Review Journal of Autism and Developmental Disorders
https://doi.org/10.1007/s40489-022-00335-5

REVIEW PAPER

Interventions for Health Promotion and Obesity Prevention for Children and Adolescents with Developmental Disabilities: a Systematic Review

Mansha Mirza[1] · Jasmine P. Brown-Hollie[1] · Yolanda Suarez-Balcazar[1] · Deborah Parra-Medina[3] · Sarah Camillone[1] · Weiwen Zeng[2] · Estefania Garcia-Gomez[1] · Nazanin Heydarian[4] · Sandy Magaña[2]

Received: 22 February 2022 / Accepted: 14 July 2022

Abstract

This systematic review evaluated interventions and relevant outcomes for health promotion and obesity prevention among children and adolescents with developmental disabilities (DD). Twenty-one studies including randomized control trials (n= 9) and quasi-experimental studies (n=12) published between 2010 and 2021 met inclusion criteria related to participant characteristics, intervention type, and child obesity-related outcomes. Five types of intervention programs were identified: aerobic and strength training, sport-based physical activity, aquatic exercise, active video gaming, and diet and lifestyle. Whereas analysis of intervention outcomes, efficacy, and study rigor showed mixed results and weak evidence of effective interventions, this review identified gaps in the literature, promising strategies for addressing obesity in children with DD, and implications for practice and future research.

Keywords Health promotion · Obesity intervention · Children · Adolescents · Developmental disabilities · Physical activity

According to the Centers for Disease Control and Prevention, high rates of obesity represent a growing threat to the health of individuals (CDC, 2021). While obesity spans across all demographic boundaries, affecting different racial/ethnic and age groups, people with disabilities are at the higher end of the risk curve (Ptomey et al., 2020; Rimmer et al., 2014). Overweight and obesity are significant health concerns among children and adolescents with disabilities. According to Bandini et al. (2015), children with disabilities were 59% more likely to be obese than their peers without disabilities. Consistent with trends in obesity observed in children without disabilities, African American and Latinx children with disabilities are at a greater risk for obesity compared to White children with disabilities (Rimmer et al., 2010).

Obesity is linked to a number of medical conditions that can lead to chronic conditions impacting the person's quality of life. These conditions include higher rates of type 2 diabetes, cardiovascular disease, early maturation, gall

✉ Mansha Mirza
mmirza2@uic.edu

Jasmine P. Brown-Hollie
jpbrown2@uic.edu

Yolanda Suarez-Balcazar
ysuarez@uic.edu

Deborah Parra-Medina
parramedina@austin.utexas.edu

Weiwen Zeng
weiwenzeng@utexas.edu

Estefania Garcia-Gomez
egarc38@uic.edu

Nazanin Heydarian
nazanin.heydarian@utrgv.edu

Sandy Magaña
smagana@austin.utexas.edu

[1] University of Illinois, 1919 W Taylor., IL 60612 Chicago, USA

[2] University of Texas at Austin, 1925 San Jacinto Blvd, Austin, TX 78712, USA

[3] Latino Research Institute, University of Texas at Austin, 210 W. 24th St., Austin, TX 78712, USA

[4] University of Texas Rio Grande Valley, 1201 W University Dr, Edinburg, TX 78539, USA

Published online: 22 August 2022

bladder, and liver disease (Chen et al., 2010). Among children and adolescents with disabilities, increased body mass index (BMI) presents a greater risk of secondary conditions, defined as preventable medical, emotional, or social problems resulting directly or indirectly from an initial disabling condition (U.S. Department of Health and Human Services, *Healthy People* 2030). Secondary conditions may include chronic fatigue syndrome, pain, social stigmatization and isolation, depression, and anxiety (Reinehr et al., 2010; Rimmer et al., 2010).

Other factors that place children and adolescents with developmental disabilities (DD) at greater risk for obesity include diet and lack of physical activity. Children and adolescents with DD are more likely than without disabilities to have an unhealthy diet due to food aversions, food sensitivities, and/or allergies (Bandini et al., 2005). Furthermore, they are likely to face numerous individual, community, and environmental barriers for engaging in recreational and physical activity critical to weight management (Rimmer & Vanderbom, 2016). Typically, school and community-sponsored sports and recreation programs are not easily available or accessible to children and adolescents with DD, because these programs often lack necessary adaptations and modifications. They also face barriers in other built environments since coaches and other professionals lack knowledge and training on how to work with children and adolescents with disabilities (Rimmer et al., 2011; Suarez-Balcazar, Agudelo Orozco, et al., 2018a).

Historically, children and adolescents with disabilities have been excluded from obesity prevention research (Bandini et al., 2015). However, concerns about the high rate of obesity in this population have stimulated a growing number of studies focusing mostly on interventions to promote physical activity and/or reduce weight. While some of these studies (Li et al., 2013; Maïano et al., 2014) reported mixed efficacy of physical activity interventions on BMI and other fitness outcomes of individuals with DD, others (e.g., McGarty et al., 2018) reported that such interventions were not effective in increasing physical activity levels when compared to usual care. This emerging literature has been synthesized in a few existing reviews, including a review of behavioral outcomes following exercise interventions for children and youth with autism spectrum disorder (Bremer et al., 2016; McGarty et al., 2018), among other systematic reviews of studies conducted with adults with DD (e.g., Li et al., 2013). Despite the existing reviews and current mixed evidence, questions remain on the overall effectiveness of interventions addressing obesity in the population of children and adolescents with DD. Scholars have called for a better understanding of what interventions are evidence-based, feasible, and acceptable for this population (Bandini et al., 2015; Suarez-Balcazar, Early, et al., 2018b). This systematic review sought to evaluate interventions and relevant outcomes for health promotion and obesity prevention among children and adolescents with DD.

Methods

Search Strategy and Study Selection

The objectives of this systematic review were (1) to identify relevant interventions for health promotion and obesity prevention among children and adolescents with DD; (2) to summarize dosage, main components, and adaptations, if any, for interventions identified; (3) to describe changes in relevant outcomes; and (4) to appraise the rigor of research reporting for different types of interventions identified.

We created and registered a detailed protocol with the International Prospective Register of Systematic Reviews (PROSPERO) (Suarez-Balcazar et al., 2020). To capture as many relevant publications as possible, the following electronic databases were searched: PubMed, Cumulative Index to Nursing and Allied Health (CINAHL), PsycINFO, Cochrane Library, Psychology and Behavioral Sciences Collection, Health Source: Nursing/Academic Edition, Web of Science, Embase, and Scopus. Manual searches were also conducted with specific journals for relevant articles related to childhood, health promotion, and obesity. The following journals were searched: *Child: Care, Health and Development; Health Education; American Journal of Health Promotion; Childhood Obesity; Research in Developmental Disabilities; Journal of Intellectual Disability Research; Disability and Health; Journal of Developmental and Behavioral Pediatrics; Journal of Physical Activity & Health; Pediatrics; Preventive Medicine; Public Health Nutrition; Journal of School Nursing; and Journal of Health Education and Behavior.*

The PICO (patient/population, intervention, comparison, outcome) strategy was used to guide the identification of search terms (Aslam & Emmanuel, 2010). Consultation with a health sciences librarian assisted in refining search terms and database selection. Search terms describing the patient/population included child*, youth*, adolesc*, pediatric*, paedriatic*, student*, school age, disability, intellectual*, handicap, impair*, development*, mental*, retard*, autis*, developmental delay*, down syndrome*, cognitive*, and ASD. To capture obesity-related interventions, we included the following search terms: health promotion, health intervention, healthy lifestyle, healthy eating, obesity intervention, obesity prevention, intervention, and physical activity. For outcomes of interest, the following search terms were used: BMI, body weight, eating behaviors, physical behaviors, physical in/activity, dietary intake, sedentary behaviors, and screen time.

The research team conducted the initial database and journal searches from June to July 2020. A sample search strategy for a database is included in the supplemental materials (see Online Resource 1). Automatic search alerts were rerun monthly in each database until the beginning of data analysis in June 2021 to ensure identification of the latest studies indexed since the initial search.

Inclusion and Exclusion Criteria

We included studies that (1) focused on children and adolescents (aged 6–17 years) with DD (i.e., autism spectrum disorder [ASD], Down syndrome [DS], and intellectual disability [ID]); (2) evaluated interventions targeting obesity-related outcomes; (3) involved intervention delivery within a child's natural environment (home, school, and community); (4) were peer-reviewed articles with randomized control trials or quasi-experimental designs with group comparisons; (5) utilized a quantitative or mixed-methods approach; (6) measured primary outcomes at the level of the child; and (6) were published between 2010 and 2021.

Studies were excluded if they focused on children who were non-ambulatory or required assistance for walking (i.e., cerebral palsy), or if they focused exclusively on parent participation in the intervention or reported parental outcomes only.

Procedure for Selecting Studies

Two doctoral and two masters level research assistants worked in pairs to independently screen all articles for eligibility. Authors and journal information was blinded for all articles during the screening process. Articles were screened in three stages (title, abstract, and full-text review). They were excluded if both screeners agreed that an article did not meet all inclusion criteria or met at least one exclusion criteria. Interrater agreement rate across the two screening pairs was high (Cohen's kappa=92.7%). Disagreements were resolved by consultation with a third reviewer, who identified as a senior level researcher.

Data Extraction, Assessment of Study Quality, Rigor, and Reporting

Data extraction was conducted by six research team members who worked in three pairs consisting of a senior level researcher and a doctoral or masters level research assistant. Articles included for data extraction were divided between the pairs. Reviewers in each pair worked independently to extract data using a standardized form adapted from existing protocols (Brown et al., 2003; Kaminski et al., 2008; Zaza et al., 2000). The form included information regarding study design, sample characteristics, key elements of the intervention, cultural adaptations, outcome measures, and study findings.

We adapted Reichow's (2011) evaluative method to rate the rigor of research reporting and determine the overall level of evidence for each study. Reichow's (2011) method is well-established and widely used to evaluate research involving group comparisons. The method involves three stages. In the first stage, studies were evaluated on primary quality indicators (deemed critical for establishing a study's validity) and secondary quality indicators (deemed important but not critical for validity). A scoring sheet was developed to rate each study on the 14 primary quality indicators under the following categories: participant characteristics and sample selection, independent variable, dependent variables, comparison group, and data analysis. Studies were rated as "high quality," "acceptable quality," and "unacceptable quality" for each primary indicator category. For example, for the primary indicator of "data analysis," studies were rated as "high quality" if they met all the following criteria: data analysis was guided by a priori power analysis, *p* values or confidence intervals were reported, baseline differences were addressed, and missing data were accounted for in analyses. Studies were rated as "acceptable" if at least three of these criteria were met; and as "unacceptable" if less than three criteria were met.

The scoring sheet also included nine secondary quality indicators (fidelity and adherence monitoring, co-intervention effects, blinded raters, assessment of maintenance, attrition effects, effect size reporting, rigorous randomization procedures, and randomization concealment where appropriate). The total number of secondary indicators addressed by each study was calculated. Each study was independently rated by the same senior researcher-research assistant pair. Interrater reliability was calculated as percent agreement across all indicators scored for that study. The overall interrater reliability was 88%. Disagreements within pairs were resolved through discussion and, if needed, by consulting with another senior researcher from the review team.

In the second stage of quality appraisal, overall rigor of research reporting was determined for each study by synthesizing the study's ratings on primary and secondary indicators. Using criteria adapted from Reichow (2011), studies were categorized as "strong" if they received "high quality" ratings for all primary quality indicators and addressed four or more secondary quality indicators; "adequate" if they received "high quality" or "acceptable quality" ratings on primary quality indicators and addressed at least two secondary quality indicators; and "weak" if they received "unacceptable quality" ratings on any primary quality indicator or addressed less than two secondary quality indicators.

