premise that children with DCD have individual problems (Dewey & Wilson, 2001; Mandich et al., 2001; Sugden & Chambers, 2003; Wright & Sugden, 1996). The six sessions were scheduled over a 6–8-week period, aiming for one per week. Aquatic therapy sessions were 30 min in duration as this is reported as the most commonly used period in children with neuromotor impairments (Getz et al., 2006). Six sessions were decided upon as the clinical observations of the treating therapist suggested children with DCD show improvement after four to six sessions of aquatic therapy.

The wait-list control group was advised to continue with life as usual and that they would be contacted after the 6–8 weeks to be reassessed and informed when a place was available in the aquatic physiotherapy program.

### *Data Analysis*

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 15). A Shapiro–Wilks test of normality was carried out on the M-ABC total impairment scores, the PSPCSA subtests and total scores, and the individual responses of the participation questionnaire to evaluate the distribution of the sample. The mean posttest results for the M-ABC total impairment scores were statistically analyzed using analysis of covariance (ANCOVA). The subtest scores and total scores on the PSPCSA were analyzed by a ranked ANCOVA because the data were not normally distributed. The pretest scores were used as the covariant for both analyses (ranked and not ranked).

The scores of each group on individual questions of the participation questionnaire were analyzed by the Mann–Whitney U-test (using the "exact" function on the SPSS program to allow for the small sample size) to calculate the level of significance. In addition, any comments added by the parents regarding changes in their child's participation were recorded descriptively.

TABLE 2. Attendance of Children Receiving Aquatic Therapy Program

| | Week of study | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1 | A1 | S1 | S2 | S3 | S4 | S5 | S6<br>A2 | | | | | | | | | |
| 2 | A1 | S1 | S2 | | S3 | S4 | S5 | S6<br>A2 | | | | | | | | |
| 3 | A1 | S1 | S2 | S3 | | S4 | S5 | S6<br>A2 | | | | | | | | |
| 4 | A1 | S1 | S2 | S3 | | | | S4 | S5 | S6<br>A2 | | | | | | |
| 5 | A1 | | S1 | | | | S2 | S3 | S4 | | | S5 | S6<br>A2 | | | |
| 6 | A1 | | S1 | S2 | S3 | S4 | | | | | S5 | S6 | | | A2 | |

A1: preintervention assessment; S1–6: aquatic sessions 1 to 6; A2: postintervention assessment; a blank indicates failure to attend scheduled appointment.

An effect size for the primary outcome (M-ABC) was calculated as a standardized mean difference with 95% confidence intervals, in *Revman5*, using the posttest means and standard deviations (SD), and participant numbers for each group.

## RESULTS

The scheduled appointments compared with actual attendances are summarized in Table 2. The length of time, in weeks, required for children to be able to attend the six scheduled sessions and two assessments, ranged from the scheduled 7 weeks up to 15 weeks. Eighteen scheduled appointment times were missed or cancelled, which represents 50% of the total 36 sessions needing to be rescheduled for the study. The issues identified by the treating therapist and parents for not achieving the scheduled attendance were related to pool availability at times suitable for the parent (transport), the child's school needs, or the therapist availability.

The pre- and posttest scores for the three measures—the M-ABC, PSPCSA, and questionnaire—are presented in Table 3. The mean scores for the M-ABC show that the total impairment score for the control group increased (indicating poorer performance) by 2.6 points (14%) and decreased (indicating improvement in performance) for the intervention group by 3.9 (20%). The ANCOVA ($F$ 1,9 $= 4.78$, $p = .057$) was just below the significance level. M-ABC impairment scores and change in percentiles for each participant are included in Table 4. In the aquatic therapy group, two participants had pretest scores that indicate a definite motor problem (below the 5th percentile) and posttest scores that indicate borderline motor difficulties (between the 5th and 15th percentile). One child in the control group had a pretest score that indicates a definite impairment (below the 5th percentile) and a posttest score that indicates no impairment (above the 15th percentile).

