EFFECTS OF EXERGAMING ON HEALTH AND FITNESS OUTCOMES FOR STUDENTS WITH DISABILITIES: A META-ANALYSIS

By

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Abstract

Objective: To determine the effects of exergaming on health and skill related fitness using previous studies.

Methods: A standard meta-analytic procedure incorporating inclusion and exclusion criteria, literature search, coding procedures, and statistical analysis were used to identify and synthesize 20 studies. Cohen's criteria for effect size were used to evaluate results.

Results: There was a moderate effect (g=0.44) for groups that participated in exergaming. Although there were positive and negative results in different health related and skill related fitness measures, no conclusive statements were made due to the lack of studies found for each outcome.

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Introduction

The United States Department of Human Health Services have reported that regular participation in physical activity improves physical, psychological, and emotional outcomes (United States Department of Human Health Services (USDHHS, 2018). Physical education is designed to provide children the knowledge, skills, and confidence to pursue a physically active lifestyle (Shape America, 2015). Physical education is an academic subject that provides cognitive content to develop motor skills, knowledge, and behaviors for physical activity and fitness (Center for Disease Control and Prevention (CDC), 2022). Currently, mandatory school requirements for physical education differ with only 38% having an established minimum time requirement (Shape America, 2016). Additionally, only 20.9% of elementary schools, 46% of middle schools, and 46% of high schools require physical education (USDHHS, 2014). According to the CDC (2020) only 24% of children and adolescents with disabilities are meeting the 60 minutes or more of daily physical activity recommendations. Between 2000 and 2020, 52% of schools exempted students with a cognitive disability, and 86% exempted students with long-term physical and medical disabilities from physical education. The lack of physical education opportunities for students with disabilities prevents access to the benefits of regular exercise that include, motor skill development, strengthening of muscles and bones, and brain health (CDC, 2020; USDHHS, 1996). Virtual Reality (VR) gaming and Exergaming is an alternative strategy that has demonstrated positive results towards

engaging children in physical activity participation and a positive attitude towards physical activity (Gao, 2015; 2020).

Goa (2017) reported exergaming and virtual reality gaming can have the same positive effects on children's light physical activity, moderate to vigorous activity, and energy expenditure. When requirements for physical education vary, the quality and quantity of school-based programming may produce learning outcomes that do not always result in positive or desired student learning outcomes (Kohl & Cook, 2013). Exergaming has been effective in challenging children to become physically active and children with disabilities may find exergaming to be an alternative to physical activity due to accessibility and its ability to increase motor skills (Hoking, 2019).

Researchers of exergaming have reported increases in motor function (i.e., fine motor skills, coordination, balance) and cognitive functioning (i.e., communication, attention span, social responsiveness) for intervention groups with specific disabilities (i.e., cerebral palsy and autism spectrum disorder; (Mesa Gresa, 2018; Rathinam, 2018; Ravi, 2016; Tripette, 2017). What is less clear from research synthesizing exergaming results is the effects in different settings (home, school), in sex (male/female), age groups (elementary, middle, high school), and more rigorous research designs that use control groups to be able to infer results (Bidiss, 2010; LeBlanc, 2013; Gao 2020). Therefore, the purpose of the current investigation was to determine the effectiveness of Virtual Reality and Exergaming on skill and health related fitness outcomes for disabled populations. A secondary purpose was to conduct sub-group (moderator) analyses to explain the variability between categorical variables.

Methods

Search Strategy

Search strategies were developed through the use of combinations of the following keywords including: Exergaming, Virtual Reality Gaming, Kinect, Wii-Fit, Active video games, Physical Education, Education, Adapted Physical Education, Physical Activity, Adapted Physical Activity, and Exercise. SPORTDiscus, PubMed/Medline, ERIC, Child Development And Adolescent Studies, and ProQuest - Dissertation and Theses: The Humanities and Social Sciences Collections databases were searched using the key terms up to and including February, 2023. In addition, manual searches of reference lists of articles identified in searches as well previous meta-analysis or systematic reviews of exergaming and physical activity.

