THE EFFECTS OF AQUATIC PROGRAMS ON STUDENTS WITH DISABILITIES FITNESS AND SKILL-BASED OUTCOMES; A META-ANALYSIS

By

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ABSTRACT

THE EFFECTS OF AQUATIC PROGRAMS ON STUDENTS WITH DISABILITIES FITNESS AND SKILL-BASED OUTCOMES; A META-ANALYSIS

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The purpose of the meta-analysis was to determine the impact of aquatic-based interventions on health-related fitness and skill-based outcomes for children with disabilities. PRISMA guidelines were used to complete the procedures of the meta-analysis. Twenty-three studies met the inclusion criteria and results indicate that overall, aquatic programming likely positively affects students with disabilities and health-related fitness outcomes. Recommendations provide direction for future studies to help improve intervention results.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Department of Health and Human Services *Youth Physical Activity Guidelines* (2018) recommends school aged children aged 6 to 17 complete 60 minutes or more of moderate-to-vigorous physical activity per day. Unfortunately, most children do not meet the recommended guidelines which has resulted in documented declines in overall health status (i.e., body composition, fitness; Masanovic et al., 2020). Researchers have concluded that childhood patterns that facilitate inadequate physical activity increase serious health concerns children may face later in life (Boreham & Riddock, 2001; Kushi et al., 2006). Additionally, children with disabilities are more prone to decreased activity levels (Rimmer et al., 2004) when compared to their typically developing peers (Fraga-Pinkham et al., 2011; McCoy et al., 2016). A recommended physical activity for both children with disabilities and their typically developing peers is aquatic activities (Sato et al., 2015). Opportunities to participate in aquatic programming are often provided as a part of physical education programming in schools for students to develop and maintain physical activity guidelines (Cardon et al., 2004; Rasberry et al., 2011). Additionally, schools may also provide adapted physical education for students with disabilities to improve their motor skill competence, movement concepts, social responsibility, and maintaining health and physical fitness (Mcnamara & Pan, 2020).

Reports often show there are declines in daily physical activity levels among children beginning in their formative years (Strong et al., 2005). When children do meet the above recommended physical activity guidelines, researchers have reported the benefits of physical activity include improvements in muscular strength, bone density, cardiovascular health, and body composition (Obrusnikova & Miccinello, 2012). Additionally, researchers have concluded that childhood patterns that facilitate inadequate physical activity increase serious health concerns children may face later in life (Masanovic et al., 2020). Since children and adolescent physical activity levels decrease as age increases across a number of demographic variables, understanding how health is affected across different groups becomes important.

A population of children that experiences larger numbers of decreased physical activity levels is children with disabilities (Rimmer et al., 2004). The Centers for Disease Control (2016) reported that obesity rates are 38 percent higher in children with disabilities compared to children without disabilities. Several reasons for the differences in activity levels (e.g., physical challenges, motor deficits) for children with disabilities have been studied with numerous and disparate results (Bloemen et al., 2014). Children with disabilities often face physical challenges that may lead to less physical activity and some of these challenges include motor deficits, several compounding issues stemming from the challenges of multiple disabilities, and at times a need for instruction from qualified professionals to best work with their specific needs (Fraga-Pinkam et al., 2010; Healy et al., 2017; Healy et al., 2018; Must et al., 2015; Obrusnikova & Miccinello, 2012; Rasberry et al., 2011). Most often children with disabilities also need further assistance and supervision when participating in programs and because of issues like parental time constraints, lack of peer exercise partners, lack of opportunities to participate in community activity and organized sports teams, and the high costs of joining programs, many of these children do not have the opportunity to join different programs that may be offered for other children (Fraga-Pinkham et al., 2010; Healy et al., 2017; Healy et al., 2018; Majnemer et al., 2008; Must et al., 2015; Obrusnikova & Miccinello, 2012; Rasberry et al., 2011; Rimmer et al., 2004). Additionally, some of the social constraints that children with disabilities face like behavioral struggles, preference for solo screen-based sedentary activities, communication deficits, and the anxiety surrounding the competitive nature of sports can also deter children from participating in physical activities (Fraga-Pinkham et al., 2010; Healy et al., 2017; Healy et al., 2018; Must et al., 2015; Obrusnikova & Miccinello, 2012; Rasberry et al., 2011).

Schools provide an opportunity for students to develop and maintain physical activity guidelines as well as support children in their growth in motor development, known as physical education (Rasberry et al., 2011). Due to increased obesity rates amongst school-aged children in the United States, a need for physical education became more necessary (Pate et al., 2006). Physical education programming is designed for students of all abilities, but many schools offer additional programming with adaptations for children with disabilities known as adapted physical education. Adapted physical education programs offer education to help improve their motor skill competence, movement concepts, social responsibility, and maintaining health and physical fitness (Mcnamara & Pan, 2020). Students participating in adapted physical education helps individuals reach their health and fitness related goals that may not be included in general physical education (Mcnamara & Pan, 2020).