Effect-size estimates for the M-ABC were −0.89 (standardized mean difference) with 95% confidence intervals −2.11 to 0.32, and therefore failed to reach significance ($p = .15$). Using this *large* effect estimate, a sample size of 21 in each

TABLE 3. Pre- and Posttest Scores for Children with DCD in Aquatic Therapy and Control Groups

| | | Aquatic therapy ($n = 6$) | | Control group ($n = 6$) | |
|---|---|---|---|---|---|
| | | Pretest | Posttest | Pretest | Posttest |
| M-ABC | | | | | |
| | Mean (SD) | 19.4 (6.7) | 15.5 (4.1) | 18.2 (4.9) | 20.8 (6.5) |
| | SEM | 2.7 | 1.7 | 2.0 | 2.7 |
| | 95% CI | 12.7–26.1 | 11.5–19.6 | 13.2–23.1 | 14.3–27.2 |
| PSPCSA | | | | | |
| —Total | Median (min/max) | 2.6 (2.4/3.6) | 2.7 (2.4–3.4) | 3.3 (2.2–3.8) | 3.3 (2.4–3.9) |
| —Physical | | 2.8 (2.3/3.3) | 3.0 (2.2–3.5) | 3.3 (2.5–4.0) | 2.9 (1.7–4.0) |
| —Cognitive | | 3.3 (2.2–3.8) | 3.4 (2.3–4.0) | 3.8 (2.5–4.0) | 3.8 (2.7–4.0) |
| —Peer | | 2.4 (1.8–3.8) | 2.5 (1.5–4.0) | 3.1 (1.7–4.0) | 3.3 (1.0–4.0) |
| —Maternal | | 2.1 (2.0–3.7) | 2.7 (1.5–3.8) | 2.6 (2.2–3.7) | 2.7 (1.8–4.0) |
| Participation | | | | | |
| —School | Median (min/max) | | 3.5 (3–4) | | 3.5 (3–5) |
| —Self-care | | | 3 (2–4) | | 3 (3–4) |
| —Sports | | | 3.5 (3–4) | | 3.5 (3–5) |
| —Social | | | 3 (3–4) | | 4 (3–5) |
| —Self-esteem/ confidence | | | 4 (3–4) | | 4 (3–4) |

M-ABC: Movement Assessment Battery for Children—total impairment score; PSPCSA: Pictorial Scale of Perceived Competence and Social Acceptance.

group would have 80% power to detect an effect size of 0.89, using a two group *t*-test with a 0.050 two-sided significance level. Making a conservative estimate of 30% dropout, we would recommend a sample size of 30 per group in future studies.

TABLE 4. Pre- and Posttest Total Impairment Scores and Percentile Scores for the M-ABC (Lower Score Indicates Less Impairment)

| Subject | Preintervention score | Preintervention percentile | Postintervention score | Postintervention percentile |
|---|---|---|---|---|
| Intervention | | | | |
| 1 | 22.0 | <1 | 17.0 | 2 |
| 2 | 17.0 | 2 | 17.5 | 1 |
| 3 | 10.5 | 15 | 11.5 | 13 |
| 4 | 15.5 | 3 | 13.0 | 6 |
| 5 | 21.5 | 3 | 12.0 | 12 |
| 6 | 30.0 | <1 | 22.0 | <1 |
| Control | | | | |
| 7 | 18.5 | 4 | 23.5 | 2 |
| 8 | 10.5 | 13 | 17.5 | 1 |
| 9 | 17.5 | 5 | 26.0 | <1 |
| 10 | 16.0 | 2 | 9.0 | 18 |
| 11 | 21.5 | <1 | 25.5 | <1 |
| 12 | 25.0 | 1 | 23.0 | 2 |

Ranked ANCOVA results for cognitive competence ($F$ 1,9 = 0.102, $p$ = .76), peer acceptance ($F$ 1,9 = 0.63, $p$ = .45), physical competence ($F$ 1,9 = 0.47, $p$ = .058), and maternal acceptance ($F$ 1,9 = 0.52, $p$ = .45) were not significant. The ANCOVA result for the components combined also was not significant ($F$ 1,9 = 0.08, $p$ = .78).

