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Group swimming and aquatic exercise programme for children with autism spectrum disorders: A pilot study

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Abstract
Objective: To evaluate the effectiveness of a 14-week aquatic exercise programme for children with autism spectrum disorders (ASD).
Design: Non-randomized control trial.
Methods: Twelve children participated in this pilot study with seven participants in the aquatic exercise group and five in the control group. The programme was held twice per week for 40 minutes per session. Swimming skills, cardiorespiratory endurance, muscular endurance, mobility skills and participant and parent satisfaction were measured before and after the intervention.
Results: No significant between-group changes were found. Within-group improvements for swimming skills were found for the intervention group. Programme attendance was high. Parents and children were very satisfied with the programme activities and instructors.
Conclusions: This pilot programme was feasible and showed potential for improving swimming ability in children with ASD. Exercise intensity was low for some participants, most likely contributing to a lack of significant findings on fitness outcomes.

Keywords: *aquatic exercise*, *adapted exercise*, *swimming*, *autism*, *Asperger syndrome*, *high functioning autism*

Resumen
Objetivo: Evaluar la efectividad de un programa de ejercicio acuático de 14 semanas con niños con trastorno del espectro autista (ASD).
Diseño: Ensayo clínico no aleatorizado.
Método: Doce niños participaron en este estudio piloto con siete participantes en el grupo de ejercicios acuáticos y cinco en el grupo control. El programa sellevó a cabo dos veces por semana durante 40 minutos por sesión. Se realizaron ejercicios acuáticos, cardiorrespirtatorios, fortalecimiento muscular y movilidad, midiendo la satisfacción de los padres y participantes antes y después de la intervención.
Resultados: No se encontraron diferencias significativas entre ambos grupos.Los padres y niños se observaron muy satisfechos con el programa de actividades así como los instructores.
Conclusión: Este programa piloto mostró potencial para mejorar la capacidad de nado en los niños con ASD. El ejercicio fue de baja intensidad para algunos participantes, contribuyendo a hallazgos significativos en los resultados del estado físico.

Palabras Clave: *ejercicio acuático*, *ejercicio adaptado*, *natación*, *autismo*, *síndrome de Asperger*, *autismo altamente funcional*

Introduction

Daily moderate-to-vigorous physical activity is important for children because it promotes fitness and health and prevents chronic conditions [1]. Initial evidence suggests that physical activity levels for children with autism spectrum disorders (ASD) are lower than for peers without ASD [2, 3]. Children with ASD or other developmental disabilities who have limitations in physical activity are at risk for obesity [4, 5]. In addition, medications used to treat resistant behavioural disorders in children with ASD have been shown to cause weight gain [6]. Incorporating physical activity and healthy diets in conjunction with these prescribed medications has been recommended for weight control [7]. Although

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moderate-to-vigorous physical activity is often recommended for children with ASD to promote health and prevent chronic conditions, it may be difficult for families to promote this level of activity for their children.

School-aged children who are typically-developing tend to select physical activities that can be done with peers such as playing on the playground, participating in sports or being active in recreational programmes [8]. The competitive nature of community-based sports and recreation programmes, however, may limit successful participation of children with ASD. Some children with ASD have physical impairments including decreased trunk strength, co-ordination and gross motor skills which may limit their ability to participate in physical activities with peers [9, 10]. Lack of interest or motivation to exercise may also make it difficult for a child with ASD to comply with daily physical activity recommendations [11]. Children with ASD often have unique ways of learning, paying attention and reacting to sensory input (visual, auditory and tactile) [12–15], which may also limit their ability to participate in physical activities with peers. Limited participation in community-based sports and recreation activities may further restrict experiences in communication and socialization with peers, which is typically an area of difficulty for children with ASD.

The majority of evidence on exercise interventions for children with autism has focused on behavioural outcomes [16]. Only two studies have investigated the fitness outcomes of exercise programmes. The evidence suggests that exercise may improve muscle strength and endurance and aerobic fitness [17] or BMI [18] in children with moderate-to-severe forms of autism. Almost all reported exercise programmes for children with autism have emphasized land-based exercise programmes.

An aquatic exercise programme has the potential for improving fitness in children with ASD. Water provides resistance, which may be used to increase muscle strength and endurance and aerobic capacity while at the same time offering a fun and motivating environment for children. The water environment is also characterized by the properties of buoyancy and hydrostatic pressure which may provide children with ASD with sensory input and postural support to facilitate improvements in sensory and social behaviours (e.g. maintaining eye contact and paying attention) and motor skills [19, 20]. Swimming is often a component of an aquatic exercise programme. Swimming is a recreational activity that individuals with and without disabilities can enjoy across the lifespan.