Programming in adapted physical education often recommends aquatic interventions for students due the effects of buoyancy and fewer movement restrictions (Broach & Dattilo, 1996). Research has reported that aquatic activities and sports can better a person's overall physical health by improving a participant's cardiovascular health, muscular strength, coordination, mobility, spatial awareness, and decrease pain (Fraga-Pinkham, 2010; Hall, 2013). Additionally, another major benefit of involvement in aquatic interventions is the minimal pressure it puts on an individual's joints due to the buoyancy of the water (Hall, 2013; McNamara et al., 2015). Previous research also notes that aquatic programming has numerous psychological benefits like increased socialization, enhanced self-confidence, decreased anxiety, and improved body image (Broach & Dattilo, 1996; Scott et al., 2020).

Based on the recommendation and frequency of aquatic activities/programming, the purpose of the current investigation was to determine the effectiveness of aquatic-based interventions for children with disabilities in school programming. Past research has indicated a lack of aquatic program intervention details as well as limited understanding of water-based modalities (Kārkliņa et al., 2013). Other research has indicated a decline in physical fitness for students around the world (Masanovic et al., 2020). Due to the lack of research in the overall understanding of the implementation of aquatic interventions and their impact on children with disabilities in physical activity contexts, it will be important to understand the specific impacts of aquatic activities and sports on the physical health and well-being of children with disabilities. Previous meta-analytic reviews have made suggestions to improve the implementation of aquatic programs for different populations, such as incorporating land exercises with the interventions, changing water temperatures based on participant needs, having appropriate amount of supervision for increased participation, and increasing duration of the interventions (Depiazza et al., 2019; Lahart et al., 2018; Oh & Lee, 2021). However, the efforts of these previous reviews have not provided a comprehensive summary of how aquatic programming and/or interventions includes health-related fitness, skill-related fitness, and/or motor skill development as the aquatics programming is regularly prescribed for children and adolescents with disabilities to improve gravity/land-based movement outcomes. Therefore, the primary purpose of this investigation was to determine the impact of aquatic-based interventions on health-related fitness levels, skill-related fitness levels, and motor skill development for children with disabilities.

METHODS

Search Strategy

The author began the study by searching the literature with several keywords using the PRISMA guidelines (Moher et al., 2009). The keywords determined by the authors when searching the databases for articles to be included were: *swimming, aquatics, aquatics sports, physical education, education, adapted physical education, physical activity, adapted physical activity, community programs, interventions, experiment,* and *control.* When searching using the specified keywords, combinations of the keywords were used identifying the water-based activity (aquatics, swimming, aquatic sports), setting/context (adapted physical education, adapted physical activity, physical education, physical activity, community programs, etc.), and design of the study (intervention, etc.). The combinations of the keywords were used in multiple academic search databases including *Sports DISCUS, Dissertations and Theses- Humanities and Social Science Collectors, ERIC, PubMed/Medline, Child Development, and Academic Studies*. After the searches were completed, a three-step process was initiated to screen the first portion of saved articles. Stage one consisted of the author conducting the first initial searches using the keywords previously determined. When searching, the author would read the titles of the articles and save ones they felt were relevant to the study. Once saving the articles into *EndNote 20X*, the database was screened for duplicate articles and removed those that were found. During stage two, the author read the abstracts of the articles saved to *EndNote 20*, to determine if the articles meet the inclusion criteria initially determined prior to the searches. If the abstract was unavailable, the study was excluded. In stage three, the author then read the full texts of the final articles and excluded ones that did not meet the inclusion criteria.

Inclusion and Exclusion Criteria

An inclusion criterion was implemented during the study for the searches to decide what articles would be saved. The inclusion criteria for the study included: (a) the study was conducted in physical education/physical activity setting in which inclusion of students with disabilities occurs in students ages 3-22 years; (b) the study described a practice, program, or intervention implemented in a water-based environment and connected to school-based physical education programming; (c) the study reported health-related, skill-related fitness, and/or motor skill development outcomes from the aquatics environment; (d) study has included quantitative descriptive statistics and/or inferential statistics to be able to estimate an effect size; and (e) the study was in the English Language and was conducted between January 1970 and December 2022.

Coding and Data Extraction

To begin coding and data extraction, the authors follow the formalized process established by Brown, Upchurch, & Acton, (2003). The information from the study was divided into three parts categorically: *methodological*, *participant*, and *study features*. The methodological category included the design of the study (i.e., within or between subjects), duration of the study (weeks), setting of the program (i.e., school, community, or therapeutic), type of training with specialized instructors (i.e., aquatic training, disability training, no training), the focus of the program (i.e., games, technique, exercise). The participant information included location/country, gender, country, disability, and sample size. The study features that were coded included the outcome measures (i.e., objective measures, subjective measures, or both), whether the study was funded or unfunded, and publication status (unpublished or published). The coder then independently reviewed and reported the codes for each study that met the predetermined inclusion criteria; these codes were examined to search for any discrepancies between the previous coding. Disparities between study codes were analyzed and determined as factual or interpretive. All factual errors were corrected; interpretative errors were reviewed and determined the appropriate code by an addition coder.