In the third stage of quality appraisal, overall level of evidence was determined for interventions considering the rigor of all studies associated with that intervention. According to Reichow's method (Reichow, 2011), established and probable EBP interventions must be supported by multiple methodologically rigorous studies conducted by at least two research teams located in different geographical areas. Reichow (2011) recommends a cutoff *Z* score of 60 points for an intervention to be classified as established EBP and a score of >30 points for a probable EBP based on the following Z score formula for group comparison studies:

(Number of studies with strong rigor of research reporting * 30) + (Number of studies with adequate rigor of research reporting * 15)

Results

Twenty-one studies met the established criteria (see Fig. 1). Of these, nine were RCTs and 12 were quasi-experimental studies involving comparisons between non-randomized groups. Countries/regions where studies were conducted included the USA (*n*=5), Belgium (*n*=2), Brazil (*n*=1), China (*n*=1), Hong Kong (*n*=2), Serbia (*n*=1), South Korea (*n*=1), Spain (*n*=2), Sweden (*n*=2), and Taiwan (*n*=2). Two studies did not report countries of origin or geographic locations. Characteristics of the 21 studies are summarized in Table 1. Below, we provide an analysis of participant characteristics, types of intervention, study outcomes and intervention efficacy, and study rigor.

Participant Characteristics

The 21 studies included a total of 1211 children. Approximately half of these children (*n*=616) received some type of intervention. Study sample sizes ranged from 12 to 203 children (not accounting for attrition) with an average sample size of 55 children across studies. Intervention group sample sizes ranged between 6 and 125 participants. Most studies (*n*=19) focused on children with a primary diagnosis of Down syndrome, ASD, including Asperger's and PDD-NOS, or ID of varying severity with or without comorbidities.

Children and adolescents' ages ranged from 5 to 26 years with most studies (*n*=13) reporting a mean age between 12 and 17 years. Gender of participants was reported as binary across studies. Most studies (*n*=14) reported predominantly male samples with proportions of male participants ranging from 54 to 100%. Three studies (Curtin et al., 2013; Ulrich et al., 2011; Wu et al., 2017) reported predominantly female samples with proportions of female children ranging from 56 to 81%. Only seven studies reported participants' race/ethnicity. Of these, three studies (Kong et al., 2019; Pan, 2011; Wu et al., 2017) reported that participants were 100% Asian, and one study (Fragala-Pinkham et al., 2011) reported 100% White participants. Three studies (Curtin et al., 2013; Ptomey et al., 2015; Ulrich et al., 2011) reported more diverse samples although the proportions of White participants ranged from 70 to 95%. Only two of these studies (Curtin et al., 2013; Ulrich et al., 2011) reported small proportions (2-5%) of Hispanic/Latinx participants.

Types of Intervention

A wide variety of interventions with varying dosages were identified. The shortest intervention involved five sessions over a period of 1 week (Ulrich et al., 2011), while the longest involved 108 sessions delivered over 36 weeks (Suarez-Villadat et al., 2020). Interventions were most commonly 8–12 weeks long (*n*=9). Target recipients for most interventions (*n*=15) were children and adolescents with DD only. A few interventions additionally involved parents (*n*=4), siblings (*n*=1), peers (*n*=1), and peers as well as school staff (*n*=1). Interventions were delivered in a variety of settings including schools (*n*=8), community-based organizations (*n*=2), in-home (*n*=2), and other sports facilities (*n*=4). The remaining five studies did not specify intervention settings.

Four of the 21 studies identified a guiding theoretical framework for their respective interventions. Theoretical frameworks included the International Classification of Functioning, Disability and Health (George et al., 2011), Bandura's social learning theory (Lee et al., 2017), principles of motor learning and physical fitness learning (Pan, 2011), and dynamic systems theory (Ulrich et al., 2011). Since most studies did not include an intervention theory or conceptual framework, interventions were categorized into five broad categories based on their primary focuses and main components. Each of these categories is described below (see Table 1 and Online Resource 2).

Aerobic and Strength Training Exercise Programs

Nine studies (Boer et al., 2014; Elmahgoub et al., 2011; George et al., 2011; González-Agüero et al., 2011; Kim & Lee, 2016; Kong et al., 2019; Seron et al., 2014; Wu et al., 2017; Xu et al., 2020) focused on promoting physical activity through aerobic and/or strength training exercise programs. These interventions comprised a defined exercise regimen performed under the supervision of qualified trainers including physical therapists, physical therapy students, certified physical educators or personal trainers, and a Tai Chi master. Exercise regimens included rhythmic gymnastics (*n*=1), Tai Chi (*n*=1), sprint interval training (*n*=1), circuit training (*n*=3), or a combination of aerobic (e.g., dancing, treadmill, stationary bike, jumping jacks) and resistance exercises (e.g., resistance bands, medicine balls, plyometric jumps) (*n*=3). Intervention settings, where specified, included schools and indoor sports centers. Duration of exercise sessions ranged from 25 to 75 min offered at a frequency of two to five times per week. Total duration of interventions ranged from 8 to 21 weeks.

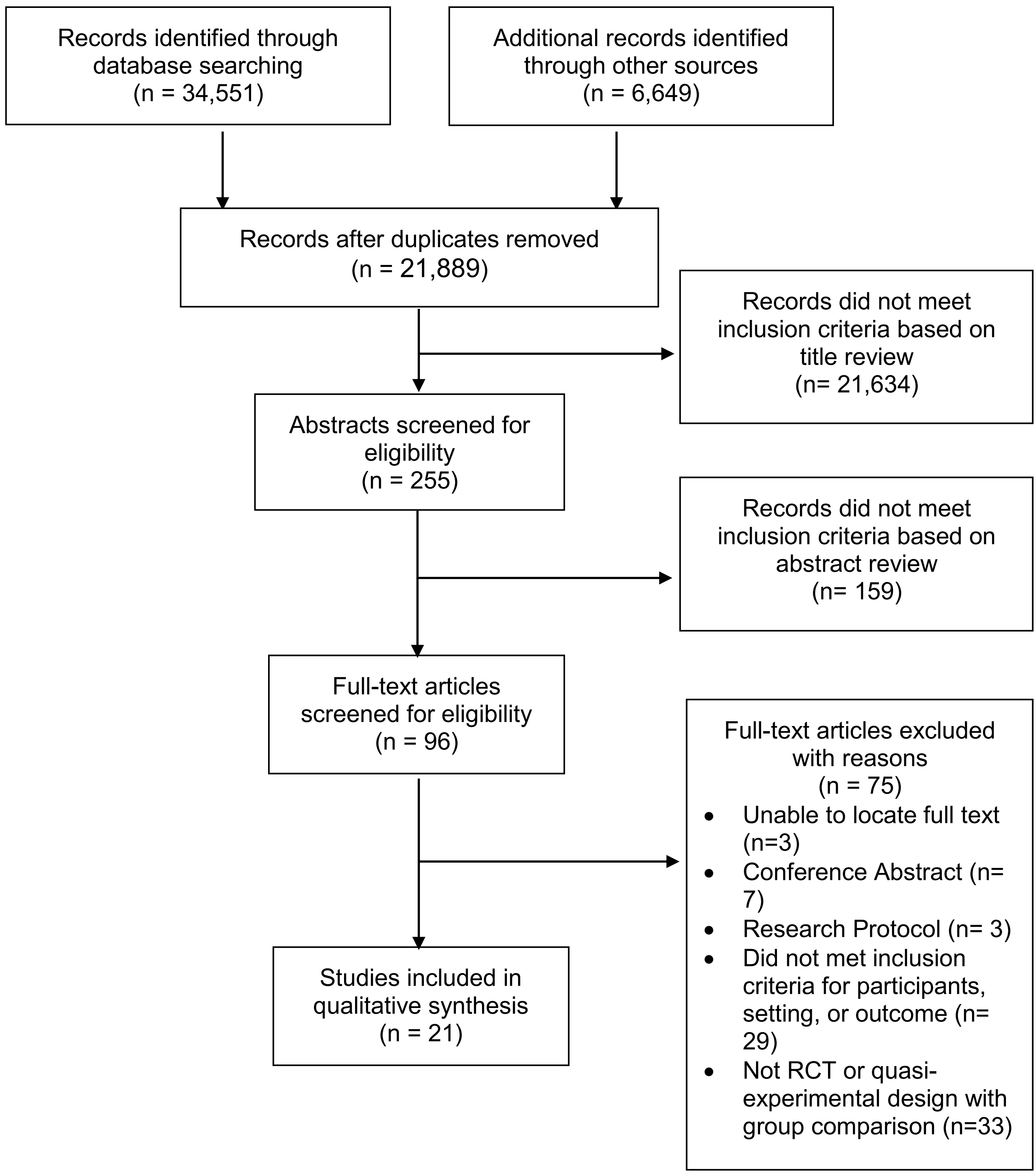

Fig. 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram for study screening process

All nine interventions in this category were offered in-person and all but one focused exclusively on children and adolescents with DD as intervention recipients. One study (George et al., 2011) additionally included parent training to facilitate an exercise program at home. With one exception (González-Agüero et al., 2011), which was offered one-on-one, all interventions were offered in group format. Adaptations specific to children and adolescents with DD included use of sticker charts and positive feedback to incentivize participation (George et al., 2011; González-Agüero et al.,

Table 1. Summary of participant characteristics, intervention details, study findings, and rigor