Aquatic exercise is often recommended as an effective physical fitness activity for children with ASD; however, very little evidence is available to support these recommendations. In a recent article, Pan [21] reported that eight children with high functioning autism or Asperger syndrome who participated in a 10-week water exercise and swimming programme made improvements in aquatic skills and demonstrated an overall decrease in behaviour problems as compared to children in the control group. Improvements in physical fitness and a decrease in stereotypical behaviours were reported for a 9-year-old child with autism after a three times per week swimming programme lasting 10 weeks [22]. In a multiple single subject design study, improvements in aquatic skills were reported for four boys with autism after participating in a 10-week aquatic programme which used constant time delay teaching methods [23]. Another study included children with ASD in their group aquatic exercise programme for children with various disabilities and found improvements in cardiorespiratory endurance and swimming skills after a 14-week intervention [24]. No studies to date have evaluated the effectiveness of aquatic exercise on swimming skills and fitness specifically for children with ASD. The purpose of this pilot study was to examine the effectiveness of a group aquatic exercise programme on fitness and swimming skills for children with ASD.

Methods

Participants

The participants were recruited through flyers sent to local school Special Education Parent Action Committees and autism support groups for families and children. The inclusion criteria were: (1) child diagnosed with an ASD, (2) 6–12 years old, (3) medically able to participate in an aquatic exercise programme, (4) no anticipated medication or other intervention changes during the research study period, (5) no requirement for constant individualized monitoring of medical or behavioural status and (6) able to follow directions and comply with fitness testing. Children were excluded from the study if they had experienced any orthopaedic injuries (fractures or sprains) or surgeries which limited their arm or leg movements within 3 months of fitness testing or if they were scheduled for a medical procedure during the study period. Children were also excluded if they had open wounds or active infections or had marked fearfulness to enter the water which would limit participation in an aquatic programme.

Participants and their parents provided written informed assent or consent to participate in this study. Prior to fitness testing, parents filled out an

eligibility form and a demographic form containing information about their child's diagnoses and other medical information. A convenience sample of 13 white, non-Hispanic children aged 6–12 years participated in this study. One child in the intervention group did not complete the second testing session within 3 weeks of the end of the intervention period due to travel complications and family obligations; therefore, the participant's results were not available for the data analysis. Complete data are available for 12 children with ASD and summarized in Table I. Seven children were in the intervention group and five were in the control group. The participants in this study were functioning on the high end of the autism spectrum and had IQs in the normal range according to parent report. This is consistent with diagnoses of Asperger syndrome, high functioning autism or pervasive developmental disorder–not otherwise specified (PDD-NOS). All participants had some experience being in a community fitness centre or backyard pool with family members and enjoyed being in the water. The majority of children (intervention group $n=6$; control group $n=2$) required floatation devices for safety in the water in these settings.

Children in the control group were asked to maintain their usual schedules, routines and levels of activity. They were asked to refrain from new sports activities or group exercise programmes during the 14-week intervention period. They had the opportunity to participate in an aquatic exercise programme after the intervention was completed.

Procedure

A non-randomized control trial design was used for this pilot study. The first eight participants were assigned to the intervention group and the next five were assigned to the wait-list control group. A wait-list control group provided incentive for control group participation and allowed all children to have access to the aquatic intervention and its potential benefits. This study was approved by the Franciscan Hospital for Children Institutional Review Board.

Outcomes were measured once at baseline before the intervention was initiated and once at the end of the 14-week intervention. Each child was tested individually by a paediatric physical therapist who was masked to the study design and previous test data. The same order of testing was followed for both test sessions and standardized testing procedures were used. Height and weight were recorded at baseline and body mass index was calculated to provide additional health status information.

Outcome measures

Two measures of swimming skills were collected. Parents completed the Swimming Classification Scale at pre- and post-test to provide information about the swimming abilities of their child. The Swimming Classification Scale has five levels ranging from Level 1 to Level 5 (see Table II) [24]. The Swimming Classification Scale has been used in a previous study and was responsive in a sample which included children with ASD [25]. Parents were given a copy of the scale and asked to select the level that best described their child's swimming abilities. In addition, parents completed a demographic questionnaire with 16 items that represented components of the Swimming Classification Scale in addition to other water skills such as submerging face in the water or holding breath while under water.

Table I. Participant characteristics.

Child	Diagnosis	Age	Gender	BMI percentile	Baseline swimming classification scale level*	Medications
Intervention group (Mean age 9.6, SD 2.6)						
1	Asperger syndrome	6.3	M	76	1	none
2	Asperger syndrome	7.4	M	88	1	nasonex, patoral
3	PDD-NOS	7.9	M	75	2	none
4	Asperger syndrome	9.4	M	97	3	ritalin
5	PDD-NOS	10.5	M	38	4	none
6	Asperger syndrome	12.5	F	97	4	none
7	Asperger syndrome	12.9	M	32	1	depakote, risperdal, tenex
Control group (Mean age 9.6, SD 1.3)						
1	PDD-NOS	8.4	M	72	4	none
2	Asperger syndrome	8.8	M	33	2	none
3	PDD-NOS	9.4	M	93	1	singulair, flovent, zantac
4	PDD-NOS	9.6	M	31	4	none
5	High functioning autism	11.8	M	24	4	none

*Swimming Classification Scale Level 1 represents a novice swimming level and Level 5 represents an advanced swimming level. This scale is described further in Table II.