Outliers

Studies with two standard deviations above or below the overall mean effect were outliers and were identified from the residual scores (z-scores). If an outlier was present then a sensitivity analysis was performed to determine each study's influence on overall results and the final decision to retain or remove the study (Greenhouse, 1994). If results remained significant ($p<0.05$) and within the 95% confidence interval, then the outlier was retained.

Publication Bias

Publication bias is considered to the influence of missing information from studies that may not be included in meta-analytic results (Rothstein et al., 2005). While a comprehensive search strategy was developed to review both published and unpublished literature additional analyses were required. In order to determine the likelihood of publication bias, four separate procedures were to identify and determine the impact of publication bias. The initial process began by observing the a funnel plot which places each study in the analysis using the standard error (y-axis) and effect size (x-axis) to determine if the plot was either symmetrical or asymmetrical. If there was asymmetry within a funnel plot, then a "Trip and Fill" procedure was performed to identify missing studies and their placement on the funnel plot as well as adjust the effect size and corresponding statistics (Duval, 2000 a, b). The two final analyses were used to evaluate the influence of small study effects were a rank order correlation procedure and a regression intercept method to determine the contributions of studies with smaller sample sizes on overall summary findings (Begg & Mazumdar, 1994; Egger et al., 1997).

Effect Size Calculations

Comprehensive Meta-Analysis (CMA) version-4 software was used to calculate effect size statistics (Borenstein, 2022). The effect size metric system selected was Hedges *g* because the number of studies did not meet a threshold ($k > 20$) which would potentially overestimate the summary effect (Hedges, 1981). Data was extracted from the studies for the primary methods to estimate effect size calculations included means (M), sample sizes (N), and standard deviations (SD). If the primary methods for data extraction were not available within the study the F-values, t-values, and/or P-values were then extracted in replacement (Rosenthal, 1994). A random effects model was used to interpret meta-analytic results for the summary effect size(s) as there was expected sampling error and between study variance for studies to be included in the analyses (Borenstein et al., 2009). Cohen's (1988) criteria for estimated effect size can be interpreted by size: small (>0.20), moderate (>0.50), and large >0.80).

Heterogeneity of Variance

Heterogeneity of variance was expected given the literature and types of studies that were included in the analysis. To evaluate heterogeneity of variance four separate metrics were used and included prediction intervals, the Q-value, tau-squared (τ^2), and I-squared (I^2). The Q-value provides an interpretation of the observed dispersion and precision between studies (Borenstein et al., 2019) The tau-squared value estimates the amount of variance between studies based on the true effect size. I-squared value provides an estimation of the ratio between the true and observed study effects with larger values (0 – 100 percent) which would allow moderator analyses to explain additional variability (Borenstein et al., 2019).