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Boer et al., 2014	RCT	*n*=54 children, 46 analyzed Age Range NR, *M*=17 65% Male, 35% Female Race/Ethnicity: NR Primary diagnosis: ID with a wide variety of conditions	TX1: Sprint interval training (SIT) – warm-up, sprint interval block (30% of peak Watt for five minutes), continuous aerobic exercise, another sprint interval block (30% of peak Watt for five minutes), and cool down. All exercises consisted of cycling TX2: Continuous aerobic training – warm-up, cycling, walking/running, stepping, and cool down. CO: Typical programming	TX: 40 min sessions 2×/wk (only specified for SIT) 15 wks	School TX1: Physiotherapists TX2: NR	Pre and post 15-wk intervention	BMI	NS difference b/w groups	NR	Weak
							Waist circumference	Significant difference b/w TX1 and CO in favor of TX1 ($p<.05$) Significant difference b/w TX2 and CO in favor of TX2 ($p<.05$)	NR	
							Body fat %	Significant difference b/w TX1 and CO in favor of TX1 ($p<.05$) Significant difference b/w TX1 and TX2 in favor of TX1 ($p<.05$) Significant difference b/w TX2 and CO in favor of TX2 ($p<.05$)	NR	
							Cardiorespiratory fitness – maximal cardiopulmonary exercise test, peak VO2	Significant difference b/w TX1 and CO in favor of TX1 ($p<.05$) Significant difference b/w TX1 and TX2 in favor of TX1 ($p<.05$)	NR	
							Cardiorespiratory fitness – maximal cardiopulmonary exercise test, peak HR	NS difference b/w groups	NR	
							Cardiorespiratory fitness – maximal cardiopulmonary exercise test, ventilatory threshold	Significant difference b/w TX1 and CO in favor of TX1 (p<.05) Significant difference b/w TX1 and TX2 in favor of TX1 (p<.05) Significant difference b/w TX2 and CO in favor of TX2 (p<.05)	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Curtin et al., 2013	RCT	n=21 children and parents 13-26 yrs, M=20.5 yrs 19% Male; 81% Female Race/Ethnicity: 95% White, 5% Hispanic/Latinx Primary diagnosis: Down Syndrome Parent characteristics NR	TX: The first half of each session, attended by parents and children, focused on education about basic nutritional concepts (balanced diet, healthy food choices, controlled portions) and exercises through simple verbal instruction, demonstrations, activities (e.g., games), and taste tests. In the 2nd half, children participated in practice and taste tests while parents met separately as a group for informal support/discussion. An individualized diet and physical activity plan were developed for each participant. A behavioral intervention was also conducted by a behavioral specialist who provided instruction on behavioral strategies such as diet/activity monitoring, modification of "stimulus control" conditions at home, modeling, daily/weekly goal setting, and positive reinforcement CO: Same as above, excluding behavioral intervention.	TX and CO: 90 min sessions 1×/wk 24 wks followed by 3 months of tapered intensity (4 bi-weekly sessions, followed by 2 sessions that met every third week)	University Center TX: Dietitian, a therapeutic recreation specialist, behavioral specialist CO: Dietitian, a therapeutic recreation specialist, behavioral specialist	Pre intervention, immediately post 24-wk intervention, 6 mos after completing intervention	Weight	Significant difference in favor of TX immediately (p=.005) and 6 mos post-intervention (p=.002)	NR	Weak
							Body fat (bioelectrical impedance)	NS difference b/w groups immediately and 6 mos post-intervention	NR	
							MVPA	Significant difference in favor of TX immediately post-intervention (p=.01); NS difference b/w groups 6 mos post-intervention	NR	
							Fruit intake	NS difference b/w groups immediately and 6 mos post-intervention	NR	
							Vegetable intake	Significant difference in favor of TX 6 mos post-intervention (p=.009); NS difference b/w groups immediately post-intervention	NR	
							Treat intake	NS difference b/w groups immediately and 6 mos post-intervention	NR	
Dickinson & Place, 2014	RCT	n=100 children 5-15 yrs, M= NR 79% Male; 21% Female Race/Ethnicity: NR Primary diagnosis: moderate to severe intellectual difficulties	TX: Typical physical education program plus Nintendo Wii and the software package "Mario and Sonics at the Olympics" Including athletics, aquatics, fencing, and table tennis games CO: Typical physical education program including sporting activities such as basketball, athletics, gymnastics, and swimming, as well as dance and other ball games, such as cricket.	30—45 mins of standard PE 2×/week plus 15 min Wii 3×/week Total duration -NR	School TX: School teachers CO: School teachers	Pre- and post-intervention	BMI	Significant difference in degree of change in favor of TX (p<.001)	Large*	Adequate
							Cardiorespiratory fitness – beep test	Significant difference in degree of change in favor of TX (p<.001)	NR	
							Aerobic capacity – 10x5 shuttle test	Significant difference in degree of change in favor of TX group (p<.01)	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Elmahgoub et al., 2011	Quasi	n=45 children 14-22 yrs, Mean = NR Gender: NR Race/Ethnicity: NR Primary diagnosis: Fragile X syndrome, Fetal alcohol syndrome, Prader–willi syndrome, Hydrocephalus, Pervasive development disorder, Sotos syndrome, Steinert syndrome; associated ASD, ADHD, epilepsy among some children	TX1: Combined exercise training including warming up (stretching of the large muscle groups and cardiovascular exercises at low resistance), cycling, strength training of the biceps brachii and triceps brachii, stepping, strength training of the quadriceps and hamstrings, and cooling down (stretching of the large muscle groups and cardiovascular exercises at low resistance) TX2: Same as TX1 but with a different frequency CO: Typical programming	TX1: 50 min sessions 3×/wk 10 wks TX2: 50 min sessions 2×/wk 15 wks	School TX1: Physiotherapists TX2: NR CO: NR	Pre- and post-intervention (10-15 wks)	BMI	Significant difference in evolution b/w TX1 and CO in favor of TX1 (p<.05); NS difference b/w TX1 and TX2	Small*	Adequate
							Waist Circumference	Significant difference in evolution b/w TX1 and CO in favor of TX1 (p<.05); NS difference b/w TX1 and TX2	Small*	
							Body Fat (bioelectrical impedance)	Significant difference in evolution b/w TX1 and CO in favor of TX1 (p<.05); NS difference b/w TX1 and TX2	NR	
							Cardiorespiratory Fitness – maximal cardiopulmonary exercise test, peak VO2	NS difference b/w any groups	NR	
							Cardiorespiratory Fitness – maximal cardiopulmonary exercise test, peak HR	Significant difference in evolution b/w TX1 and CO in favor of TX1 (p<.05); NS difference b/w TX1 and TX2	NR	
Fragala-Pinkham et al., 2011	Quasi	n=13 children, 12 analyzed 6-13 yrs, M=9.6 yrs 92% Male; 8% Female Race/Ethnicity: 100% White Primary diagnosis: Asperger Syndrome, PDD-NOS, High functioning autism	TX: Group aquatic activities involving aerobic activities, strength and endurance training, cool down and stretching; adaptations to learning style and sensory needs of participants including concrete instructions, simplified exercises, physical guidance as needed, recommendations of goggles/earmuffs/wet suit as needed; written schedule for added structure CO: Typical programming	TX: 40 min sessions 2×/wk 14 wks	Community-based organization TX: Community worker/aquatic staff supervised by a pediatric physical therapist CO: NR	Pre and post 14-wk intervention	Cardiorespiratory Fitness – ½ mile walk/run, time to complete	NS difference b/w TX and CO	NR	Weak
George et al., 2011	Quasi	n=22 children, 19 analyzed 5-21 yrs, M= M=12(TX) 13(CO) Gender: NR Race/Ethnicity: NR Primary diagnosis: ASD, Down Syndrome, ID, CP, Spina Bifida, Arthrogryposis Parent characteristics NR	TX: Walking or running on an indoor track, followed by stretching, large group activities (step aerobics, dance, obstacle course, ball skills), cardiovascular activities and strength training plus a parent education session which outlined a home exercise program and described record keeping for the program. CO: Typical programming	TX: 60-75 min sessions 2×/wk 8 wks	College sports center TX: Doctor of physical therapy students and undergraduate students CO: NR	Pre and post 8-wk intervention	BMI	NS difference b/w TX and CO	NR	Weak
							Cardiorespiratory Fitness – modified PFT	NS difference b/w TX and CO	NR	
							Energy Expenditure Index	NS difference b/w TX and CO	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
González-Agüero et al., 2011	RCT	n=26 children, 25 analyzed 10-19 yrs, M=13.7 (TX) 15.4 (CO) 50% Male, 50% Female Race/Ethnicity: NR Primary diagnosis: Down Syndrome	TX: Exercise group consisting of conditioning and plyometric jumps training. The training consisted of 1 or 2 rotations in a circuit of 4 stages including jumps, lateral rows, biceps curls and frontal rows with elastic fitness bands, wall press-ups, catching and throwing adapted medicine balls. Program was offered in four intensity-groups (quartiles) depending on body weight. When participants showed excessive facility for performing exercises, they were transferred to the next intensity-group. CO: Typical programming	TX: 25 min sessions 2×/wk 21 wks	Unspecified TX: Investigator and assistants CO: NR	Pre and post 21-wk intervention	Fat Mass	Group x Time interaction NS	NR	Weak
							Lean Mass	Significant Group x Time interaction (p=.027) in favor of TX	NR	
Kim & Lee, 2016	RCT	n=12 children 14-16 yrs, M=14.9 (TX) 15 (CO) 100% Male Race/Ethnicity: NR Primary diagnosis: ID	TX: Circuit exercise program – warm-up and stretching; progression from 4 to 6 circuits including three strength exercise (elastic-band exercise and medicine ball exercise) and two cardiovascular exercises (side-step, jumping jack); cool down CO: Typical programming	TX: 40 min sessions 4×/wk 12 wks	Unspecified TX: Investigator and instructor CO: NR	Pre and post 12-wk intervention	Body fat %	Significant Group x Time interaction (p=.026) in favor of TX	Small*	Weak
Kocić et al., 2017	Quasi	n=50 children Age Range NR, M=15.7 (TX) 15.9 (CO) 54% Male; 46% Female Race/Ethnicity: NR Primary diagnosis: Mild ID	TX: Adapted basketball training focusing on ball handling, reception, passing, and shooting CO: Typical Programming	TX: 25-35 min sessions 4×/wk 8 wks	Unspecified TX: Investigators CO: NR	Pre and post 8-wk intervention	Body Fat (bioelectrical impedance)	NS difference b/w TX and CO	NR	Weak
							Cardiovascular Fitness – Resting HR	NS difference b/w TX and CO	NR	
							Cardiovascular Fitness – HR during 6MWT	NS difference b/w TX and CO	NR	
							Cardiorespiratory Fitness – 6MWT, distance	Significant difference in degree of change in favor of TX ($p<.05$)	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Kong et al., 2019	Quasi	n=53 children 10-18 yrs, M=14.9 yrs 84.9% Male; 15.1% Female Race/Ethnicity: 100% Asian Primary diagnosis: ID without Down Syndrome	TX1: Customized 8-form Tai Chi routine developed by a Tai Chi master TX2: Aerobic dance sessions CO: Art and craft activity	60 min sessions 2×/wk 12 wks	Indoor sports facility TX1: Tai Chi master with more than 10 years of teaching experience TX2: Certified physical educator and personal trainer CO: NR	Pre and post 12-wk intervention	BMI	Significant Time effect (p=.006); Group effect NS; Group x Time interaction NS	Small* for all 3 groups	Weak
							Waist-Hip Circumference	Time effect NS; Group effect NS; Group x Time interaction NS	NR	
							Body Fat (Sum of skinfolds)	Time effect NS; Group effect NS; Group x Time interaction NS	NR	
							Cardiorespiratory Fitness – 6MWT, distance	Significant Time effect (p<.001) Group effect NS; Significant Group x Time interaction (p=.034) in favor of TX2	Large* for aerobic exercise group Small* for Tai Chi and Control groups	
Lau et al., 2020	Quasi	n=203 children, 194 analyzed 8-18 yrs, Mean=NR 72% Male, 28% Female Race/Ethnicity: NR Primary diagnosis: ID with ASD as a secondary diagnosis for some	TX: Participants were paired with a peer and provided an Active Video Game and Xbox 360 Kinect technology. Participants were free to choose the games they liked in the Xbox 360 Sport Season Series 1 and 2. Season 1 included boxing, track and field, 10-pin bowling, table tennis, beach volleyball and football. Season 2 included baseball, skiing, tennis, golf, darts and American football. CO: Typical programming	TX: 30 min sessions 2×/wk 12 wks	School TX: School PE teachers CO: NR	Pre and post 12-wk intervention	BMI	NS difference b/w groups on adjusted analyses	NR	Adequate
							Body Fat (bioelectrical impedance)	NS difference b/w groups on adjusted analyses	NR	
							MVPA time	NS difference b/w groups on adjusted analyses	NR	
							Sedentary time	NS difference b/w groups on adjusted analyses	NR	
Lee et al., 2017	RCT	n=115 children and parents of 63 intervention children 8-16 yrs, M=13.4 (TX) 15.3 (CO) 71% Male; 29% Female Race/Ethnicity: NR Primary diagnosis: Mild ID Parents: wide range of income and education levels	TX: Structured weight management program promoting healthy eating and regular exercise via training sessions at school and extended to the home via mHealth tools to encourage parental involvement; support and monitoring from the school's nurses, peers, teachers and parents, who acted as "agents for change" CO: Typical programming	TX: 60 min sessions 1×/wk 24 wks	Home and School Unspecified	Pre and post 24-wk intervention	BMI	NS difference b/w groups on adjusted analyses	NR	Adequate
							Body Fat %	NS difference b/w groups on adjusted analyses	NR	
							Waist-Hip Ratio	NS difference b/w groups on adjusted analyses	NR	
							Food Pyramid Test	NS difference b/w groups on adjusted analyses	NR	
							Sports Pyramid Test	Significant difference in favor of TX (p<.001)	NR	
							Snack Choice Test	Significant difference in favor of TX (p=.04)	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Pan, 2011	Quasi	n=30 children 7-12 yrs, M=8.6 yrs 66% Male; 33% Female Race/Ethnicity: 100% Asian Primary diagnosis: ASD	TX: Structured social and floor warm-up activities, aquatic skills practice, games/activities, cool down activities; Participating child and sibling assigned to a trained instructor throughout the program for instructional and safety reasons; Goals individually determined to meet the specific needs of each participant in cooperation with the consultation of therapists; Organization of the physical environment (e.g. clear boundary markings to help children know where they may and may not go) and visual schedules and work systems (e.g. board with pictures and words to describe the routine and the daily aquatic activity) CO: Received the intervention after a waiting period	TX and CO: 70 min sessions 2×/wk 14 wks	Indoor hydrotherapy and swimming pool TX and CO: Trained instructors	Pre intervention, immediately post 14-wk intervention, 14 wks after completing intervention	BMI	NS differences b/w TX and CO children immediately post and 14-wks post-intervention	NR	Adequate
							Body Fat (bioelectrical impedance)	NS differences b/w TX and CO children immediately post and 14-wks post-intervention	NR	
							Cardiovascular Fitness - PACER test	NS differences b/w TX and CO children immediately post and 14-wks post-intervention	NR	
Pejčić et al., 2019	Quasi	n=122 children, 60 analyzed 13-17 yrs, M=14.9 Gender: NR Race/Ethnicity: NR Primary diagnosis: mild ID	TX: 'Special Sports' physical fitness program beginning with warm-up and muscle-strengthening exercises followed by 10 repetitions of 2 or > technical elements of football (controlling the ball, shooting at goal and passing the ball) and basketball (controlling the ball, catching the ball, passing the ball and shooting baskets) and ending with muscle relaxation. CO: Regular program of the Ministry of Education, Science and Technological Development of the Republic of Serbia	TX: 30 min sessions 4×/wk 12 wks CO: As above with 1 session/wk dedicated to the selected sport and a 45-min swimming session/wk	School TX and CO: PE teachers	Pre and post 12-wk intervention	Cardiorespiratory Fitness – 25-meter run, time	Significant difference in favor of TX (p=.014) on adjusted analyses	Medium to Large**	Weak