Table II. Swimming classification scale.

Level	Description
1	Unable to swim a lap even *with* a floatation device (e.g. kickboard, aquatic noodle, belt). Requires physical assistance from an adult in order to stay afloat and to move around in the water.
2	Able to swim at least one lap *with* two or more foam pieces on the floatation belt. May require supervision (verbal cueing) from an adult but does not require physical assistance to swim one lap in the pool.
3	Able to swim at least one lap *with* one foam piece on the floatation belt. May require supervision (verbal cueing) from an adult but does not require physical assistance to swim one lap in the pool.
4	Able to swim one lap *without* a floatation device and without stopping. May require supervision (verbal cueing) from an adult but does not require physical assistance to swim one lap in the pool.
5	Able to swim several laps *without* stopping and *without* a floatation device; working on swim stroke techniques for several strokes including backstroke and front crawl. Does not require any physical assistance for swimming.

Responses on these items were consistent with parent ratings on the Swimming Classification Scale and support parents as reliable on classifying their children's swimming abilities. Also, the primary author scored intervention group participants on the Swimming Classification Scale during the first and last swim class sessions and compared these to the parent ratings on the pre-test and post-test Swimming Classification Scores and scores for the first session for the control group were compared to the post-test scores and there was 100% agreement.

The second swimming skills measure, the YMCA Water Skills Checklist [26], was completed by the aquatic staff during the first week of the programme and again on the last week of classes to evaluate improvements in swimming and water safety skills. The checklist consists of seven programme levels ranging from Polliwog (beginner) to Porpoise (advanced) and there are 10–12 water skills at each level. The skills include stroke techniques as well as water safety knowledge and rescue skills.

The YMCA Water Skills Checklist testing was conducted by having each child demonstrate the skill required for each item on the checklist. If the child demonstrated the skill according to the specified criteria, then the item was scored as completed. The aquatic director assisted with recording the item scores for each child and, if there were any disagreements, the child was asked to perform the skill again so that the aquatic staff and aquatic director could re-score that item and come to agreement. The pre-test scores were not available during the post-test scoring so as not to bias the aquatic staff.

Curriculum-based assessment checklists such as the YMCA Water Skills Checklist are commonly used by swim instructors to determine an individual's level of aquatic skills. The checklist provides information about what skills a child needs to function effectively in an integrated class [27]. For this pilot study, the numbers of skills on the checklist that the child completed out of a possible 76 items were summed by the primary author at the end of the study. A pool was not available during the pre-test and post-test sessions for the control group so the YMCA Water Skills Checklist was only completed for the intervention group.

Cardiorespiratory endurance was measured using the half mile walk/run which is an indirect and valid measure of aerobic fitness in school-aged children [28, 29]. Standardized feedback was provided by the tester at regular intervals to keep the child focused on the task. The time it took for the child to complete the distance was recorded. High test–re-test reliability with Intra-class Correlation Coefficient (ICC) = 0.94 (95% Confidence Interval (CI_{95}) = 0.60–0.99); $p = 0.003$ has been established for the half mile for six children with PDD-NOS or high functioning autism [30].

Muscle endurance was measured by the modified curl-up and isometric push-up tests. These tests are valid and reliable measures of muscular endurance for children without disabilities and for children with intellectual disabilities or mild physical impairments [31]. High test–re-test reliability of ICC = 0.89 (CI_{95} = 0.18–0.98); $p < 0.001$ has been established for modified curl-up for six children with PDD-NOS or high functioning autism [30]. Standardized instructions specified in the Brockport Fitness Test manual were used to administer these tests [31].

Mobility skills were recorded using the Multidimensional Paediatric Evaluation of Disability Inventory Mobility scale (M-PEDI) [32]. Parents completed the 159-item standardized questionnaire while their child participated in other testing procedures. The M-PEDI has been used in other fitness intervention studies [24, 33] and includes items which may reflect changes in functional endurance (i.e. walk 1–2 blocks, walk 2–3 miles hiking uphill, run ½ mile, 1 mile or 3 miles without stopping, swim ¼ mile without stopping and tread water for 10 minutes). The test–re-test reliability for the M-PEDI is high (ICC = 0.98) for children with motor impairments [34] and for children with autism and other developmental disabilities [30].

Table III. Intervention components and activities.