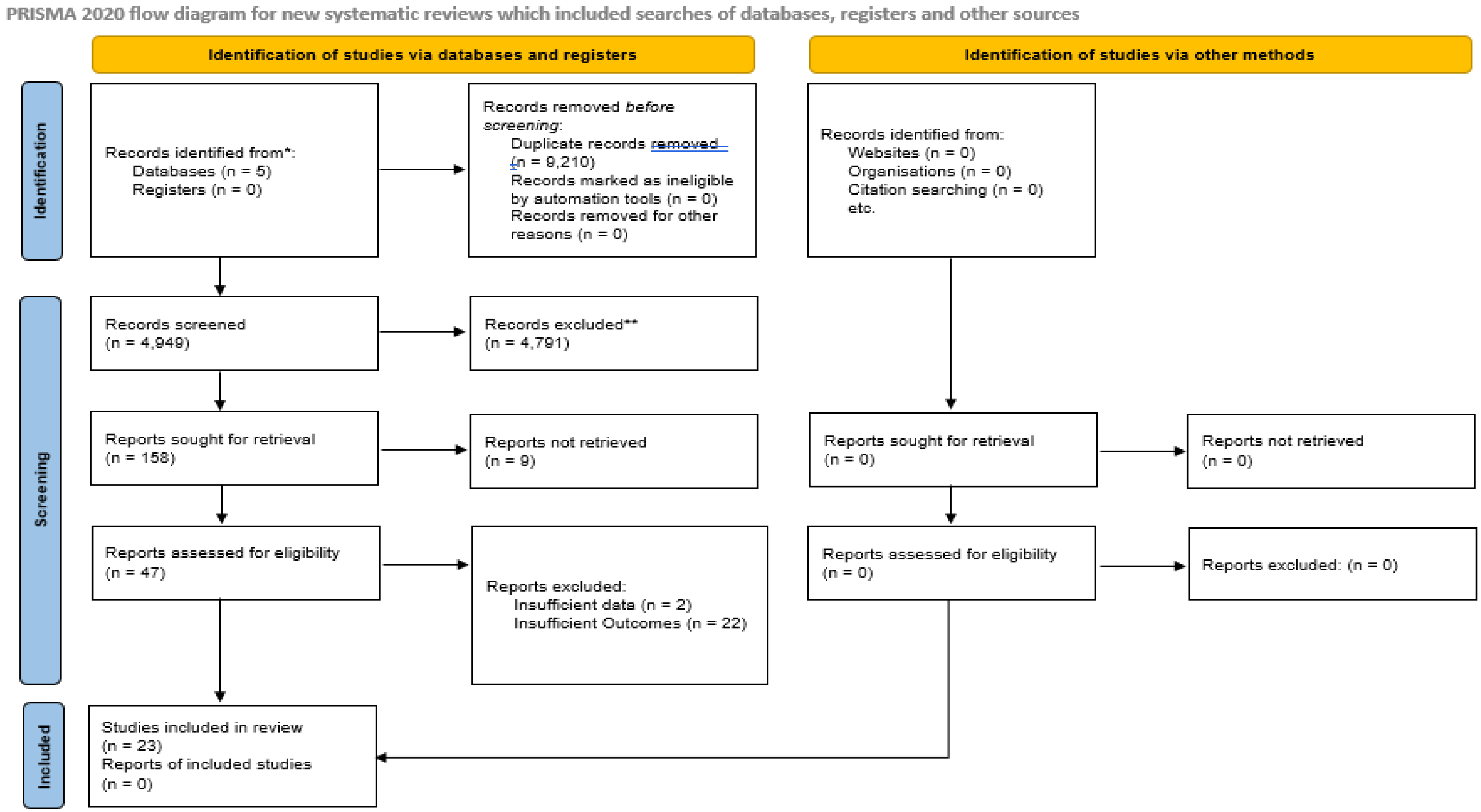
RESULTS

The primary purpose of the meta-analysis was to determine the effectiveness of aquatic-based interventions on health-related fitness, skill-related fitness, and skill development outcomes for children with disabilities. Twenty-three studies met the inclusion criteria with 397 participants involved. All studies that met the inclusion criteria were published and of the twenty-three, seven received funding. Cerebral palsy, autism spectrum disorder, and down syndrome were the most frequent disabilities researched among the included studies. Sample sizes varied from six participants to forty with most studies including both males and female participants. Figure 1 presents the search strategies and article screening process used to determine the final sample of included studies. Table 1 provides the coding information for the methodological, participant, and study characteristics that were extracted from each paper. Cohen's (1988) criteria was used to find the outcome effects with the use of standardized mean differences and summarize the effect sizes as small (≥0.20), moderate (≥0.50), and large (≥0.80).

Outliers and Publication Bias

Using a random effects model to interpret the model results, three studies were identified as outliers and included Zanobini et al., 2019 (z = -2.03), Marzouki et al., 2022 (z = 2.29); Chang et al., 2017 (z = 2.77). A sensitivity analysis was performed to determine the final status for each of the studies identified as outliers. The "one study removed" procedure in CMA determined that changes would had a marginal influence on results (g = -0.07). the overall estimate of effect with results remaining significant (*k* = 24, *g* = 0.72, $P \leq 0.001$) and within a 95% confidence interval. Based on results from the sensitivity analysis, all three outliers were retained for final calculations.

Figure 1. Flowchart for Aquatics Search Process



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Table 1. Descriptive Characteristics for Aquatic Studies Meeting Inclusion Criteria