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Ptomey et al., 2015	RCT	n=20 children and parents 11-18 yrs, M=14.9 yrs 55% Male; 45% Female Race/Ethnicity: 70% White, 20% Black, 5% Asian, 5% Other Primary diagnosis: ID with secondary diagnoses including ASD and Down Syndrome Parents: 48.1 yrs, 95% female, >HS education	TX: Enhanced Stop Light Diet with addition of fruits and vegetables (>=5 servings/day) and high-volume, low-energy portion-controlled meals (PCMs) consisting of two entrées and two shakes per day. Participants could also pick foods from the Stop Light Diet picture guide, if they were still hungry or unable to consume the entrée or shake, and portion-controlled meals were shipped to participants' homes weekly. CO: Conventional Reduced Energy Diet as recommended by the US Department of Agriculture MyPlate approach. Participants' energy needs were estimated and a deficit of 500 to 700 kcal/day was prescribed including five servings of fruits and vegetables per day. Participants were provided examples of meal plans consisting of suggested servings of grains, proteins, fruits and vegetables, dairy, and fats based on their energy needs, and they were counseled on appropriate portion sizes using 3-dimensional food models. Common element for TX and CO: 90-minute, at-home diet orientation and lifestyle modification session (social support, self-monitoring, physical activity, environmental control, and self-efficacy) conducted by a registered dietitian nutritionist (RDN) followed by weekly at-home education sessions that were conducted over video chat (FaceTime, Apple, Inc) on the iPad. During weekly sessions, RDN reviewed diet and physical activity data (collected via the Lose It! Application and Fitbit activity trackers) and answered questions, problem-solved, promoted goal setting, and provided support.	TX and CO: 90 min intro session followed by 30 min sessions 1×/wk 8 wks	Home with digital access TX and CO: Registered dietitian nutritionist	Pre and two months post-intervention	BMI change	NS difference b/w groups on adjusted analyses	NR	Weak
							Waist Circumference	NS difference b/w groups on adjusted analyses	NR	
							Mean Daily Energy Intake	Significant difference in favor of TX (p=.048) on adjusted analyses	NR	
							Diet Quality (Healthy Eating Index)	Significant reduction in empty calories in both groups. NS difference b/w groups on adjusted analyses	NR	
							MVPA Time	NS difference b/w groups on adjusted analyses	NR	
							Sedentary Time	Significant reduction in both groups. NS difference b/w groups on adjusted analyses	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Seron et al., 2014	Quasi	n=41 children Age Range NR, M=15.5 61% Male; 39% Female Race/Ethnicity: NR Primary diagnosis: Down Syndrome	TX1: Warm-up; aerobic training on a treadmill/bike with a heart rate intensity of 50-70% of HR reserve; stretching TX2: Warm-up; resistance training composed of 9 exercises (e.g. bench press machine, leg extension, front pull-down, cable biceps curl, standing hip flexion with ankle weights), with 3 sets of 12 maximum repetitions; stretching CO: Typical programming	TX1: 50 min sessions 3×/wk 12 wks TX2: 50 min sessions 2×/wk 12 wks	Unspecified Unspecified	Pre and post 12-wk intervention	BMI	Significant difference b/w groups with improvement in TX1 (p<.05)	NR	Weak
							Body Fat (Plethysmography)	Significant difference b/w groups with deterioration in CO (p<.05)	NR	
							Waist Circumference	NS difference b/w groups	NR	
Suarez-villadat et al., 2020	RCT	n=45 children 12-15 yrs, M= 13.9 (TX) 13.7 (CO) 56% Male; 44% Female Race/Ethnicity: NR Primary diagnosis: mild to severe ID	TX: Swimming in front crawl style and breaststroke style; exercises using equipment like pull-buoy, tables, shovels, fins; ending with soft swim for muscle relaxation CO: Use of water games to do physical activity	TX: 50 min sessions 3×/wk 36 wks CO: unspecified time session 2×/wk 36 wks	Unspecified TX and CO: Qualified swim coaches along with a specialist in adapted physical activity	Pre and post 36-wk intervention	BMI	Significant difference in degree of change in favor of TX (p=.001)	Large**	Adequate
							Waist Circumference	Significant difference in degree of change in favor of TX (p=.049)	Large**	
							Body Fat (Skinfold thickness)	Significant difference in degree of change in favor of TX (p=.049)	Large**	
Ulrich et al., 2011	RCT	n=72children, 46 analyzed 8-15 yrs, M=12 44% Male; 56% Female Race/Ethnicity: 87% White, 4% Black, 2% Hispanic/ Latinx, 7% Other Primary diagnosis: Down Syndrome	TX: Adapted bicycle riding using a summer camp format with consecutive days of individual instruction. Adaptive bicycles were customized for each participant with roller wheels taper progressing from 1-8 changes based on the child's performance. CO: Typical programming	TX: 75 min sessions 5×/wk 1 wk	Community-based organization TX: Trained community workers/ staff with professional experience with children with I/DD CO: NR	Pre intervention, 7 wks post-intervention, 1 yr post	BMI	Significant Group x Time interaction (p=.028) in favor of TX	Small*	Weak
							Body Fat (Skinfold thickness)	Significant Group x Time interaction (p=.047) in favor of TX	Small*	
							MVPA time	Significant Group x Time interaction (p=.006) in favor of TX	Small* at 7 wks post; Medium* at 1 yr post	
							Sedentary time	Significant Group x Time interaction (p=.023) in favor of TX	Small*	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Wallén et al., 2013	Quasi	n=89 children 16-21 yrs, M=19 yrs 51% Male; 49% Female Race/Ethnicity: NR Primary diagnosis: ID, Down Syndrome, ASD	TX: Plate model intervention - Model plate 25 cm in diameter with a 4-cm edge and colored pictures of different food categories on the edge. The idea behind the plate was explained to all students by the health education teacher. School staff were encouraged to discuss the purpose of the plate during lunchtime and comment on missing items when the food was taken or being eaten. The school cafeteria served food high in fiber, cooked at the school, with a wide selection of both raw and cooked vegetables, legumes and fruits, and skimmed milk or water to drink. All sweets, sodas, and ice creams removed from school cafeteria. One portion was recommended, and vegetables were suggested if second or more servings were wanted. Additional breakfast items and fruits were available at a low cost. CO: Typical programming	Unspecified	School TX: School educators and lunch staff CO: NR	Unclear, most likely post-intervention only	BMI	NS difference b/w groups	NR	Weak
							Lunch eaten in Kcal	NS difference b/w groups	NR	
							% Fat consumed	Significant difference in favor of TX (p=.031)	NR	
							% Protein consumed	NS difference b/w groups	NR	
							% Carbohydrates consumed	Significant difference in favor of CO (p=.035)	NR	
Wu et al., 2017	Quasi	n=43 children 13-19 yrs, M=17 yrs 44% Male; 56% Female Race/Ethnicity: 100% Asian Primary diagnosis: ID with secondary diagnoses including Down Syndrome, vocal dysfunction, ASD, Mental Disorder	TX: Cross circuit training involving trips of ascending and descending stairs, the use of aerobic device (treadmill, step machine, cross trainer, and stationary bicycle), sit-ups, and consecutive jumps with both feet together CO: Typical programming	TX: 50 min sessions 5×/wk 12 wks	School Unspecified	Pre and post 12-wk intervention	BMI	NS difference b/w TX and CO on age-adjusted analyses	NR	Weak
							Body Fat (Body fat composition analyzer)	NS difference b/w TX and CO on age-adjusted analyses	NR	
							Cardiovascular Fitness – modified Bruce Protocol Treadmill Stress test, max HR	Significant difference b/w TX and CO in favor of TX (p=.04)	NR	

Table 1. (continued)

Study citation	Design	Sample	Group comparisons	Frequency and duration	Setting Delivered by	Follow-up	Dependent variables (outcomes)	Findings	Effect size	Rigor
Xu et al., 2020	Quasi	n=22 children Age Range NR, M=7.2 (TX) 7.5 (CO) 59% Male; 41% Female Race/Ethnicity: NR Primary diagnosis: ASD, Down Syndrome, ID	TX: Adapted Rhythmic Gymnastics Program including class routines to promote the interaction between children and teachers; warm-up; core activities including basic rhythmic gymnastics skills such as imitating animals and exercise games such as crawling to compete with other peers; cool-down; visual, verbal, and musical cues to motivate participation CO: Typical programming	TX: 50 min sessions 3×/wk 16 wks	School TX: Teachers	Pre and post 16-wk intervention	BMI Cardiovascular Fitness – modified PACER test	NS difference b/w TX and CO NS difference b/w TX and CO	NR NR	Weak

*Cohen's d where $d = 0.2$ is considered a "small" effect, 0.5 represents a "medium" effect, and 0.8 denotes a "large" effect

**Partial eta squared where $\eta 2 = 0.01$ is considered a "small" effect, 0.09 represents a "medium" effect, and 0.25 denotes a "large" effect

2011), planning sufficient time to become familiar with exercises and equipment (González-Agüero et al., 2011), and use of visual/verbal/physical cues, modeling, or exaggerated demonstrations (George et al., 2011; Xu et al., 2020). Three studies reported implementation barriers including decline in participants' motivation over the course of the intervention (Elmahgoub et al., 2011), fatigue among interventionists, children's refusal to participate in group exercise (George et al., 2011), and difficulty with completing rigorous exercise regimens due to impaired balance and limited muscle strength (Wu et al., 2017).