Inclusion and exclusion criteria

Studies that were included, met the following criteria (i) Study involved the use of an interactive video game during participation in (or outside of) physical education/physical activity setting; (ii) study was conducted in physical education/physical activity for children or adolescents ages 3-22 years diagnosed with a disability; (iii) study reported skill and/or health-related fitness outcomes; (iv) study included quantitative descriptive statistics and/or correlations to be able to estimate an effect size (v) study was written in the English Language between 1970 and February 2023.

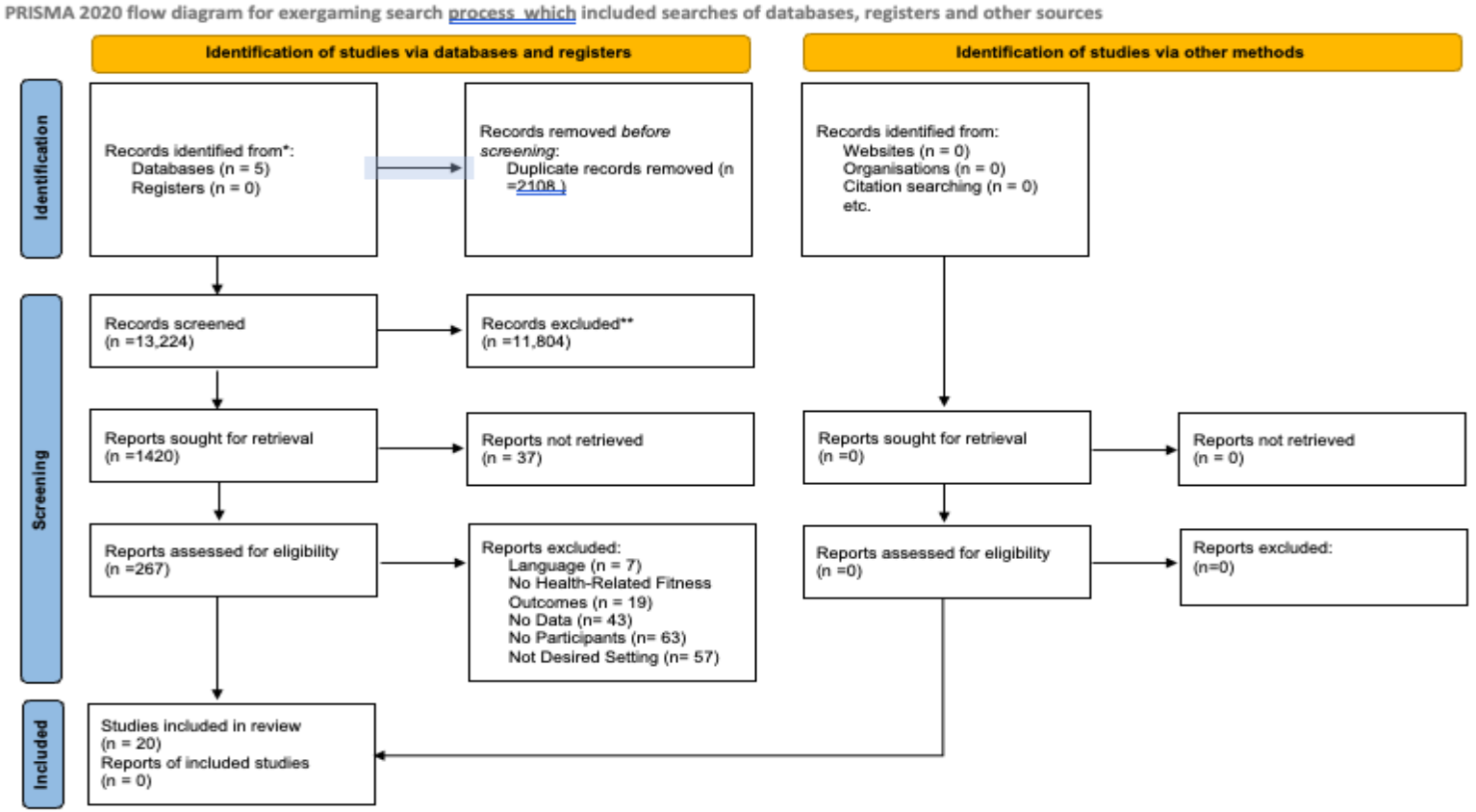
Identification of Relevant Studies

Potentially relevant articles were examined by two authors who (i) screened the titles; (ii) screened the abstracts; and (iii) if abstracts were not available or did not provide sufficient data, retrieved the entire article which was then screened to determine whether it met the inclusion criteria. Where there was uncertainty or disagreement regarding inclusion, a discussion was held between the two authors to reach a decision.