Programme components	Specific programme activities
Warm up and aerobic activities	Movement activities in the shallow end for warm up: running in place, jumping jacks, reciprocal arm and leg movements, hopping on one foot, karate kicks, jumping in place and jumping forwards, backwards and sideways
	Swimming laps: Front stroke, elementary backstroke, front crawl, back crawl, breast stroke and kicking with a kickboard
	Obstacle courses: running in the water or swimming while going under, over and around obstacles or retrieving dive rings
	Games: shooting baskets into a basketball net; playing keep the ball away from the coaches; straddle sitting on the aquatic noodle and 'racing the horse' the length of the pool
Strengthening activities	Upper extremity exercises using bar bells or aquatic noodles and water resistance including latissimus pull down, triceps press, bicep curl, chest press
	Lower extremity exercises using bar bells or cuff weights including one-legged heel raises, front leg press, wall squats and straight leg kicks to the front, side and back and lower
	Hip flexion bilaterally while supported on aquatic noodle to work on hip flexors and lower abdominals and supine float to upright sitting as modified sit-ups
	Climbing out of pool not using the ladder and jumping into the pool
Cool-down and stretching	Movement activities in the water at a slow pace including marching in place, arm circles, and leg circles
	Stretching in the shallow end of the pool: stretches were held for 20–30 seconds and repeated twice for each side. The following muscles or muscle groups were targeted: pectorals, latissimus, triceps, trunk lateral flexion stretch, hamstring, quadriceps and plantarflexors

Satisfaction was measured with programme satisfaction questionnaires which were completed at the end of the 14-week aquatic programme by children in the intervention group and their parents. The parent questionnaire was specifically designed to evaluate a group exercise programme and has been used in previous fitness interventions [24, 33, 35]. Face and content validity of the parent questionnaire were established by four physical therapists, one occupational therapist and two parents of children with disabilities and revisions were made. The child version of the questionnaire was designed for this study. It was reviewed for clarity and comprehension by three school-aged children who had participated in other fitness interventions and had a diagnosis of ASD or cerebral palsy.

Intervention

The group aquatic exercise programme was held two times per week for 14 weeks at a YMCA. The 40-minute programme consisted of 20–30 minutes of aerobic activities, 5–10 minutes of muscular strength and endurance training and 5 minutes of cool down and stretching activities. A certified lifeguard was present for all pool sessions. A paediatric physical therapist supervised all pool sessions. In addition, a 1:2 adult-to-child ratio of YMCA aquatic staff to participants was provided to ensure safety and optimal participation. The aquatic staff provided instruction on swimming techniques and assisted children with the exercises.

The exercise programme consisted of lower body and trunk strengthening using foam barbells, cuff weights, aquatic noodles and water resistance. For the aerobic conditioning component children participated in swimming laps, shallow water running, jumping and hopping activities and ball games with a focus of increasing their heart rates so they exercised at a moderate-to-vigorous intensity (Table III). Participants used a variety of swimming strokes depending on their skill level—some strokes that they had mastered and some that they were learning. Children who were learning to swim (Swimming Classification Scale Levels 1 or 2) primarily worked on front stroke and elementary back stroke; whereas children who were at Swimming Classification Scale Levels 3–5 practiced a variety of swimming strokes including front crawl, back crawl, breast stroke and side stroke. The training intensity was set at 50–70% of maximum heart rate (HR) and calculated using the Karvonen equation: [(Maximum HR − Resting HR) × (50–70%)] + Resting HR. An estimated maximum HR of 200 [36] and resting HR ranging from 70–90 were used to calculate the training heart rates which ranged from 135–167 beats per minute.

Heart rate was monitored during one exercise class per week for each participant using chest strap heart rate monitors (Polar™) typically used by athletes. At the end of each session, the amount of time each child spent in the target heart rate zone was recorded. Exercise dosing includes programme frequency, duration and intensity. The intended exercise dosing plan for this study was 20 minutes of moderate-to-vigorous exercise two times per week during the first 2 weeks, progressing to 30 minutes or more per class for 12 weeks. This exercise dose was

selected because it was effective for improving cardiorespiratory endurance in a previous aquatic exercise study that included children with ASD [24] and it was feasible considering the community setting and funding available.

Several programme adaptations were used to address the unique sensory and social-emotional needs and learning styles of children with ASD. Aquatic staff provided concrete verbal instructions combined with demonstration. Exercises were simplified and physical guidance of the movements was provided as needed so children would succeed in the activities. To address sensory processing and modulation difficulties, the use of earplugs to muffle sounds, a wet suit to increase tolerance to the cool water and well fitting goggles to reduce eye irritation were recommended as needed. For the programme one child used earplugs, two children used a wetsuit shirt or vest and six children used swim goggles. A written schedule of exercises and activities was posted for each session for added structure. The number of laps a child completed during a session was recorded and children were encouraged to improve their lap record at each session.

Data analysis

Because groups were not randomly selected, this study examined the extent of differences in key confounding variables between intervention and control groups. These variables included age, gender, diagnosis and pre-intervention outcome measures using Chi-square or independent sample *t*-tests.

Between-group differences (differences in post-tests between the aquatic intervention and wait-list control groups) were determined using independent sample *t*-tests for interval data. Between-group differences on the Swimming Classification Scale was determined using the Mann-Whitney *U*-test for ordinal rank data. Paired *t*-tests were used to determine within group change in the YMCA Water Skills Checklist because this outcome was only measured in the intervention group pre- and post-intervention. In addition, the Wilcoxin signed ranks test was used to evaluate within-group change on the Swimming Classification Scale for the intervention group.