Sports-Based Physical Activity Programs

Three studies addressed physical activity through training in specific sports skills. Target sports included football and basketball (Pejčić et al., 2019), basketball (Kocić et al., 2017), and bike riding (Ulrich et al., 2011). Interventions in this category focused on training participants in technical elements of the selected sport(s) such as ball control, ball passing, ball catching, shooting goals and baskets, self-launching, braking, and turning a bike. Two studies (Kocić et al., 2017; Ulrich et al., 2011) reported adapting the interventions to the learning and physical needs of children and adolescents with DD. For example, riding equipment was adapted to include rear handles so that trainers could better protect and guide the participants, larger and lower seats to allow foot contact with the ground, and special rollers to minimize fear of falling (Ulrich et al., 2011).

Intervention settings were reported in two studies. Of these, one intervention was school-based and delivered by school Physical Education (PE) teachers (Pejčić et al., 2019) and the other was offered by staff at a local community center (Ulrich et al., 2011). All three sports-based interventions were delivered in-person and focused exclusively on children and adolescents with DD without parent, sibling, or peer involvement. Interventions involving ball sports were conducted in group format during 25- to 35-min sessions occurring four times per week and over a period of 8–12 weeks (Kocić et al., 2017; Pejčić et al., 2019). The bike riding intervention was conducted one-on-one over a 1-week period involving five consecutive sessions of 75 min each. No specific implementation barriers were reported by any of the sport-based physical activity intervention studies.

Aquatic Exercise Programs

Three studies (Fragala-Pinkham et al., 2011; Pan, 2011; Suarez-Villadat et al., 2020) focused on aquatic exercise programs involving one of more of the following activities: pool-based aerobic and endurance exercises, aquatic skills training, and water games. Programs were adapted for children and adolescents with DD by incorporating strategies such as simplified exercises, physical guidance, boundary markings to encourage children to stay in the designated area, and visual schedules using pictures and words to describe the routine. Props such as pull buoys, shovels, fins, swim goggles, wet suits, and earmuffs were provided as needed.

Intervention settings, when reported, included a community center (Fragala-Pinkham et al., 2011) and an indoor pool at an unspecified location (Pan, 2011). Programs were delivered in-person by community center staff (Fragala-Pinkham et al., 2011), swim coaches (Suarez-Villadat et al., 2020), and unspecified trained instructors (Pan, 2011). Two of the three studies in this category offered the intervention in a group format (Fragala-Pinkham et al., 2011; Suarez-Villadat et al., 2020) while the third (Pan, 2011) combined group activities with individualized goal setting support and paired the children and adolescents with DD with a non-disabled sibling. None of the studies involved parents or peers. Sessions were 40–70 min long and conducted 2–3 times per week. Total duration of the intervention ranged from 14 to 36 weeks. No specific implementation barriers were reported other than the potential loss of access to aquatic facilities and ongoing practice after study completion.

Physical Activity Programs Based on Active Video Gaming

Two studies focused on promoting physical activity among participants through structured engagement in active video games either in addition to standard PE at school or as a standalone intervention. Gaming consoles included Nintendo Wii (Dickinson & Place, 2014) and Xbox 360 (Lau et al., 2020). Both studies used software packages focusing on kinetic sports games such as tennis, table tennis, football, baseball, track and field sports, and aquatic sports. The video gaming interventions were group-based and delivered in-person by school teachers during regular school hours. Gaming sessions were 15–30 min long and conducted 2–3 times per week over a period of approximately 12 weeks. Parents and siblings were not included in these interventions, although Lau et al. (2020) did involve peers without DD. No specific adaptations were reported.

One study (Lau et al., 2020) in this category reported multiple barriers to intervention delivery. Specifically, the intervention dosage was restricted by rigid school schedules, children and adolescents with DD had trouble following instructions and practicing specific sport skills, the competitive nature of sports games triggered emotional disturbances among children, and the high teacher to student ratio precluded customized game selection and problem-solving (Lau et al., 2020).

Diet and Lifestyle Interventions

Four studies involved diet and lifestyle interventions. Of these, one was a school-based intervention that focused exclusively on dietary modifications by removing unhealthy food items from the school cafeteria, reconfiguring the free lunch menu with healthy food options, and making healthy and low-cost breakfast and snack items available to students during the school day (Wallén et al., 2013). In addition, educators and lunch staff introduced students to healthy diet concepts based on the "Plate Model" (Camelon et al., 1998). The intervention neither involved parents nor included any home-based components. Frequency, intensity, and duration of the intervention were not specified.

The remaining three interventions in this category (Curtin et al., 2013; Lee et al., 2017 ; Ptomey et al., 2015) were behavioral interventions that focused more broadly on lifestyle modification. Common components of the three interventions included initial education about nutrition and physical activity concepts which was provided one-on-one or in group format. This was followed by setting individualized diet and physical activity goals, alongside support with problem-solving and goal planning. When specified, interventionists included therapeutic recreation specialists, behavioral specialists, and/or dietitians. No specific adaptations were reported in the studies focusing on diet and lifestyle interventions.

One intervention (Curtin et al., 2013) was conducted in-person at a university center while the other two (Lee et al., 2017; Ptomey et al., 2015) were delivered in-person either at home or school with remote follow-up via digital applications such as WhatsApp and FaceTime. All three interventions included parents, and in one case (Lee et al., 2017) also peers and school staff. Sessions were 60–90 min long and conducted once per week. Total duration of interventions ranged from 8 to 24 weeks. One intervention (Curtin et al., 2013) included further follow-up over 3 months at a tapered intensity. Implementation barriers included difficulty with accommodating participants' restricted eating and limited time during sessions to master recommended exercises (Curtin et al., 2013). In one study (Ptomey et al., 2015), portable tablets (i.e., iPads) were provided to participating families for the duration of the intervention suggesting limited long-term sustainability of technology-dependent interventions.

Study Outcomes and Intervention Efficacy

Outcomes evaluated across studies included anthropometrics (e.g., BMI, body fat percent, waist-hip ratio), changes in body structures and functions (e.g., leg extension strength), performance of generic physical skills (e.g., standing long jump distance, balance) and sports-specific physical skills (e.g., ball handling and reception skills), physical activity participation (e.g., sedentary time, time spent in moderate to vigorous physical activity [MVPA]), physiological (e.g., peak heart rate, peak V02) and performance-based measures (e.g., Treadmill Stress Test) of cardiovascular fitness, dietary outcomes (e.g., percent carbohydrates consumed, Healthy Eating Index), psychosocial outcomes (e.g., snack choice, self-efficacy in physical activity), and knowledge tests (e.g., Food Pyramid Test). Parent outcomes were generally not examined with the exception of one study (Lee et al., 2017), which measured parents' cooking preferences. Most studies measured outcomes before and immediately after the intervention. Three studies conducted an additional follow-up at 14 weeks (Pan, 2011), 6 months (Curtin et al., 2013), and 1 year (Ulrich et al., 2011) post-intervention, respectively. This section summarizes study findings for outcomes relevant to this systematic review (see Table 1 for details).

Anthropometrics: BMI, Body Fat, and Body Circumferences

Sixteen studies examined changes in BMI and/or weight; fifteen examined body fat percentage via bioelectrical impedance, plethysmography, or skin fold measurement; and seven examined body circumferences. For studies that examined both BMI and weight, we only report findings related to BMI as BMI is considered a better indicator of body composition in growing children (Doak et al., 2013).

Of the nine studies that focused on aerobic and strength training exercise programs, BMI was examined as an outcome in seven. Of these, five studies (Boer et al., 2014; George et al., 2011; Kong et al., 2019; Wu et al., 2017; Xu et al., 2020) found non-significant differences in evolution of BMI between usual care/passive control and experimental conditions. Two studies noted significant improvements in BMI favoring the experimental interventions. Seron et al. (2014) found that children who received 12 weeks of aerobic exercise training demonstrated improved BMI compared to children who received resistance training or usual care. Similarly, Elmahgoub et al. (2011) found that compared with typical programming, a combined aerobics and strength training exercise program offered 2–3 times a week over 10–15 weeks showed significant improvement in BMI with a small effect size.

Seven aerobic and strength training studies examined body fat percentage. Of these, two studies found non-significant effects related to customized Tai Chi or aerobic dance (Kong et al., 2019), and circuit training (Wu et al., 2017). Four studies found that relative to typical programming, changes in body fat percentage were significantly better for children who received sprint interval training or continuous aerobics training (Boer et al., 2014), circuit training (Kim & Lee, 2016), aerobic exercise or resistance training (Seron et al., 2014), and a combined aerobics and strength training exercise program (Elmahgoub et al., 2011). Effect sizes where reported (Elmahgoub et al., 2011; Kim & Lee, 2016) were found to be small. One study (González-Agüero et al., 2011) found a non-significant difference from typical programming for changes in fat mass, but significant difference for lean mass in favor of a 21-week circuit training program.

Four studies in this intervention category examined waist circumference or waist-hip ratio. Two of these (Kong et al., 2019; Seron et al., 2014) found no significant intervention effects, while the other two (Boer et al., 2014; Elmahgoub et al., 2011) found that children who received interventions such as sprint interval training, continuous aerobic training, and a combined aerobic plus strength training program demonstrated significantly better outcomes than those in control conditions.

Only one (Ulrich et al., 2011) of the three sports-based physical activity programs examined BMI as an outcome, while two (Kocić et al., 2017; Ulrich et al., 2011) examined body fat percentage. Kocić et al. (2017) found non-significant differences between typical programming and adapted basketball training for changes in body fat. Ulrich et al. (2011) found significant improvement in BMI and body fat with a small effect size in favor of adapted bicycle training compared with typical programming. None of the studies in this intervention category examined body circumferences.

Among the three aquatic exercise programs, two (Pan, 2011; Suarez-Villadat et al., 2020) examined changes in BMI and body fat percentage; of these, one study (Suarez-Villadat et al., 2020) additionally examined changes in waist circumference. Pan (2011) found non-significant differences in evolution of BMI and body fat between children who received the 14-week program and those in the waitlist-control group, whereas Suarez-Villadat et al. (2020) found that their structured 36-week swimming program conferred a significant advantage over unstructured water games for all three anthropometric outcomes with large effect sizes.

The two studies on active video gaming demonstrated mixed results in relation to BMI and body fat percentage. Lau et al. (2020) found non-significant effects of active video gaming compared with typical programming for BMI and body fat percentage. Dickinson and Place (2014) found a significant and large effect on BMI after standard PE plus Nintendo Wii training compared with PE alone. Neither study in this category examined body circumferences.

All four studies focusing on diet and lifestyle interventions included BMI or weight as an outcome. Two of these studies (Curtin et al., 2013; Lee et al., 2017) additionally examined body fat percentage, and two (Lee et al., 2017; Ptomey et al., 2015) examined body circumferences as well. Two studies in this intervention category (Lee et al., 2017; Wallén et al., 2013) found non-significant effects of the experimental interventions versus typical programming for BMI. The other two studies were small-scale RCTs that involved comparisons between two active interventions.

Ptomey et al. (2015) found non-significant differences in evolution of BMI and waist circumference between two different diet modification programs with a common element of diet orientation and lifestyle change. Of note, children in both programs demonstrated within-group reduction in BMI and waist circumference from baseline. Similarly, Curtin et al. (2013) compared two lifestyle modification programs, one with and the other without support from a behavioral specialist. They found that participants' weight reduced significantly more when a behavioral specialist was involved than when no behavioral support was provided. Reduction in percent fat was also greater in the behavioral intervention group although this divergence between groups did not reach statistical significance.