Data Extraction and Coding

Detailed information was extracted from each article by author (JA) and included sample characteristic sex (male, female), disability type (Cerebral Palsy(CP), Intellectual Disability(ID), Cystic Fibrosis(CF), Developmental Coordination Disorder(DCD), Hand Burn (H Burn), Autism Spectrum Disorder(ASD), Ataxia, Developmental Disorder(DD), Deafness, and Spina Bifida(SB), setting (Therapeutic, School, and Community), focus (Health Related Fitness(HRF), Skill Related Fitness(SRF), Motor Skill(MS)), type of interactive game (Wii-Fit(WF), Xbox Kinect(XB), and Multiple Games(M)), country, study type, funding, publication type, length of intervention, research design, and specific outcome measure. When studies combined multiple sources of assessment to derive a conclusion of exergaming that reflected multiple domains or the specific derivation of exergaming, studies were examined to ensure they followed inclusion criteria. Information about the association between exergaming and physical activity, were extracted by Author (JA) for use in calculating effect. The Second Author (RB) reviewed the extracted information.

Figure 1. Primsa 2020 Flow Diagram for Exergaming Search Process



Outliers and Publications Bias

Data were screened to identify outliers and determine the potential influence of publication bias. Studies with scores outside the 95 percentile of the mean effect size (z-score $\geq \pm$ 1.96) were categorized as an outlier. Sensitivity analyses were conducted to examine the impact of retention/removal of outliers on the overall effect estimate of interactive video games on skill and health related fitness. If the effect size remained significant and within 95 percent confidence interval, studies that were categorized as an outlier were kept within the study. Evidence of publication bias was assessed in three ways: inspection of funnel plots (Begg,1994), application of the 'trim and fill' procedure (Duval, 2000) and calculation of a 'fail-safe N' estimate (Rosenthal,1979).

Effect Size Calculations

Comprehensive Meta-Analysis (CMA) version-2 software was utilized to calculate effect size statistics (Borenstein, Hedges, Higgins, & Rothstein, 2005). Hedges g was the effect size metric selected as the number of studies ($k<20$) in different analyses (moderator and outcomes) were smaller and used to correct for an overestimate the effect size (Hedges, 1981). Data extracted from included studies uses mean (M), sample size (N), and standard deviation (SD) as the primary methods for effect size calculations. When these data were not available, F-values, t-values, and/or P-values were extracted from each study (Rosenthal, 1994). A random-effects approach was used to model error for the current meta-analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009). A random effects model uses both sampling error and between study variance to estimate the effect size. Also, when several outcomes were extracted, the study was the unit of analysis and a procedure was

used that averaged the outcomes for a single effect size calculation (Borenstein, Hedges, Higgins, & Rothstein, 2009). Cohen's (1988) criteria for small (> 0.20), moderate (>0.50), and large (> 0.80) effect sizes was used to aid the interpretation of results.

Results

The primary purpose of the meta-analysis was to determine the effectiveness of exergaming interventions on health-related fitness, skill-related fitness, and skill development for disabled school-aged children. Twenty studies (k = 20) met the inclusion criteria including 335 participants from 15 countries across the world (Asia, Europe, Middle East, and North America) with the most frequent disabilities being studied involved cerebral palsy, autism spectrum disorder, and developmental delays. All studies that met the inclusion criteria were published and seven of the 20 studies were grant funded using a combination of subject and objective measures for collecting data from children with disabilities. Sample sizes varied from eight to 105 participants with the majority of studies including both male and female subjects. Figure 1 presents the search strategies and article screening process used to determine the final sample of included studies. Table 1 provides the coding information for the methodological, participant, and study characteristics that were extracted from each paper. Cohen's (1988) criteria was used to find the outcome effects with the use of standardized mean differences and summarize the effect sizes as small (≥0.20), moderate (≥0.50), and large (≥0.80).