Response percentages were calculated for the close-ended items on the satisfaction questionnaires. Responses to the open-ended questions on the parent satisfaction questionnaire were reviewed and key themes were identified.

Results

At baseline, there were no significant differences between the intervention and the control groups on demographic variables (age, gender and diagnosis) or on any of the other pre-test baseline scores for the outcomes measures of the Swimming Classification Scale levels, cardiorespiratory endurance, M-PEDI scores or isometric push-up scores. However, there was a significant difference on the baseline modified curl-up scores, with the control group scoring significantly higher than the intervention group.

After the 14-week intervention, no significant between-group differences were found. Between-group effect sizes ranged from moderate (0.66) on the Swimming Classification Scale to low (0.18) on mobility skills (M-PEDI). Significant within-group differences were found for the intervention group on the YMCA water skills checklist ($p = 0.001$) and the Swimming Classification Scale ($p = 0.02$) (see Table IV). Within-group effect sizes

Table IV. Results.

Outcomes	Group	Pre-test mean (SD)	Post-test mean (SD)	Between group mean difference	Within group mean difference
Swimming Classification Scale (levels)	Intervention	2.43 (1.13)	4.14 (0.69)	0.54	1.71[a]
	Control	3.40 (1.52)	3.60 (1.14)		0.2
YMCA Water Skills Checklist (raw scores)	Intervention	35.57 (28.37)	44.29 (24.47)	N/A	8.72[b]
½ mile walk/run (minutes)	Intervention	7.60 (1.36)	6.88 (1.11)	0.44	0.72
	Control	7.48 (0.85)	7.32 (1.11)		0.16
Mobility skills (scaled scores)	Intervention	75.17 (8.28)	77.42 (11.72)	1.59	2.25
	Control	75.12 (4.92)	75.83 (4.71)		0.71
Modified curl-ups (repetitions)	Intervention	7.57 (4.24)	13.0 (3.46)	1	5.43
	Control	14.0 (3.61)	12.0 (4.64)		−2
Isometric push-up (seconds)	Intervention	9.43 (9.0)	17.57 (10.28)	5.41	8.14
	Control	13.85 (8.05)	12.16 (10.62)		−1.69

[a]Significant within-group difference, $p = 0.02$.
[b]Significant within-group difference, $p = 0.001$.

ranged from high (1.51) on the Swimming Classification Scale to low (0.27) on the mobility skills (M-PEDI). All of the children in the intervention group improved one or more levels on the Swimming Classification Scale, including three children who improved by two levels and one child who improved by four levels. One child in the control group improved by one level and the other four children stayed at the same level on the Swimming Classification Scale.

On the programme satisfaction questionnaire, parents reported high levels of satisfaction with the programme activities, aquatic instructors and class size, as shown in Table V. All of the parents reported that their child made improvements in strength, endurance and swimming skills as a result of the programme. Overall, parents reported that their children enjoyed the programme and the programme provided an opportunity for exercise. One parent commented 'Don't change anything. Our son had a great time and got exercise. Those two things together are rare and greatly appreciated'. Most parents also mentioned the positive social aspects of the programme. Another parent noted 'My child always looks forward to going to the class and interacting with the friends he has met'.

Overall, participants liked the aquatic exercise programme and reported that they made improvements in swimming skills and endurance (see Table VI). Participants especially liked swimming laps and playing water games. They also liked being with the other children and instructors during the classes. Children reported that they did not like leaving the pool or taking a shower at the end of the class.

Of the 28 scheduled pool sessions, all of the children attended 22 or more sessions. Attendance ranged from 79–100%. The average time children exercised in their THR over the 14-week intervention was 15.4 minutes during a 40-minute class and the range was 3–36 minutes (Figure 1). For weeks 2–4, children spent an average of 9.3 minutes of a class in their THR and by weeks 12–14, children spent an average of 20 minutes exercising in their THR. A significant difference ($p = 0.01$) was found between amount of time children were able to exercise in their THR at the beginning of the programme and the last 4 weeks of the programme.

Discussion

Aquatic programmes are frequently recommended as a way to increase physical activity for children with ASD; however, very little information is available on the effects of an aquatic exercise programme on improving swimming skills and fitness in children with autism. The purpose of this pilot study was to examine the effectiveness of a group aquatic exercise programme for children with ASD. Significant improvement in swimming skills was found for the intervention group; however, no between-group differences were found for any of the outcomes. These non-significant results may be due to Type II error in that the small sample sizes for each group limited power of the study to detect group differences even if they did exist. Other positive trends suggest that this pilot aquatic programme may have resulted in significant group differences if a larger sample size was used. A within-group intervention analysis confirmed that swimming skills improved in the intervention group. The muscular endurance variables (isometric push-up and modified curl-ups) had large within-group effect sizes ranging from 0.90–1.28, but did not meet the cut-off for statistical significance, possibly due to the small sample size. Overall, participants and their parents were satisfied with the aquatic programme.