In summary, intervention efficacy for anthropometric outcomes appeared to be mixed for aerobic and strength training exercise programs, sports-based physical activity programs, aquatic exercise programs, and active video gaming. Body fat percentage was one outcome where aerobic and strength training exercise programs were more likely to demonstrate significantly positive intervention effects. Diet and lifestyle interventions did not perform better than typical programming with regard to anthropometric outcomes, although within-group improvements were noted in studies comparing two active interventions.

Cardiovascular Fitness

Eleven studies examined physiological or performance-based measures of cardiovascular fitness. Among these, six studies focused on aerobic and strength training exercise programs. Of these, two found non-significant differences in performance of physical fitness tests between control participants and those who received a rhythmic gymnastics program (Xu et al., 2020) or those who received a combined aerobic and strength training program (George et al., 2011). Two studies found that compared with control conditions, aerobic dance exercise (Kong et al., 2019) and circuit training (Wu et al., 2017) were associated with superior performance or better physiological response during physical fitness tests, respectively. Two studies in this intervention category found mixed intervention effects for cardiovascular outcomes. Boer et al. (2014) found that children who received sprint interval training demonstrated significant improvements in peak VO2 and ventilatory threshold compared with those who received continuous aerobic training or typical programming. The continuous aerobic training group also performed significantly better than the typical programming group on these outcomes. On the other hand, changes in peak heart rate were not significantly different between groups. Similarly, Elmahgoub et al. (2011) found significant improvement in peak heart rate, but not in peak V02 after combined exercise training compared with typical programming.

Two (Kocić et al., 2017; Pejčić et al., 2019) of the three sports-based physical activity programs examined cardiovascular outcomes. Both studies found significant improvements in performance of physical fitness tests among children who received adapted football and/or basketball training compared with children receiving typical programming. Pejčić et al. (2019) reported a medium to large effect size for this outcome. Kocić et al. (2017) additionally evaluated physiological indicators and found non-significant differences in evolution of resting and active heart rate.

Among the three aquatic exercise programs, two (Fragala-Pinkham et al., 2011; Pan, 2011) examined changes in performance of physical fitness tests. Both studies found non-significant differences between intervention and control conditions on this outcome. One study on active video gaming (Dickinson & Place, 2014) found that children who received Nintendo Wii training in addition to PE showed significantly better improvement in performance of fitness tests than those who received standard PE only. None of the studies focusing on diet and lifestyle interventions evaluated outcomes related to cardiovascular fitness.

In summary, intervention efficacy for cardiovascular outcomes appeared to be mixed for aerobic and strength training exercise programs but showed some promise for sports-based physical activity programs and active video gaming. Aquatic exercise programs did not perform better than control conditions regarding cardiovascular outcomes.

Engagement in Physical Activity

Four studies included accelerometry-based evaluations of engagement in physical activity, specifically time spent being sedentary and in moderate to vigorous physical activity (MVPA). One (Ulrich et al., 2011) of the three sports-based physical activity programs examined this outcome and found significant differences in evolution of sedentary and MVPA time with small effects in favor of an adapted bicycle riding program compared with typical programming. One of the two active video gaming studies (Lau et al., 2020) addressed physical activity and found non-significant differences between intervention and control conditions for changes in sedentary and MVPA time.

Physical activity was examined by two of the four studies in the diet and lifestyle intervention category. Both studies compared two active interventions. Ptomey et al. (2015) found non-significant differences in evolution of sedentary and MVPA time between two different diet modification programs with a common element of diet orientation and lifestyle change. However, both interventions were associated with a significant within-group reduction in time spent being sedentary. Curtin et al. (2013) found that time spent in MVPA decreased for children who received nutrition and activity education only, while it increased for those who received additional behavioral support.

Given the small number of studies in each intervention category that addressed physical activity engagement, overall patterns of efficacy are difficult to determine as only one study found significant differences in sedentary time and MVPA.

Dietary Changes

Three studies, all in the diet and lifestyle modification category, evaluated changes in dietary intake. One study (Wallén et al., 2013) found that although percent protein and calories consumed were not significantly different between children in the control condition and those who received a school-based multifactorial diet intervention, consumption of percent fat was significantly lower, and consumption of percent carbohydrates was significantly higher in the intervention group.

Two studies compared distinct dietary/lifestyle interventions and found significant differences within or between groups on some dietary outcomes but not others. Curtin et al. (2013) compared nutrition and activity education programs with and without behavioral support. Differences between groups were non-significant for fruit and treat intake. However, the group without behavioral support showed significant within-group improvement in fruit intake, while the group that received behavioral support had significant within-group improvement in treat intake. The behavioral support group also fared significantly better on vegetable intake during the intervention and at the 6-month follow-up. Similarly, Ptomey et al. (2015) found daily energy intake to be significantly better after the "Enhanced Stop Light Diet" compared with a conventional reduced energy diet based on the MyPlate approach. The study also found a significant reduction in consumption of empty calories for both diet modification programs, although between-group differences in overall diet quality were not significant.

Overall, intervention efficacy for dietary outcomes appeared to be mixed across studies focusing on diet and lifestyle modification. Furthermore, the use of behavioral support yielded mixed results.

Study Rigor

Using criteria adapted from Reichow (2011), 15 studies were assigned a quality rating of "weak," and six studies were assigned a quality rating of "adequate" (see Table 1). None of the studies met the criteria for "high" rigor. Common limitations related to primary quality indicators included possibility of sample selection bias (n=20), lack of intervention theory (n=17), inadequate details about intervention settings (n=16), lack of training of interventionists (n=20), lack of a standardized intervention manual or protocol (n=9), and lack of reliability and/or validity indices for measurement of dependent variables (n=15). Common limitations related to secondary quality indicators included lack of monitoring for intervention fidelity and adherence (n=17), lack of follow-up outcome measures to assess maintenance (n=18), lack of control for co-intervention effects (n=14), and lack of blind raters for outcome assessments (n=17). For the nine RCTs, specifically, additional limitations included lack of randomization concealment (n=8), and lack of details about randomization procedures (n=8).

The overall level of evidence of each intervention category identified in this review was determined using Reichow's criteria (Reichow, 2011). None of the intervention categories met the recommended threshold for "established" EBP. Aquatic exercise programs approached Reichow's (2011) cutoff for "probable" EBP (Z=30) based on at least two of three group design studies demonstrating "adequate" rigor. Active video gaming programs also approached a "probable" level of evidence with both studies in this category assigned an "adequate" rating for rigor (Z=30). Diet and lifestyle interventions could be categorized as "not an EBP" at this time as only one of the four studies in this category was rated as "adequate" (Z=15). Similarly, only one of nine studies focusing on aerobic and strength training exercise programs was rated as "adequate." Therefore, these types of interventions could also be categorized as "not an EBP" (Z=15). All three studies focusing on sports-based physical activity programs were rated as "weak" warranting an overall rating of "not an EBP" for these interventions.

Discussion

This review identified five types of interventions across 21 studies addressing obesity prevention in children and adolescents with DD. The small number of RCTs and quasi-experimental studies identified points to the lack of obesity prevention research involving this population. In contrast, the body of literature for preventing obesity in non-disabled children is well-established and is projected to accrue at a rate of 2000–4000 records per year (Brown et al., 2019). A recent systematic review on this topic identified 153 RCTs, none of which addressed disability (Brown et al., 2019). Therefore, this systematic review addresses an important gap in the literature on this topic. Given the relatively small body of literature, we found for children and adolescents with DD, nuanced interpretation of intervention efficacy by age groups was not possible. However, some broad overall trends were noted.

Of the five intervention types identified in this review, four focused on physical activity alone through a range of exercise interventions including aerobic and strength training exercise, sports-based exercise, aquatic exercise, and active video gaming. This finding is in contrast with the body of literature on obesity prevention among non-disabled children, where the majority of interventions across age groups use a combination of diet and physical activity (Brown et al., 2019). Within the fifth category of diet and lifestyle interventions, one study focused on dietary changes alone, while the other three focused on changing dietary and activity behaviors in combination.

Studies in this review that combined diet and physical activity intervention involved active comparisons. Therefore, it was not possible to interpret the superiority of these interventions over typical programming. However, these interventions showed significant within-group improvement in anthropometrics, physical activity levels, and dietary changes suggesting some promise. There was also weak and mixed evidence from a single study that behavioral support may be a beneficial component of interventions promoting healthy diet and physical activity (Curtin et al., 2013). This intervention type did not meet the threshold of EBP and further research is needed to make conclusive practice recommendations. Of note, such combined interventions are aligned with obesity prevention strategies promoted by the Centers for Disease Control and Prevention which recommends multi-component interventions incorporating engagement in physical activity training and nutrition education along with behavioral strategies (CDC, 2011; Maïano et al., 2014). For younger children without disabilities, interventions that combine diet with physical activity have proven to be more effective in reducing the risk of obesity than those focusing on diet or physical activity alone (Brown et al., 2019). For older children without disabilities, interventions focusing on physical activity alone have proven effective, while combined interventions have shown promise (Brown et al., 2019).

In the present review, intervention types focusing on physical activity alone were found to have mixed efficacy for anthropometric outcomes indicating they might or might not improve BMI and adiposity in children and adolescents with DD. Our certainty in these effects is low for aerobic and strength training programs and sports-based exercises, which did not meet the threshold of EBP, whereas for aquatic exercises and active video gaming, our certainty is moderate as these interventions approached the threshold for "probable" EBP. This finding of mixed efficacy for physical activity interventions for reducing obesity risk among children and adolescents with DD is in contrast with the proven efficacy of such interventions for preteens and adolescents without disabilities. A possible explanation for the contrasting findings could be that children and adolescents with DD lack the balance, endurance, and motor skills for sustained participation in complex exercise regimens (Wu et al., 2017) and also struggle with following instructions and practicing specific sports (Lau et al., 2020). This speaks to the necessity to adapt obesity prevention interventions to the needs of children and adolescents with DD and the local context. Rimmer et al. (2014) argue that evidence-based health promotion and obesity prevention programs for children with disabilities should consider a set of inclusion recommendations and adaptations separated into one of four content domains which include the built environment, services, instruction, and equipment. Necessary adaptations support the full inclusion of an individual into an existing health promotion program addressing implementation barriers reported by some studies in this review such as lack of participant engagement, difficulty maneuvering equipment, and challenges with learning complex sports rules.

Our review also found that sports-based exercise programs and active video gaming showed promising effects on cardiovascular fitness outcomes. This finding is consistent with those reported by systematic reviews of physical activity interventions for youth and adults with DD (Jeng et al., 2017; Li et al., 2013; Maïano et al., 2014). However, there is some concern about the acceptability of such interventions by younger children with DD as the competitive nature of real and virtual sports games can trigger emotional disturbances in this population (Lau et al., 2020).

Another important finding of this review was the limited involvement of parents in interventions, which was observed in only four studies. This finding also stands in contrast with the evidence base for obesity-related interventions for children without DD (Mehdizadeh et al., 2020; van der Kruk et al., 2013). Systematic reviews have shown that involving parents either during the core intervention or during maintenance resulted in higher improvement in BMI and other outcomes for children, and that medium- to high-intensity parental involvement was associated with effectiveness of long-term childhood obesity interventions (Mehdizadeh et al., 2020; van der Kruk et al., 2013). These findings suggest that parental involvement should also be considered in obesity-related interventions of children and adolescents with DD. Prevalent disability and rehabilitation frameworks such as the International Classification of Functioning (WHO, 2001) recognize that parents and family are an important part of the environmental context of children and adolescents with DD. Therefore, it is important that future interventions meaningfully engage parents especially if the goal is to engender sustainable lifestyle changes that carry over into the home and community life of children and adolescents with DD.