The comparison of posttest results from the intervention and control groups on each component of the participation questionnaire were not significant: school physical activities ($p$ = .71), self-care ($p$ = 1.00), sports and recreation ($p$ = .71), social activities ($p$ = .41), and self-esteem and confidence ( = 1.00).

## DISCUSSION

This pilot RCT investigating aquatic therapy for children with DCD identified feasibility issues to help guide future research into aquatic intervention in DCD and provides effect sizes for sample size calculations. Given our small sample, the results are inconclusive regarding the effectiveness of aquatic physiotherapy on the motor skills of children with DCD. However, the study did identify trends that this therapy may have benefits for motor skills (M-ABC, $p$ = .057) and self-concept (physical competence, $p$ = .058), and offers support for further large-scale, high-quality research, using measures for multiple domains, i.e., motor activities, self-perception, and participation.

### Feasibility

The first objective addressed was to ascertain the feasibility of an aquatic therapy program for children with DCD. This investigation revealed a number of unexpected barriers that could be avoided in future larger studies and in clinical situations. Although it was expected that some participants would have problems with attendance, it was not expected that the rate would be so high. This resulted in one child withdrawing from the study, and also led to the six sessions taking up to 12 weeks rather than the scheduled 6 weeks. In our study, resources, including pool access, were limited. The therapist providing the intervention had her normal caseload on top of the participants in the study. Additionally, the therapist worked on a part-time basis and only during school hours. Thus children had to be taken from school to attend morning aquatic physiotherapy sessions and then be returned to school by a parent. Parents reported that these requirements were the main limiting factors for attendance. These factors, although explained to parents prior to consent, proved to be a barrier to consistent attendance and need to be taken into account for clinical service provision planning.

In public hospital systems, missed appointments are a common occurrence for both the adult and pediatric population (Pesata, Pallija, & Webb, 1999). Reasons reported for nonattendance in the literature are numerous, with many similar to the reasons of nonattendance in this study including vacations, school holidays, transportation difficulties, illnesses, forgetting, and difficulties attending during opening hours (Pesata et al., 1999).

The therapist providing the intervention reported that the aquatic environment appeared to be enjoyable for most of the participants, though the children were not questioned on this formally. Those who were initially tentative in early lessons quickly developed skills in the water, which boosted confidence and morale and subsequently improved their attitude toward the water. Children generally found the water to be fun and were more willing to try tasks and skills they avoided on land. Although children were generally cooperative, some children were distracted and overstimulated and/or took longer to feel comfortable in the water. Thus it appears an individualized approach—at least initially—may be important to accommodate the requirements of different children.

We chose a relatively low intensity of aquatic therapy, based on clinical experience and the clinical pragmatics that time and resources were limited, whereas the literature for land-based DCD intervention supports a higher frequency. For example, a meta-analysis by Pless and Carlsson (2000) concluded that an intervention frequency of at least three to five times per week is particularly useful. They also showed that group programs are effective, therefore, future research into aquatic therapy may include both a higher frequency and a group format if resources allow.

The other question of interest related to the feasibility is the usefulness of the trialed outcome measures. We found the M-ABC and PSPCSA to be easy to administer and clinically meaningful in that the data were easy to interpret and reflected constructs that informed the clinicians and parents. The lack of significant findings may be more due to the small sample size than the lack of sensitivity to change over to a relatively short period. The purpose-devised participation questionnaire appeared to gather the answers we hoped for in a timely fashion; however, its overall psychometric strength needs to be confirmed. In future studies, we would recommend one of the longer, established participation questionnaires.