One other pilot study evaluated the effects of a swimming programme for children with high functioning autism and Asperger syndrome and found similar results of improved swimming skills after a10-week programme [21]. That study focused on social skills and behavioural outcomes and did not focus on fitness parameters or exercise intensity. Although this study did not formally measure behaviour for the participants, the majority of parents of the participants in the intervention group commented on improvements in behaviour as a result of the aquatic programme. They commented on the programme satisfaction questionnaire that, after swimming classes, children had fewer negative behaviours and demonstrated better attention and focus while doing their homework. They also noted that social skills during the group sessions were better, such as increased eye contact, engaging in appropriate conversation with peers and instructors and following class rules and class routines.

A low exercise dose may have influenced the outcomes. Programme duration and frequency was 40-minute sessions held twice per week for 14 weeks and programme attendance was high. However, exercise intensity for each participant varied over the course of the 14-week programme. The intended exercise dosing plan for this study was 20 minutes or more of moderate-to-vigorous exercise two times per week during the first 2 weeks, progressing to 40 minutes per class, but instead the exercise intensity was lower for most participants. Some of the children spent a large portion of their time in the aquatic exercise programme floating or swimming slowly, which resulted in minimal increases in heart rate and less vigorous physical activity levels.

Table V. Parent version: Programme satisfaction questionnaire results.

	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
Overall programme satisfaction					
Overall, how would you rate your satisfaction with the aquatic exercise programme?	85.7%	14.3%	0%	0%	0%
Were you satisfied with the aquatic exercise programme class instructors?	85.7%	14.3%	0%	0%	0%
Were you satisfied with the facility (pool, changing rooms, parking, accessibility)?	28.6%	42.9%	14.3%	14.3%	0%
Were you satisfied with the location of this aquatic exercise programme?	71.4%	28.6%	0%	0%	0%
Were you satisfied with your child's accomplishments after participating in this aquatic exercise programme?	57.1%	28.6%	14.3%	0%	0%
Were you satisfied with the *fitness testing procedures* at the beginning and end of the programme?	85.7%	14.3%	0%	0%	0%
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Programme activities					
The aquatic exercises and activities were at an appropriate level for my child (not too easy and not too hard)	42.9%	28.6%	28.6%	0%	0%
The aquatic exercise classes were interesting and held my child's attention most of the time	42.9%	57.1%	0%	0%	0%
The class size (number of children who attended the aquatic exercise programme) was appropriate	71.4%	28.6%	0%	0%	0%
The classes provided opportunities for social interaction with other children.	57.1%	42.9%	0%	0%	0%
Two times per week was the right amount of time for the aquatic exercise classes.	28.6%	57.1%	14.3%	0%	0%
The 45-minute aquatic exercise class was a good length of time for my child.	57.1%	42.9%	0%	0%	0%
Programme instructors					
The class instructors created a fun atmosphere where my child felt welcomed and motivated to participate	85.7%	14.3%	0%	0%	0%
The class instructors provided my child with sufficient instructions and assistance	85.7%	14.3%	0%	0%	0%
The class instructors had the appropriate knowledge and expertise to work with my child	57.1%	42.9%	0%	0%	0%
The class instructors were responsive to my suggestions	42.9%	28.6%	28.6%	0%	0%
There were enough instructors to assist and supervise my child to ensure safety during the aquatic exercise programme	85.7%	14.3%	0%	0%	0%
Facility					
There was enough exercise equipment for my child to use during the aquatic exercise classes	85.7%	14.3%	0%	0%	0%
The pool was an appropriate size for the aquatic exercise classes	71.4%	28.6%	0%	0%	0%
The pool was accessible for my child	85.7%	14.3%	0%	0%	0%
The changing rooms were accessible	42.9%	14.3%	28.6%	14.3%	0%
Adequate parking was available	85.7%	14.3%	0%	0%	0%
Child's accomplishments					
After participating in the aquatic programme, my child's *strength* (ability to lift heavier objects/toys, kick a ball harder, etc.) improved	42.9%	42.9%	14.3%	0%	0%
After participating in the aquatic programme, my child's *endurance* (ability to participate in movement activities for longer periods) improved	42.9%	57.1%	0%	0%	0%
After participating in the aquatic programme, my child's *self esteem/confidence* improved	42.9%	42.9%	14.3%	0%	0%
After participating in the aquatic programme, my child's *balance* (ability to move around without tripping and falling) improved	28.6%	57.1%	14.3%	0%	0%
After participating in the aquatic programme, my child's *gross motor skills* (ability to run/walk, catch a ball, jump, etc.) improved	28.6%	42.9%	28.6%	0%	0%
After participating in the aquatic programme, my child's *ability to participate with a group of children* improved	14.3%	71.4%	14.3%	0%	0%
After participating in the aquatic programme, my child's *swimming skills* improved	85.7%	14.3%	0%	0%	0%

Table VI. Child version: Programme satisfaction questionnaire.