Implications for Practice

The body of evidence in this review does not conclusively support any specific intervention with a high level of certainty. However, no adverse effects were reported for any intervention either. Therefore, service providers may offer "probable" EBP interventions including aquatic exercise programs and active video gaming as long as the programs are adapted for the safety and comfort of children and adolescents with DD and that families understand existing uncertainties about intervention benefits. Our review identified some useful strategies for providers to consider when adapting interventions to the physical and learning needs of children and adolescents with DD such as verbal and visual cues, modeling and demonstration of exercises, use of adapted equipment, and dedicated time to become familiar with equipment and setup.

Service providers may also be interested in replicating effective interventions locally. While none of the studies reviewed examined the cost-effectiveness of interventions, some interventions may be considered more feasible and replicable than others. For example, interventions delivered during regular school hours by teachers or PE instructors or those offered at community fitness centers by center staff and swim coaches might be easier to replicate without significant financial overlays. On the other hand, interventions involving specialized equipment and delivered by professionals such as physiotherapists, nutritionists, and behavioral specialists would entail substantial expenses and may not be justifiable without additional evidence supporting their effectiveness. Overall, issues related to sustainability and cost-effectiveness warrant future research given the lack of existing evidence.

A final practice consideration would be format of intervention delivery. Most interventions reviewed were delivered in-person with only two studies involving a remote or virtual component. With the advent of the COVID-19 pandemic, it is important to expand opportunities for virtual participation of both parents and children. The two studies that involved a virtual component demonstrated that video chat platforms such as WhatsApp and FaceTime might be feasible for this purpose.

Implications for Future Research

Several implications emerge for future research. Future studies need to include theoretically driven interventions (McGarty et al., 2018) and incorporate voices of participants and parents to enhance acceptability and sustainability in the natural environment, such as at home and in the community (McGarty et al., 2018). For sustainability of interventions across settings and time, it is also important to consider necessary adaptations and accommodations to ensure safety and minimize the risk of injuries (Li et al., 2013).

Methodological rigor and quality of reporting also need to be improved in future research. This finding is consistent with Jeng et al.'s (2017) systematic review on exercise training for adolescents with DD, which found a similar lack of methodological rigor within studies reviewed. Future studies can enhance rigor by ensuring blinding of outcome evaluation, assessing maintenance through long-term follow-up measures, using valid and reliable assessments and instruments, standardizing interventions, and evaluating adherence and fidelity. It is also important that steps taken to enhance rigor be reported in publications.

Future studies should also consider the impact of the COVID-19 pandemic on the obesity rates of children and adolescents with DD. This systematic review was conducted during the COVID-19 pandemic and no study included in the review was implemented during these unprecedented times. A CDC report indicates that the rate of increase in BMI almost doubled in US children and adolescents aged 2–19 years during the pandemic compared to pre-pandemic. Furthermore, it is estimated that children and adolescents with DD are at higher risk for increase in BMI (see https://www.cdc.gov/obesity/index.html). Therefore, it is important to develop and evaluate obesity prevention interventions that can be safely and smoothly delivered to this population under pandemic-related restrictions.

Considerations related to age, gender, racial, ethnic, and income diversity are also important for future research. This review included studies with participants spanning a broad age range. As literature on this topic grows, future reviews should consider separating analyses by age groups (0–5, 6–12, 13–18 years). Most studies in this review included predominantly male samples. Although developmental disabilities are more prevalent among males, childhood obesity is higher among females, especially within Black and Latinx communities (CDC, 2019; Ogden et al., 2020; State of Childhood Obesity, 2020; Zablotsky et al., 2019). Therefore, we need more studies evaluating the efficacy of interventions for girls with DD. Only a few (seven) studies in this review reported race and ethnicity. Of these, only three studies identified diverse participants, a smaller number being from Hispanic/Latinx background. Given the high rate of obesity among Black and Latinx children with disabilities (see Rimmer et al., 2011) in the USA, future studies based in the USA and other countries with racial and ethnic diversity need to recruit more diverse samples. There is also a need for research based in lower and lower-middle income countries as all studies identified in this review were conducted in high- and upper-middle-income countries. Childhood obesity in general is recognized as a global phenomenon and is believed to be growing at a faster rate in many developing countries. Similarly, prevalence of childhood disability is high in low- and lower-middle-income countries (Emerson & Llewellyn, 2021). Therefore, it is important for international funding bodies to support research on obesity prevention among children and adolescents with DD in low- and middle-income countries (Chung, 2017).

Limitations

This review has a few limitations. We only included peer-reviewed RCTs and quasi-experimental studies with group comparisons. Therefore, relevant studies using varied experimental designs and program evaluations published in the gray literature were possibly missed. A language bias might also exist as only studies published in English were considered. We also did not search trial registries to identify unpublished studies. However, many of the studies in this review had negative findings, thereby lowering the possibility of publication bias.

Conclusion

The health promotion and obesity prevention interventions analyzed in this review yielded mixed results. This review identified intervention strategies and relevant adaptations that could be incorporated in health promotion programs for children and adolescents with IDD. Interventions such as sports-based exercise programs and active video gaming showed promise, but more research is needed to confirm their effectiveness. Overall, evidence-based recommendations are hindered by limitations in rigor of research reporting. This systematic review points to the need for future research involving theoretically grounded and rigorous intervention studies designed to address obesity in children and adolescents with DD.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40489-022-00335-5.

Acknowledgements We would like to acknowledge Zully Guerra and Brielle Seitelman for assisting with database searches and data extraction.

Funding The contents of this research project were developed under a grant from the United States Department of Health and Human Services, Administration for Community Living (ACL), National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) Grant #90DPHF0005-01-00 (P.I. Sandy Magaña). However, those contents do not necessarily represent the policy of the Department of Health and Human Services (DHHS), and you should not assume endorsement by the federal government.

Declarations

Conflict of Interest The authors declare no competing interests.

References

*Study included in the review

Aslam, S., & Emmanuel, P. (2010). Formulating a researchable question: A critical step for facilitating good clinical research. *Indian Journal of Sexually Transmitted Diseases and AIDS, 31*(1), 47–50. https://doi.org/10.4103/0253-7184.69003

Bandini, L. G., Curtin, C., Hamad, C., Tybor, D. J., & Must, A. (2005). Prevalence of overweight in children with developmental disorders in the continuous National Health and Nutrition Examination Survey (NHANES) 1999–2002. *Pediatrics, 146*(6), 738–743. https://doi.org/10.1016/j.jpeds.2005.01.049

Bandini, L. G., Danielson, M., Esposito, L. E., Foley, J. T., Fox, M. H., Frey, G. C., Fleming, R. K., Krahn, G., Must, A., Porretta, D. L., Rodgers, A. B., Stanish, H., Urv, T., Vogel, L. C., & Humphries, K. (2015). Obesity in children with developmental and/or physical disabilities. *Disability and Health, 8*(3), 309–316. https://doi.org/10.1016/j.dhjo.2015.04.005

*Boer, P-H., Meeus, M., Terblanche, E., Rombaut, L., Wandele, I. D., Hermans, L., Gysel, T., Ruige, J., & Calders, P. (2014). The influence of sprint interval training on body composition, physical and metabolic fitness in adolescents and young adults with intellectual disability: A randomized controlled trial. *Clinical Rehabilitation*, *28*(3), 221–231. https://doi.org/10.1177/0269215513498609

Bremer, E., Crozier, M., & Lloyd, M. (2016). A systematic review of the behavioural outcomes following exercise interventions for children and youth with autism spectrum disorder. *Autism, 20*(8), 899–915. https://doi.org/10.1177/1362361315616002

Brown, S. A., Upchurch, S. L., & Acton, G. J. (2003). A framework for developing a coding scheme for meta-analysis. *Western Journal of Nursing Research, 25*(2), 205–222. https://doi.org/10.1177/0193945902250038

Brown, T., Moore, T. H., Hooper, L., Gao, Y., Zayegh, A., Ijaz, S., Elwenspoek, M., Foxen, S. C., Magee, L., O'Malley, C., Waters, E., & Summerbell, C. D. (2019). Interventions for preventing obesity in children. *The Cochrane Database of Systematic Reviews, 7*(7), CD001871. https://doi.org/10.1002/14651858.CD001871.pub4

Camelon, K. M., Hådell, K., Jämsén, P. T., Ketonen, K. J., Kohtamäki, H. M., Mäkimatilla, S., Törmälä, M. L., & Valve, R. H. (1998). The Plate Model: A visual method of teaching meal planning. DAIS Project Group. Diabetes Atherosclerosis Intervention Study. *Journal of the American Dietetic Association, 98*(10), 1155–1158. https://doi.org/10.1016/s0002-8223(98)00267-3

Centers for Disease Control and Prevention (2011). *Strategies to Prevent Obesity and other Chronic Diseases: The CDC Guide to Strategies to Increase Physical Activity in the Community*. U.S. Department of Health and Human Services https://www.cdc.gov/obesity/downloads/pa_2011_web.pdf

Centers for Disease Control and Prevention (2019). *Health, United States*. U.S. Department of Health and Human Services https://www.cdc.gov/nchs/data/hus/hus18.pdf

Centers for Disease Control and Prevention (2021). *Adult Obesity Facts*. U.S. Department of Health and Human Services https://www.cdc.gov/obesity/data/adult.html

Chen, Kim, S. E., Houtrow, A. J., & Newacheck, P. W. (2010). Prevalence of obesity among children with chronic conditions. *Obesity, 18*(1), 210–213. https://doi.org/10.1038/oby.2009.185

Chung, C. (2017). Obesity and malnutrition: Two sides of one crisis. The New Humanitarian. https://deeply.thenewhumanitarian.org/malnutrition/articles/2017/12/15/obesity-and-malnutrition-two-sides-of-one-crisis-2

*Curtin, C., Bandini, L. G., Must, A., Gleason, J., Lividini, K., Phillips, S., Eliasziw, M., Maslin, M., & Fleming, R. K. (2013). Parent support improves weight loss in adolescents and young adults with down syndrome. *Pediatrics*, *163*(5), 1402–1408. https://doi.org/10.1016/j.jpeds.2013.06.081

*Dickinson A, & Place, M. (2014). A randomised control trial of the impact of a computer-based activity programme upon the fitness of children with autism. *Autism Research and Treatment*, *2014*(2014), 419653–419659. https://doi.org/10.1155/2014/419653

Doak, C. M., Hoffman, D. J., Norris, S. A., Campos Ponce, M., Polman, K., & Griffiths, P. L. (2013). Is body mass index an appropriate proxy for body fat in children? *Global Food Security, 2*(2), 65–71. https://doi.org/10.1016/j.gfs.2013.02.003

*Elmahgoub, S.S., Calders, P., Lambers, S., Stegen, S. M., Van Laethem, C., & Cambier, D. C. (2011). The effect of combined exercise training in adolescents who are overweight or obese with intellectual disability: The role of training frequency. *Journal of Strength and Conditioning Research*, *25*(8), 2274–2282. https://doi.org/10.1519/JSC.0b013e3181f11c41

Emerson, E., & Llewellyn, G. (2021). The circumstances of children with and without disabilities or significant cognitive delay living in ordinary households in 30 middle- and low-income countries. *Disabilities, 1*(3), 174–186. https://doi.org/10.3390/disabilities1030014

*Fragala-Pinkham, M.A., Haley, S. M., & O'Neil, M. E. (2011). Group swimming and aquatic exercise programme for children with autism spectrum disorders: A pilot study. *Developmental Neurorehabilitation*, *14*(4), 230–241. https://doi.org/10.3109/17518423.2011.575438

*George, C.L., Oriel, K. N., Blatt, J.P., & Marchese, V. (2011). Impact of a community-based exercise program on children and adolescents with disabilities. *Journal of Allied Health*, *40*(4), E55–E60.