	Methodological Characteristics				Sample Characteristics			Study Characteristics				
Study	**Design**	**Train**	**Focus**	**Time**	**Setting**	**Disability**	**Gender**	**Country**	**N**	**Measure**	**Fund**	**Status**
Akinola et al., 2019	B	T	E	10	T	CP	B	Nigeria	30	O	U	P
Ansari et al., 2020	B	A	TEG	10	U	ASD	B	Iran	30	O	U	P
Caputo et al,. 2018	Both	A	TG	40	T	ASD	B	Italy	26	S	U	P
Casey et al., 2010	W	AD	ET	16	C	ID	B	Canada	8	O	U	P
Chang et al., 2014	B	A	E	8	S	ADHD	B	Taiwan	30	O	F	P
Chu et al., 2012	B	D	GT	16	S	ASD	B	Taiwan	21	O	U	P
Chrisagis et al., 2009	B	A	T	10	S	CP	B	Greece	6	O	U	P
Clapham et al., 2020	W	SC	T	8	C	multiple	B	US	71	O	F	P
Declerk et al., 2013	W	U	TG	6	U	CP	B	Belgium	7	C	U	P
Dimitrijevic et al., 2012	B	U	ET	6	C	CP	B	Serbia	29	O	U	P
Fragala-Pinkham et al., 2008	W	T	E	14	C	multiple	B	US	16	O	F	P
Fragala-Pinkham et al., 2014	W	TA	E	14	T	CP	B	US	8	O	F	P
Hutzler et al., 1998	B	T	T	24	T	CP	B	Israel	46	O	F	P
Kim et al., 2018	W	U	TE	16	U	multiple	B	NR	10	O	U	P
Lai et al., 2015	B	T	E	12	T	CP	B	Taiwan	28	C	F	P
Marzouki et al., 2022	B	AD	GT	8	T	ASD	B	U	22	O	U	P
Naczk et al., 2021	B	A	T	33	U	DS	B	Poland	22	O	F	P
Ninot et al., 2000	B	U	E	32	U	ID	F	France	48	C	U	P
Pan, 2010a	B	A	GT	10	C	ASD	M	Taiwan	16	O	U	P
Suarez-Villa et al., 2020	B	A	E	36	U	DS	B	Spain	45	O	U	P
Takken et al., 2003	B	T	E	20	T	JIA	B	Nether	54	C	U	P
Zanobini et al., 2019	B	AD	GT	24	T	ASD	B	Italy	33	O	U	P
Zverev et al., 2016	W	AD	ET	24	CP	P	B	U	13	C	U	P

Note. Design = Research Design. B = Between Group Comparison or W = Within Group Comparison; Train = Instructor Training. A = Aquatics Training, D = Disability Training, or N = No Training. Focus = Type of Program. G = Games, E = Exercise, or T = Technique; Time = Duration of Program. Setting = Setting of Program. S = School, C= Community, or T = Therapeutic; Disability = Disability Type. P = Physical/Behavioral or C = Cognitive; Gender = Sample Gender. F = Female Only, M = Male Only, B = Both Male and Female; Country = Study Location; N = Sample Size. Measure = Outcome Measures; O = Objective Measures Used, S = Subjective Measures Used, C = Both Objective and Subjective Measures Used. Funding = Funding Status; F = Funded and U = Unfunded. Status = Publication Status; P = Published and U = Unpublished. NR = Not Reported

Publication bias was evaluated using a visual inspection of a Funnel Plot, a Trim and Fill procedure (Begg & Mazumdar, 1994), and Egger's Regression Intercept (Egger et al. 1995). Figure 2 represents the funnel plot with the Trim and Fill procedure (Figure 2) that added three studies to the left side of the mean reducing the overall effect (g = 0.53, *95% CI* = 0.41, 0.67, $P < 0.001$) and remaining a moderate effect. Both Begg and Mazumdar's Rank Order analysis ($P = 0.04$) and Egger's Regression Intercept ($P = 0.03$) were significant suggesting the smaller size studies had larger contributions to the overall results. Even though a comprehensive search strategy was conducted of both published and unpublished literature, we cannot rule out the absence of publication bias with these findings.

Random Effects Model

The effect size using the random effects model for individuals' health and skill-related fitness when provided with aquatic programming was moderate ($g = 0.722$; $SE = 0.016$; *95% CI* = 0.47, 0.97; $P < 0.001$) across all outcomes representing seven-tenths of standard deviation increase in health-related fitness, skill-related fitness, and movement skills for groups experiencing an aquatics treatment. The meta-analytic literature has determined that analyses with fewer than 10 studies produce imprecise estimates of effect, however, the authors have selected to report outcomes with smaller samples ($k < 10$) for discussion and future research. Health-related fitness outcomes included were considered to have a marginal to moderate effect with only body composition having a minimal number of studies (k = 11, $g = 0.16$; $SE = 0.016$; *95% CI* = 0.47, 0.97; $P < 0.001$) that would allow for interpretation. Heterogeneity was present across all outcomes as prediction intervals ranging from negative to positive and small to large indicated that across comparable samples aquatics interventions range from ineffective to highly effective. Moderate to large effects were found for both skill-related fitness and skill development, however, the minimal number of studies did not meet the threshold for interpretation. While the results across outcomes appear promising the large range for prediction intervals suggests that aquatics interventions need further investigation.