Outliers and Publication Bias

A random effects model was used to interpret the model results indicating that there was a small significant effect (k =20, g = 0.44, *95% CI* = 0.03, 0.85, P = 0.04) across all outcomes. One study, Rostami et al., 2012 (z = 5.06), was identified as an outlier. A sensitivity analysis was performed to determine the inclusion status for the single outlier and results from the "one study removed" procedure in CMA determined that changes

would have been reduced (g = -0.20) as interpretation of the overall estimate of effect would remain similar, however, results would have been nonsignificant (k = 20, g = 0.22, P = 0.15). The author has selected to include the single outlier as the number of studies in the overall analysis prevents drawing conclusions related to specific outcomes. More information has been provided in the discussion and conclusions section.

Publication bias was evaluated using a visual inspection of a Funnel Plot, a Trim and Fill procedure, Begg & Mazumdar's Rank Order Analysis (Begg & Mazumdar, 1994), and Egger's Regression Intercept (Egger et al. 1995). Figure 2 represents the funnel plot with the Trim and Fill procedure that did not add studies to the left side of the distribution with the overall summary effect remaining unchanged (k =20, g = 0.44, *95% CI* = 0.03, 0.85, P = 0.04). Both Begg and Mazumdar's Rank Order analysis (P = 0.49) and Egger's Regression Intercept (P = 0.42) were not significant suggesting the smaller size studies did not have larger contributions to the overall results. However, even though a comprehensive search strategy was conducted of both published and unpublished literature and analyses suggest the influence of publication bias was minimal we cannot rule out the absence of bias in the current investigation.

Table 1. Descriptive Characteristics for Exergaming Studies Meeting Inclusion Criteria

	Methodological Characteristics				Sample Characteristics					Study Characteristics		
Study	Design	Video	Focus	Time	Setting	Disability	Gender	Country	N	Measurement	Fund	Status
Acar et al 2016	B	WF	MS	45min,2dys,6wks	T	CP	B	Turkey	30	O	U	P
Bonney et al 2018	W	WF	SRF	45min,14wks	S	DCD	F	So. Africa	16	C	F	P
Cho et al. 2016	B	WF	SRF	30Min,3dys,8wks	T	CP	B	Korea	18	O	U	P
Chiu et al 2018	W	WF	HRF/SRF	20min,3dys8wks	C	CP	B	Taiwan	20	C	F	P
De Corral et al 2014	W	WF	HRF	30min,2dys	T	CF	M	Spain	24	O	F	P
Ferguson et al 2013	B	WF	SRF	30min,3dys,6wks	S	DCD	B	So. Africa	46	O	F	P
Hammond et al 2014	B	WF	MS	10min,3dys,4wk	S	DCD	B	UK	18	O	F	P
Kamel et al. 2021	B	B	MS	50min,3dys,8wk	T	BURN	B	Egypt	50	O	U	P
Luna et al 2013	B	B	SRF/MS	30mins,2dys,8wks	S	CP	B	Spain	11	O	U	P
Pourazar et al 2021	B	XB	SRF	90min,6wks	S	CP	F	Iran	20	O	U	P
Rafiei et al 2021	B	XB	SRF/MS	35min,3dys,8wks	T	ASD	B	Iran	60	O	U	P
Regaieg et al. 2021	B	XB	SRF	60min,2dys,10wk	S	ID	B	France	24	O	U	P
Romano et al 2022	B	M	MS	60min,5dys,12wk	T	Ataxia	B	Italy	18	O	F	P
Rostami et al 2012	B	M	SRF	90min,3dys,4wk	T	CP	B	Iran	32	O	U	P
Salem et al. 2012	B	WF	SRF	2days,10wk	S	DD	B	USA	40	O	F	P
Smits et al. 2017	B	M	SRF	20min,2dys,5wks	S	DCD	B	So. Africa	18	C	U	P