	Response ratings				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The swim programme helped me learn how to swim or to improve my swimming skills	71.4%	28.6%	0%	0%	0%
The swim programme helped me to swim for a longer period without getting tired	42.9%	42.9%	14.3%	0%	0%
Would you be interested in doing the swim programme again?	Yes = 100%	No = 0%			
	I liked it a lot	I liked it	I liked it a little	I did not like it	I really did not like it
Overall, how did you like the swim programme?	85.7%	14.3%	0%	0%	0%

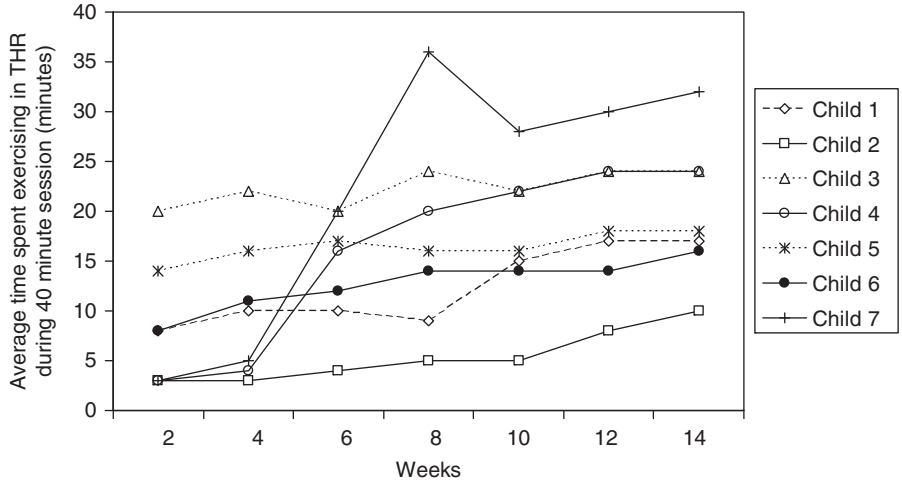

Figure 1. Amount of time participants exercised in target heart rate range during 14-week aquatic exercise programme.

The lower exercise intensity coupled with a short duration of a 14-week programme most likely influenced the outcomes because children were exposed to low doses of moderate-to-vigorous exercise. In another study, a twice per week aquatic aerobic exercise programme lasting 14 weeks was sufficient to improve cardiorespiratory fitness in children with autism and other disabilities as reported by the half mile walk/run [24]. In that study, the majority of children with autism achieved the desired exercise dosing. Other aquatic or land-based aerobic exercise programmes for children with a variety of disabilities have resulted in improvements in exercise capacity or other aerobic outcomes. These studies have employed longer exercise frequencies and durations ranging from three times per week for 12 weeks to twice per week for 8 months [37–40]. In future studies, an increase of exercise dosing by increasing frequency, duration and/or intensity should be considered.

The goals of the aquatic programme were to increase cardiorespiratory endurance and muscular endurance in addition to improving swimming skills; however, all three goals may not have been fully addressed in all of the aquatic exercise sessions. Based on observations of the intervention sessions and post-intervention interviews with the staff, more programme emphasis was focused on swimming techniques than on muscular endurance and cardiorespiratory endurance activities. Regardless, the high within-group effect sizes for the muscular endurance tests suggest that these changes may be detectable in studies with larger samples.

Lack of change in some of the measures may reflect the choice of outcomes. Performance on the half mile walk/run may be influenced not only by cardiorespiratory performance but also by motivation and interest in the test. In the future, another option may be to use a timed swimming test to see if children can swim greater distances in a set time (i.e. a test akin to the 6-minute walk test over ground). Also, in the future, it may be useful to use a sub-maximal treadmill test where the speeds and grades are pre-determined and the outcome is heart rate (HR) and oxygen consumption (VO_2) at set stages of the exercise test as well as endurance (time the child can walk and run). Treadmill tests have been shown to be reliable measures of aerobic

capacity for children with autism, multiple disabilities and those without disabilities [41, 42]. Practice sessions to familiarize children with the task of treadmill walking and running would be necessary prior to pre-test sessions. As for mobility skills, the M-PEDI was chosen because it covers a wide range of ages, it can be completed by parent report and it has some items which may reflect functional mobility changes as a result of improved fitness and physical activity. For a programme of short duration with little direct practice of the mobility skills of walking long distances and potential ceiling effects since most of the children scored within 2 SD of the norm, this may not be the appropriate measure. An intervention with a longer duration and/or intensity as well as use of other activity or participation level measures such as the Canadian Occupational Performance Measure [43] may be worthwhile to investigate in future studies. Also, quantitative measures of physical activity in the child's community environment may help assess if the intervention is associated with increased physical activity and participation opportunities. Pedometers or accelerometers may be useful measures to examine physical activity levels and activity logs would help describe the types of activities performed. Accelerometers also allow for estimates of energy expenditure to measure physical activity intensity. Lastly, adding a retention phase in future research would be helpful in understanding the lasting effects of this type of intervention.