Figure 2. Funnel Plot with Trim and Fill Procedure

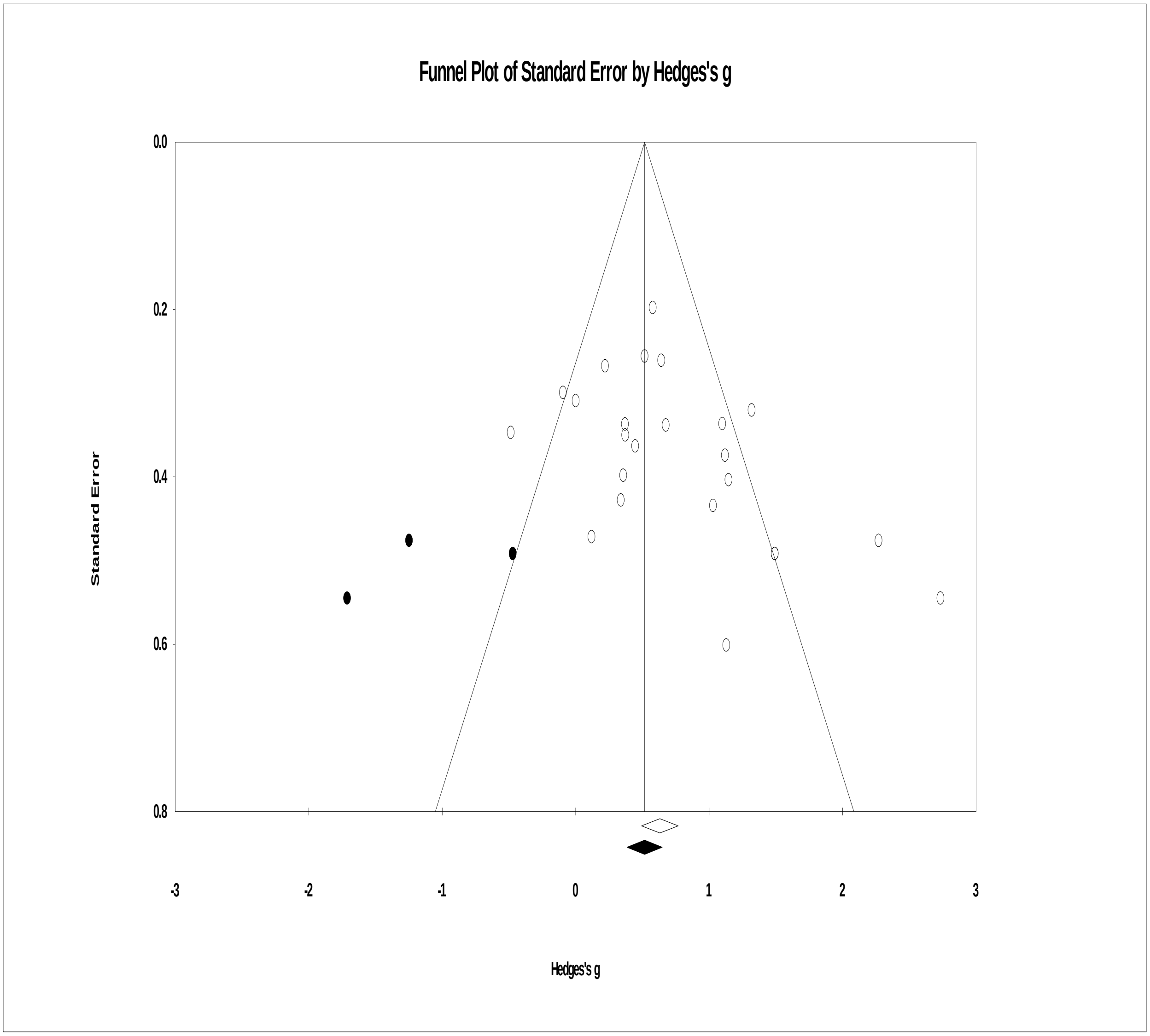


Table 2. Aquatics Outcomes

	Effect Size Statistics					Null Test		Heterogeneity Statistics			
Variable	***k***	***g***	***SE***	***s^2***	**CI**	**Z**	**P**	**PI**	***Q***	***τ^2***	***I^2***
HRF											
Body Fat	11	0.16	0.10	0.01	-0.03, 0.35	1.68	0.09	-0.06, 0.38	5.76	0	0
Cardio	8	0.74	0.34	0.02	0.48,1.01	5.43	0	0.11, 1.38	10.60	0.05	33.96
Flexibility	6	0.66	0.19	0.04	0.29, 1.02	3.49	0	-0.28, 1.59	8.17	0.08	38.78
Strength/Endurance	5	0.33	0.20	0.04	-0.06, 0.72	1.64	0.10	-0.92, 1.58	9.54	0.11	58.05
SRF											
Balance	9	0.85	0.22	0.05	0.43, 1.28	3.94	0	-0.48, 2.19	23.74	0.27	66.30
Speed	5	1.01	0.16	0.03	0.70, 1.32	6.36	0	0.50, 1.51	0.62	0	0
Skills											
Locomotor	7	1.20	0.46	0.21	0.29, 2.10	2.59	0.01	-1.97, 4.37	55.85	1.31	89.26
Manipulative	3	0.67	0.82	0.67	-0.94, 2.28	0.82	0.41	-19.49, 20.83	24.61	1.84	91.87