*González-Agüero, A.,Vicente-Rodríguez, G., Gómez-Cabello, A., Ara, I., Moreno, L. A., & Casajús, J. A. (2011). A combined training intervention programme increases lean mass in youths with Down syndrome. *Research in Developmental Disabilities*, *32*(6), 2383–2388. https://doi.org/10.1016/j.ridd.2011.07.024

Jeng, Chang, C.-W., Liu, W.-Y., Hou, Y.-J., & Lin, Y.-H. (2017). Exercise training on skill-related physical fitness in adolescents with intellectual disability: A systematic review and meta-analysis. *Disability and Health Journal, 10*(2), 198–206. https://doi.org/10.1016/j.dhjo.2016.12.003

Kaminski, J. W., Valle, L. A., Filene, J. H., et al. (2008). A meta-analytic review of components associated with parent training program effectiveness. *Journal of Abnormal Child Psychology, 36*, 567–589.

*Kim, C-G, & Lee, J.-S. (2016). Effect of startup circuit exercise on derivatives reactive oxygen metabolites, biological antioxidant potential levels and physical fitness of adolescents boys with intellectual disabilities. *Journal of Exercise Rehabilitation*, *12*(5), 483–488. https://doi.org/10.12965/jer.1632660.330

*Kocić, M., Bojić, I., Aleksandrović, M., Ignjatović, A., & Radovanović, D. (2017). Physical activity in adolescent with mental retardation: Is adapted basketball training adequate stimulus to improve cardiorespiratory fitness and sport skills performance? *Acta Facultatis Medicae Naissensis*, *34*(2), 159–168. https://doi.org/10.1515/afmnai-2017-0018

*Kong, Z., Sze, T.-M., Yu, J. J., Loprinzi, P. D., Xiao, T., Yeung, A. S., Li, C., Zhang, H., & Zou, L. (2019). Tai chi as an alternative exercise to improve physical fitness for children and adolescents with intellectual disability. *International Journal of Environmental Research and Public Health*, *16*(7), 1152. https://doi.org/10.3390/ijerph16071152

*Lau, P., Wang, G., & Wang, J. (2020). Effectiveness of active video game usage on body composition, physical activity level and motor proficiency in children with intellectual disability. *Journal of Applied Research in Intellectual Disabilities*, *33*(6), 1465–1477. https://doi.org/10.1111/jar.12774

*Lee, R. L., Leung, C., Chen, H., Louie, L. H. T., Brown, M., Chen, J.-L., Cheung, G., & Lee, P. H. (2017). The impact of a school-based weight management program involving parents via mHealth for overweight and obese children and adolescents with intellectual disability: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, *14*(10), 1178. https://doi.org/10.3390/ijerph14101178

Li, C., Chen, S., Meng How, Y., & Zhang, A. L. (2013). Benefits of physical exercise intervention on fitness of individuals with Down syndrome: A systematic review of randomized-controlled trials. *International Journal of Rehabilitation Research, 36*(3), 187–195. https://doi.org/10.1097/MRR.0b013e3283634e9c

Maïano, C., Normand, C. L., Aimé, A., & Bégarie, J. (2014). Lifestyle interventions targeting changes in body weight and composition among youth with an intellectual disability: A systematic review. *Research in Developmental Disabilities, 35*(8), 1914–1926. https://doi.org/10.1016/j.ridd.2014.04.014

McGarty, A. M., Downs, S. J., Melville, C. A., & Harris, L. (2018). A systematic review and meta-analysis of interventions to increase physical activity in children and adolescents with intellectual disabilities. *Journal of Intellectual Disability Research, 62*(4), 312–329. https://doi.org/10.1111/jir.12467

Mehdizadeh, A., Nematy, M., Vatanparast, H., Khadem-Rezaiyan, M., & Emadzadeh, M. (2020). Impact of parent engagement in childhood obesity prevention interventions on anthropometric indices among preschool children: A systematic review. *Childhood obesity, 16*(1), 3–19. https://doi.org/10.1089/chi.2019.0103

U.S. Department of Health and Human Services (n.d.). Social determinants of health. In *Healthy People 2030*. Office of Disease Prevention and Health Promotion. U.S. Department of Health and Human Services. https://health.gov/healthypeople/objectives-and-data/social-determinants-health

Ogden, Fryar, C. D., Martin, C. B., Freedman, D. S., Carroll, M. D., Gu, Q., & Hales, C. M. (2020). Trends in obesity prevalence by race and hispanic origin—1999-2000 to 2017-2018. *Journal of the American Medical Association, 324*(12), 1208–1210. https://doi.org/10.1001/jama.2020.14590

*Pan, C.Y. (2011). The efficacy of an aquatic program on physical fitness and aquatic skills in children with and without autism spectrum disorders. *Research in Autism Spectrum Disorders*, *5*(1), 657–665. https://doi.org/10.1016/j.rasd.2010.08.001

*Pejčić, A., Kocić, M., Berić, D., Kozomara, G., & Aleksandrović, M. (2019). The effects of special sports games program on physical fitness in adolescents with intellectual disability. *Acta Facultatis Medicae Naissensis, 36*(2), 120–130. https://doi.org/10.5937/afmnai1902120P

*Ptomey, L. T., Sullivan, D. K., Lee, J., Goetz, J. R., Gibson, C., & Donnelly, J. E. (2015). The use of technology for delivering a weight loss program for adolescents with intellectual and developmental disabilities. *Journal of the Academy of Nutrition and Dietetics*, *115*(1), 112–118. https://doi.org/10.1016/j.jand.2014.08.031

Ptomey, L. T., Walpitage, D. L., Mohseni, M., Dreyer Gillette, M. L., Davis, A. M., Forseth, B., Dean, E. E., & Waitman, L. R. (2020). Weight status and associated comorbidities in children and adults with Down syndrome, autism spectrum disorder and intellectual and developmental disabilities. *Journal of Intellectual Disability Research, 64*(9), 725–737. https://doi.org/10.1111/jir.12767

Reichow (2011). Development, procedures, and application of the evaluative method for determining evidence-based practices in autism. In *Evidence-Based Practices and Treatments for Children with Autism* (pp. 25–39). Springer. https://doi.org/10.1007/978-1-4419-6975-0_2

Reinehr, T., Dobe, M., Winkel, K., Schaefer, A., & Hoffmann, D. (2010). Obesity in disabled children and adolescents: An overlooked group of patients. *Deutsches Ärzteblatt International, 107*(15), 268–275. https://doi.org/10.3238/arztebl.2010.0268

Rimmer, J. H., & Vanderbom, K. A. (2016). A call to action: Building a translational inclusion team science in physical activity, nutrition, and obesity management for children with disabilities. *Frontiers in Public Health, 4*, 164–164. https://doi.org/10.3389/fpubh.2016.00164

Rimmer, J. H., Wang, E., Yamaki, K., & Davis, B. (2010). Documenting disparities in obesity and disability. FOCUS, 24, 1-16.

National Center for Dissemination of Disability Research. https://fsrtc.ahslabs.uic.edu/wp-content/uploads/sites/4/2014/04/drrp_DocumentingDisparitiesInObesityAndDisability.pdf

Rimmer, J. H., Yamaki, K., Davis, B. M., Wang, E., & Vogel, L. C. (2011). Obesity and overweight prevalence among adolescents with disabilities. *Preventing Chronic Disease, 8*(2), A41.

Rimmer, J. H., Vanderbom, K. A., Bandini, L. G., Drum, C. E., Luken, K., Suarez-Balcazar, Y., & Graham, I. D. (2014). GRAIDs: A framework for closing the gap in the availability of health promotion programs and interventions for people with disabilities. *Implementation Science, 9*(100), 1–9. https://doi.org/10.1186/s13012-014-0100-5

*Seron, B.B., Silva, R. A. C., & Greguol, M. (2014). Effects of two programs of exercise on body composition of adolescents with Down syndrome. *Revista Paulista de Pediatria*, *32*(1), 92–98. https://doi.org/10.1590/S0103-05822014000100015

State of Childhood Obesity. (2020). National Obesity Monitor. https://stateofchildhoodobesity.org/monitor/

Suarez-Balcazar, Y., Agudelo Orozco, A., Mate, M., & Garcia, C. (2018a). Unpacking barriers to healthy lifestyles from the perspective of youth with disabilities and their parents. *Journal of Prevention & Intervention in the Community, 46*(1), 61–72. https://doi.org/10.1080/10852352.2018.1386270

Suarez-Balcazar, Y., Early, A., Maldonado, A., Garcia, C., Arias, D., Zeidman, A., & Agudel-Orozco, A. (2018b). Community-based participatory research to promote healthy lifestyles among Latino immigrant families of youth with disabilities. *Scandinavian Journal of Occupational Therapy., 25*, 396–406. https://doi.org/10.1080/11038128.2018.1502348

*Suarez-Villadat, B., Luna-Oliva, L., Acebes, C., & Villagra, A. (2020). The effect of swimming program on body composition levels in adolescents with Down syndrome. *Research in Developmental Disabilities*, *102*, 103643–103643. https://doi.org/10.1016/j.ridd.2020.103643

*Ulrich, D. A., Burghardt, A. R., Lloyd, M., Tiernan, C., & Hornyak, J. E. (2011). Physical activity benefits of learning to ride a two-wheel bicycle for children with down syndrome: A randomized trial. *Physical Therapy, 91*(10), 1463–1477. https://doi.org/10.2522/ptj.20110061

van der Kruk, J. J., Kortekaas, F., Lucas, C., & Jager-Wittenaar, H. (2013). Obesity: A systematic review on parental involvement in long-term European childhood weight control interventions with a nutritional focus. *Obesity reviews: an official journal of the International Association for the Study of Obesity, 14*(9), 745–760. https://doi.org/10.1111/obr.12046

*Wallén, F., Müllerdorf, M., Christensson, K., & Marcus, C. (2013). Eating patterns among students with intellectual disabilities after a multifactorial school intervention using the plate model: Eating patterns among adolescents with ID. *Journal of Policy and Practice in Intellectual Disabilities, 10*(1), 45–53. https://doi.org/10.1111/jppi.12020

World Health Organization. (2001). *International classification of functioning, disability and health: ICF*. World Health Organization.

*Wu, W. L., Yang, Y.-F., Chu, I.-H., Hsu, H.-T., Tsai, F.-H., & Liang, J.-M. (2017). Effectiveness of a cross-circuit exercise training program in improving the fitness of overweight or obese adolescents with intellectual disability enrolled in special education schools. *Research in Developmental Disabilities*, *60*, 83–95. https://doi.org/10.1016/j.ridd.2016.11.005

*Xu, C., Yao, M., Kang, M., & Duan, G. (2020). Improving physical fitness of children with intellectual and developmental disabilities through an adapted rhythmic gymnastics program in China. *BioMed Research International*, *2020*, 2345607–2345610. https://doi.org/10.1155/2020/2345607

Zablotsky, Black, L. I., Maenner, M. J., Schieve, L. A., Danielson, M. L., Bitsko, R. H., Blumberg, S. J., Kogan, M. D., & Boyle, C. A. (2019). Prevalence and trends of developmental disabilities among children in the United States: 2009-2017. *Pediatrics, 144*(4). https://doi.org/10.1542/peds.2019-0811

Zaza, S., Wright-De Aguero, L. K., Briss, P. A., Truman, B. I., Hopkins, D. P., Hennessy, M. H., et al. (2000). Data collection instrument and procedure for systematic reviews in the guide to community preventive services. *American Journal of Preventive Medicine, 18*(1S), 44–74.