### *Effectiveness*

The assumption that properties of water can be used to develop postural control strategies, and thus improve the timing of stabilizing muscles, guided our hypothesis that aquatic therapy may improve motor skills of children with DCD. There is some evidence from clinical trials that suggests postural sway may be reduced and balance improved by aquatic therapy; however, these trials were conducted on adult populations, with lower limb injuries and/or severe arthritis, sample sizes were small, and randomization processes were not used (Douris et al., 2003; Geytenbeek, 2002; Roth, Miller, Ricard, Ritenour, & Chapman, 2006). Additionally, the water was thought to provide a safe environment to practice movement strategies and specific tasks that could potentially improve skill sets and postural control (Hadders-Algra, 2000). The trend observed for greater motor improvement (both balance and coordination components) in the aquatic group offers support for these arguments.

It has been reported that children with neuromotor impairments generally improved with aquatic therapy; however, these studies were monitoring changes in more profound motor dysfunctions than DCD (for example cerebral palsy) and are therefore difficult to generalize to children with DCD. Interestingly, one study by McManus and Kotelchuck (2007) found statistically significant improvements in gross motor performance in young children with neuromotor impairments receiving aquatic therapy compared to the control. Additionally, these authors reported that the control group's scores decreased, whilst the aquatic intervention group's scores improved slightly, similar to the M-ABC scores in the current study.

Participants in the intervention group showed a trend toward greater improvement in the M-ABC and on the subscale of perceived physical competence of the PSPCSA compared to the control group, whose mean score reduced posttest. It is important to note that the reduction in scores for the control group may represent a variation in performance rather than only a true decline. A clinically significant change for the M-ABC has been reported as requiring a change of 8.9 points though may also be as low as 3.1 (Leemrijse, Meijer, Vermeer, Lambregts, & Adèr, 1999). Three children improved by >3.1 points in the aquatic group and one in the wait-list group, again offering a trend that the effects of aquatic hydrotherapy may be clinically meaningful.

The improvement in the intervention group on the physical competence component of the PSPCSA was minimal (i.e., 5%); however, the control group's perceived physical competence decreased by 10%. This decrease in the control group coincides with the decrease in motor skills found in the M-ABC scores in the control group, lending support to the strength of the trends claimed.

Parents' comments suggest that children in both groups increased their participation in various areas in similar amounts over the testing period, except for social activities, where the control group scored better, though this was not significant. The rationale behind the translation of improved water skills into improved activity and participation levels may lie in the concepts of mastery (the experience of success) as well as the improvement in core motor skills such as balance and body awareness that underpin all motor activities at home and at school. This needs further testing.

As previously stated, the small sample size and potential confounding variables do not permit generalization of the results. Due to the limits in resources, time, and subjects, the study was carried out pragmatically. This pragmatic approach allowed a greater risk of bias or inconclusive findings; however, it also enabled recognition of feasibility issues for future research and clinical practice. As a sample of convenience from an existing clinic, the sample was not representative of the children in the nation or children who have DCD, the subjects were predominantly male (10 males to two females), all were Caucasian, and all were from similar geographical areas. Additionally, subjects (and the treating therapist) could not be blinded, which also introduced a source of potential bias. The addition of a sham or alternate intervention as a comparison would also be useful control comparison. The high rate of altered appointment time meant the trial took an extra 6 weeks for some participants, which may have compromised any effects of intensity of intervention. These potential confounding variables should all be addressed in future research.

## CONCLUSION

Aquatic therapy was a feasible intervention for children with DCD and may be effective in improving their gross motor skills. We recommend that therapists continue to use aquatic physical therapy for children with DCD, but with clear goals and outcome measures for individual children, given the current absence of high-quality evidence. Further research is warranted as establishing effective interventions for children with DCD due to the high incidence of DCD and the potential for ongoing problems in motor, affective, social, and health domains. In particular, aspects of accessibility to a suitable pool and flexibility in times of sessions need to be addressed in a rigorous RCT design, with larger numbers and equally rigorous outcome measures across relevant domains.

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