Note. *k* = number of studies, Hedges *g* = effect size, s^2 = variance, *SE* = Standard Error, *95% CI* = Confidence Interval (Lower Limit, Upper Limit), *Z* = Null Hypothesis Test; *PI* = Prediction Interval (lower limit, upper limit), τ^2 = Between Study Variance, RF = Related-Fitness, CVE = Cardiovascular Endurance. MS = Muscular Strength. ME = Muscular Endurance, * $p < 0.05$

DISCUSSION

A moderate effect size was found (*g* = 0.722; *SE* = 0.016; *95% CI* = 0.47, 0.97; *P* < 0.001) using a random effects model when determining the effect of aquatic programs on health-related, skill-related, and movement skills for children with disabilities. These results suggest aquatic activity can be beneficial for children in these areas. However, there is a need for additional research because of the small number of studies that met the inclusion criteria. Outcome measures were categorized into three groups with specific outcomes which included health-related fitness (body fat, cardio, flexibility, and strength/endurance), skill-related fitness (balance and speed), and movement skills (locomotor and manipulative). Understanding the current findings as well as how the aquatic programs were delivered in each of these specific areas provides direction and guidance for what future research should investigate.

Health-Related Fitness

Body Composition

Body composition is an important factor in children's health status and ability to maintain recommended physical activity levels (Androutsos & Zampelas, 2022). Increased weight in children can cause issues such as metabolic disorders and cardiovascular health concerns (Hsu et al., 2021). Previous research that has been conducted to improve body composition using aquatic interventions have found no effect on body composition at post intervention or follow-up (Depiazzi et al., 2019). In order for aquatics interventions to be effective at decreasing body composition several factors should be considered such as type of activity, intensity of activity, and the duration of activity (O'Donoghue et al., 2020). Most of the studies included in the current investigation focused on skill development and game play which may have contributed to insignificant findings (Casey et al, 2010; Clapham et al., 2020; Declerk et al., 2013; Kim et al., 2018; Naczk et al, 2021). Skill development contributes to both safety and enjoyment in aquatics environments; however, future interventions should focus studies that have longer time periods of continuous activity (program length and session time) as well as a focus on exercise-based programming with less rest and more active minutes in the pool that will elevate heart rate (Sideravičiūtė et al., 2006).

<u>Cardiovascular Fitness</u>

Research findings display evidence that children's cardiovascular health can predict overall heart health in adulthood as well as adult morbidity and mortality (Steinberg et al., 2016). A meta-analytic review by Lahart and Metsios (2017) on chronic physiological effects of aquatic interventions of non-elite swimmers found positive statistical effects on VO2 max in healthy children and children with asthma when provided with a swimming program. Results from the current investigation support these findings and are consistent with our studies suggesting that aquatic activities provide enough full body resistance to improve cardiovascular fitness in children with disabilities (Kim et al., 2018; Armito et al., 2015; Pan, 2011). Developing and maintaining cardiorespiratory fitness is an important factor for improving quality of life and wellness outcomes (Arija et al., 2018) and children with disabilities have lower levels of aerobic fitness than their able-bodied peers (Fowler et al., 2007; Fragala-Pinkham et al., 2008). Aquatics programming does improve children with disabilities cardiovascular health, and we encourage future studies to focus on swimming programs that measure, increase, and maintain elevated heart rates to ensure physiological benefits (Nystoriak & Bhatnagar, 2018). Additionally, future studies that implement aquatics programming for children with disabilities should use the FITT principle (frequency, intensity, time, and type) combined with enjoyable learning experiences that reinforce the benefits of aquatic activity and encourage lifelong participation in swimming (O'Donoghue et al., 2020; Nielsen et al., 2014).

Muscular Strength/Endurance

Research suggests providing children with resistance training programs with a focus on muscular strength and endurance can improve children's motor performance and reduce risk of injuries (Faigenbaum et al., 1999, Kevic et al., 2013). While research on improvements of muscular strength and endurance through aquatic programming is lacking, some studies have found benefits to muscular strength and endurance when providing specific and intense swimming interventions (Pan, 2011). However, most research studies that have investigated the effects of aquatic programming on muscular strength and endurance development did not reveal benefits, possibly due to the program's main focus in aerobic exercises followed by a fraction of the time designated to strength training (Fraga-Pinkham et al., 2008; Hinman et al., 2007; Xu, 2001). Another important consideration that was not highlighted in studies meeting inclusion criteria for the current investigation is the number of sets and repetitions balanced with appropriate rest for the fitness levels of children with disabilities (Elmahgoub et al., 2011). Future studies hoping to develop muscular strength and endurance might consider developing programming that incorporates activities and games using resistance equipment such as buoyancy dumbbells, weighted vests, and paddles using engaging and fun activities (Katsura et al., 2010).