	Methodological Characteristics				Sample Characteristics					Study Characteristics		
Tsu et al 2016	B	WF	SRF	40Min,2dys,8wks	T	ID	B	Taiwa	24	O	F	P
Tzanetakos et al 2018	W	WF	SRF	15min,2dys,5wks	S	DEAF	B	Greece	10	C	U	P
Widman et al 2016	W	M	HRF	20min/3days/16wk	T	SB	B	USA	8	C	U	P
Wuang et al. 2011	B	WF	SRF/MS	60min/2days/24wk	T	DS	B	Taiwan	105	O	U	P

Note. Design = Research Design. B = Between Group Comparison or W = Within Group Comparison; Video Game = Instructor Training. WF = Wii Fit, NS = Not Specific, or M = Multiple Games. Focus = Type of Program. HRF = Health Related Fitness, SRF = Skill-Related Fitness, or MS = Motor Skills; Time = Duration of Program Dys= Days. Setting = Setting of Program. S = School, C= Community, or T = Therapeutic; Disability = Disability Type. P = Physical/Behavioral, C = Cognitive, M = Multiple; Gender = Sample Gender. F = Female Only, M = Male Only, B = Both Male and Female; Country = Study Location; N = Sample Size. Measure = Outcome Measures; O = Objective Measures Used, S = Subjective Measures Used, C = Both Objective and Subjective Measures Used. Funding = Funding Status; F = Funded and U = Unfunded. Status = Publication Status; P = Published and U = Unpublished. NR = Not Reported.

Random Effects Model

The effect size using the random effects model for individuals with disabilities health-related fitness, skill-related fitness, and motor skill development when provided with exergaming activities made small improvements (g = 0.44; SE = 0.21, 95% CI = 0.03, 0.85; P < 0.04) across all outcomes. Results suggest that for treatment groups or conditions there was approximately four-tenths of standard deviation increase in health-related fitness, skill-related fitness, and movement skills. The width of the prediction interval (-1.41, 2.29) is noteworthy and indicates that results will vary from ineffective to highly effective across comparable samples. Finally, the meta-analytic literature has determined that analyses with fewer than 10 studies produce imprecise estimates of effect, however, the authors have selected to report outcomes with smaller samples (k < 10) for discussion and future research. Only two outcomes had a sufficient number of studies to interpret which included balance (k = 10, g = 0.38; SE = 0.21; 95% CI = -0.03, 0.79; P = 0.07) and speed (k = 10, g = 0.52; SE = 0.34; 95% CI = -0.14, 0.12; P = 0.12) having small and moderate summary effects that were not significant. Heterogeneity was present across all outcomes as prediction intervals ranging from negative to positive and small to large indicating that across comparable samples exergaming can range from ineffective to highly effective.