Participant and parent satisfaction with the programme was high. At the end of the 14-week aquatic programme, all of the children in the intervention group were given the option to participate in a second 14-week session. All of the children participated in the second session. The programme was appealing to participants as noted by high attendance rates and continued participation in the programme. The high attendance rate and high child and family satisfaction ratings also suggest that this programme is feasible to implement in a community-based setting.

Only one child in the control group improved by one level on the Swimming Classification Scale and later it was reported that the child participated in weekly private swimming lessons during the intervention period. He still required a floatation device to swim a lap in the pool even after the private swimming lessons (Level 2). This child went on to participate in the second session of the programme and by the end of the 14-week intervention he had reached level 4 of the Swimming Classification Scale. His data were used in an 'intention to treat' analysis. All of the children in the intervention group made improvements of one or more levels on the 5-level Swimming Classification Scale. At the start of the programme, the majority of participants in the intervention group (six out of seven) required assistance or floatation support for swimming and, by the end of the 14 week programme, all but one child was able to swim without floatation equipment. The ability to swim without a floatation device or assistance is an important recreational skill for children to develop.

One study limitation is the Swimming Classification Scale and the YMCA Water Skills Checklist have not been validated. The authors felt that other measures were not appropriate for this group of children who had high functioning cognitive abilities and a wide range of swimming abilities. Therefore, to strengthen the study design, two measures were used to report changes in swimming skills. One of the measures was completed by parent report (Swimming Classification Scale) and the aquatic staff completed the other measure (YMCA Water Skills Checklist). These measures were highly correlated for the seven participants (Pearson correlation $= 0.91$, $p = 0.005$). In future studies and with additional funding, a tester masked to the study design and group allocation would record swimming abilities in the intervention and control groups pre- and post-intervention.

The small sample size and lack of randomization were also limitations of this study. This pilot study, however, provides preliminary information about programme implementation of a community-based group exercise programme. The results of this pilot aquatic exercise programme support further study and suggest potential sample sizes needed in the future. The analyses of the magnitude of effect sizes between groups suggest that, in addition to the swimming tests, the isometric push-up test and the half mile walk/run test may have potential as important measures of fitness post-intervention. For example, 32 children would be needed per group to detect a significant change (average of 5 or more seconds) in the isometric push-up test with a power of 0.80 and alpha of 0.05. The sample sizes needed for detecting changes in the swimming skills, half mile and muscle endurance tests are not unreasonable and can certainly be a goal in planning future randomized clinical trials. Sample sizes in future randomized controlled trials will also be strongly influenced by subject variability on the primary outcome measures. Variability of scores was noted on most of the outcomes. Ages, swimming abilities or types of ASD may need to be restricted in future trials for a more homogeneous group to increase power and detect true group differences. Using information from the programme implementation, dosage and power analysis from this pilot, a future randomized control trial study design can be more appropriately designed to examine benefits of

community-based health and recreation programmes for children with ASD. Use of a standardized measure such as the Social Responsiveness Scale [44] to better describe the sample is suggested for future studies.

This pilot programme was feasible as implemented with a lifeguard for every session, a 1 : 2 adult-to-child ratio and structured activities. The programme was safe in that no injuries or adverse events were reported. In addition, all of the participants were high functioning in terms of physical, communication and behavioural abilities and did not require one-to-one supervision. A group swimming and aquatic exercise programme may provide children with ASD the opportunity to get physical activity in a social setting. The positive properties of water such as buoyancy and hydrostatic pressure may complement the sensory deficits and decreased muscular and cardiorespiratory endurance which frequently challenge children with ASD, allowing these children to exercise successfully in a 'just right' environment. Group swimming and aquatic exercise has the potential for providing exercise in a social environment and this may have positive aspects on social development and self-esteem in addition to positive effects on health for children with ASD. Swimming is a total body exercise that involves bilateral arm and leg movements and provides opportunities for children with ASD to practice a variety of movement patterns. Learning to swim independently can open up fitness and recreational opportunities for children with ASD. Swimming has the potential to be a socially appropriate lifetime activity that can provide physical activity as well as opportunities for children to participate with peers in a community setting.

Conclusion

A need for effective group exercise programmes for children with ASD exists. This group swimming and aquatic exercise programme which was held in a community setting was well received by participants and their families. Improvements in swimming skills were found for the intervention group. This type of programme has potential to promote fitness and physical activity for children with autism. Exercise intensity should be taken into consideration even during recreational physical activity to insure that children are truly getting sufficient moderate-to-vigorous physical activity. Opportunities to be physically active and to improve fitness and swimming skills may assist children with developing more active lifestyles, improving health and preventing chronic conditions. Future research is needed with a larger sample size and a focus on exercise intensity to provide evidence to support the effectiveness of aquatic exercise for improving swimming skills and fitness.

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