Flexibility

Benefits of flexibility training include the improvement in range of motion for individuals that allows for more ease in participating in physical activity (Piercy et al., 2019). Flexibility in disabled populations has been found to decrease with age and the importance of range of motion is critical for exercise as well as functional everyday activity (Baena-Beato et al., 2014). Basic swimming strokes and kicks put the body through large ranges of motion and have the potential improving flexibility (Lindsay & Byington, 2020). Studies in the current investigation with outcome measures for flexibility had interventions mostly with a focus on exercise and participant populations with cerebral palsy (Akinola et al, 2019; Dimitrijević et al., 2012; Fragala-Pinkham et al., 2014; Lai et al., 2015). The majority of programs used the Gross Motor Function Classification system to determine levels of flexibility. Future research should focus on the continuation of providing aquatic exercise-focused programming as well as incorporating instructional methods that teach participants fundamental swimming strokes skills like the scissor kick, butterfly arms, frog kick, and freestyle arms to continue to build a range of motion in different joints of their body. Researchers should provide similar interventions to additional groups with different physical disabilities to see the effect on their flexibility.

Skill-Related Fitness

Balance

Balance training is a current therapeutic approach for children in treatment to help improve motor skills, coordination, and overall health (Jelsma et al., 2013). This is due to buoyancy of water that forces participants to constantly stabilize the body as it changes positions through each activity (Roth et al., 2006). Research has focused on swim training's improvements in balance and hand eye coordination of elderly people (Hsu et al. 2010), however, there is a lack of research on how aquatic activity and program benefit to children's balance, specifically children with disabilities. While research is limited, there is promising evidence of swimming programs improving balance in children and adolescents (Baccouch et al., 2014) which aligns with promising results from the current meta-analysis. Activities like treading water, floating, and sliding teach students to find equilibrium and can help improve children's vestibular sense, areas future research can begin to pursue (Dartt, 2015). These activities are the basics of many swim programs, allowing it to be accessible to children of all ages and abilities.

Speed

Research that has been done on the effects speed suggests that it is a large contributor to resisting declines in cognitive performance due to age (Earles and Salthouse, 1995). Success in improving swim speed is due to improvements in muscular strength in the upper and middle body (Troup, 1999) and a focus on correct swim technique (Strzała1 and Tyka, 2009). Studies in the current meta-analysis had strong focuses on technique-based programming and exercise programming which may explain large improvements in swim speed after aquatic intervention. Improvements in speed also improve overall health-related fitness with continuous body weight activities (Earles and Salthouse, 1995). As swimming speed improves in children with disabilities, there are larger possibilities for them to participate in team swimming programs and competitive swimming programs. Continued research should investigate how exercise and technique focused programs affect speed as well as determining an effect in upper and middle muscular strength training to improve swimming speed.

Fundamental Motor Skill: Locomotor Skills and Manipulative Control

Fundamental motor skills include locomotor skills and manipulative control that form the foundation of most land-based activity. Learned fundamental motor skills in childhood allow for success in physical literacy in adulthood (Palmer et al., 2020). Research suggests that the development of motor skills allows for lifelong participation in physical activity which contributes to physical, social, and emotional health while reducing risks of metabolic disease, diabetes, and obesity (Field & Temple, 2017). Large improvements in locomotor skills were made by participants within the current meta-analysis which was likely due to the practice of basic swim skills, water-orientation skills, and aquatic games (Lee & Porretta, 2013). Effects were not as strong when analyzing manipulative control improvements amongst participants. Future research should provide aquatic programming that prioritizes using objects in the water with upper and lower extremities in order to achieve tasks or goals. Additionally, interventions that include game activities with aquatic equipment (i.e., water polo, pool volleyball, pool basketball, beach balls, etc), will possibly provide more positive results in the future.

CONCLUSIONS, SUMMARY OR RECOMMENDATIONS

A moderate effect size was found (g = 0.722; *SE* = 0.016; *95% CI* = 0.47, 0.97; P < 0.001) using a random effects model when determining the effect of aquatic programs on health-related, skill-related, and movement skills for children with disabilities. These results suggest aquatic activity can be beneficial for children with disabilities in the areas of health-related (body composition, strength/endurance, flexibility, and cardiovascular fitness), skill-related (speed and balance), and movement-based outcomes (locomotor skills and manipulative control). However, there is a need for additional research because of the small number of studies that met the inclusion criteria. While more research is needed, recommendations were made for future research based on the reported results. Future research may focus their programming based on the specific outcomes being measured, but overall, longer lengths of interventions and times in the water, instructors with both disability and aquatic training, use of aquatic equipment, and programs with a focus on both technique and exercise, are encouraged.

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