Figure 2. Funnel Plot

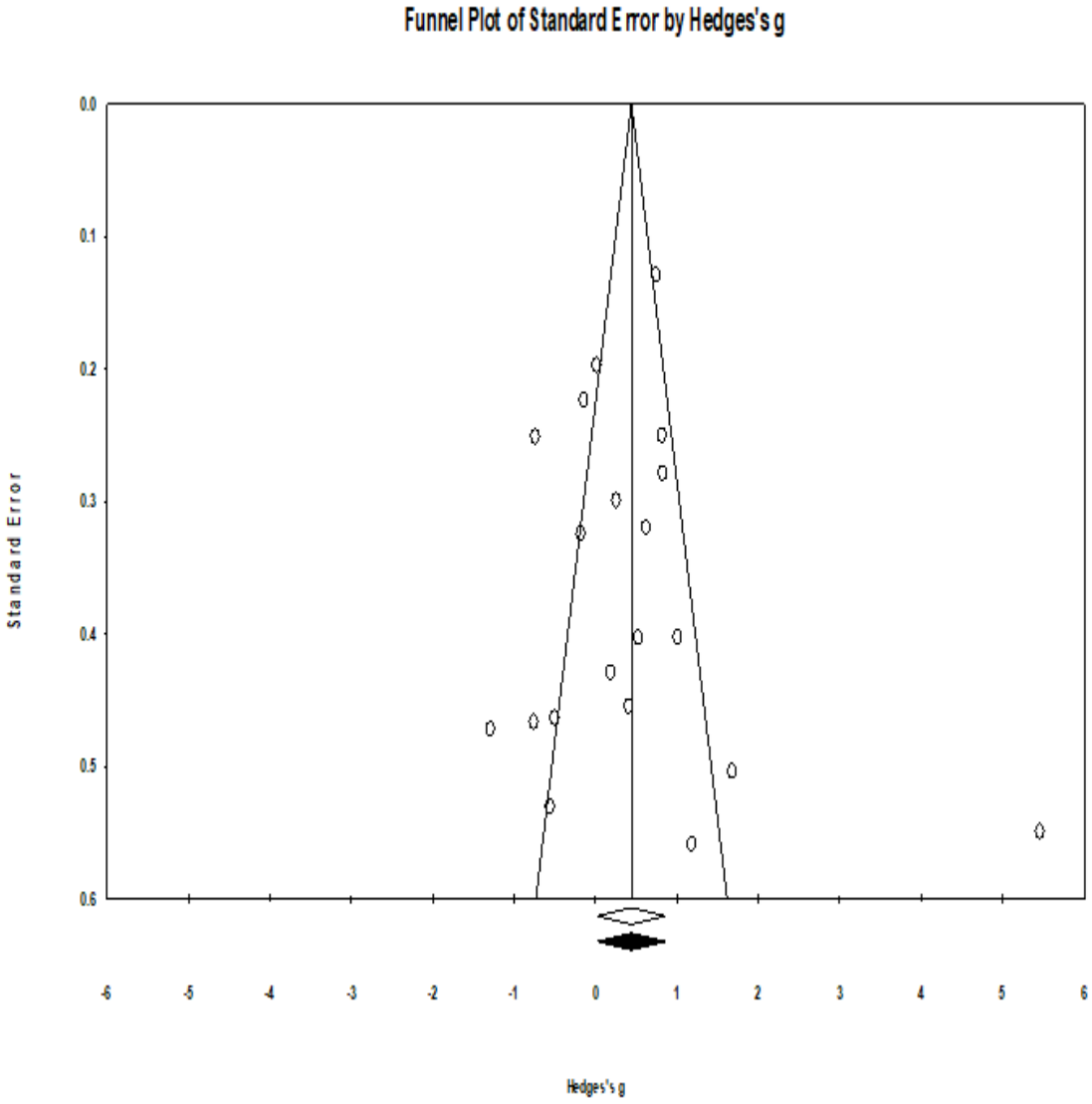


Table 2. Exergaming Outcome

		Effect Size Statistics				Null Test			Heterogeneity Statistics		
Variable	***k***	***g***	***SE***	***s²***	**CI**	**Z**	**P**	**PI**	***Q***	***τ²***	***I²***
HRF											
CVE	5	0.69	0.11	0.01	0.47,0.91	6.14	0.00	0.12,1.16	4.67	0.01	14.307
MS/ME	6	0.05	0.23	0.05	-0.39,0.50	0.24	0.81	-1.36,1.47	16.82	0.46	70.28
Flexibility	2	0.46	0.29	0.08	-0.1,1.02	1.62	0.11		1.43	0.05	30.70
SRF											
Balance	10	0.38	0.21	0.04	-0.03, 0.79	1.84	0.07	-0.94, 1.70	31.34*	0.29	71.28
Coordination	6	-0.52	0.31	0.10	-1.12,0.09	-1.68	0.09	-2.53,1.49	23.15	0.66	78.40
Speed	10	0.52	0.34	0.12	-0.14,0.12	-1.54	0.12	-1.91,2.96	92.80	1.00	90.30
Power	4	-0.08	0.38	0.14	-0.82,0.66	-0.21	0.84	-0.68,3.28	16.63	0.68	81.96
Motor Skills											
Gross/Locomotor	3	0.69	0.24	0.06	0.22,1.17	2.86	0.00	-3.12, 4.51	2.43	0.18	17.57
Manipulative/Object	2	-0.03	0.53	0.28	-1.06,1.00	0.053	0.96		4.13	0.65	75.78

Note. k = number of studies, Hedges g = effect size, s2 = variance, SE = Standard Error, 95% CI = Confidence Interval (Lower Limit, Upper Limit), Z = Null Hypothesis Test; PI = Prediction Interval (lower limit, upper limit), τ^2 = Between Study Variance, HRF = Health-Related Fitness, SRF = Skill-Related Fitness, CVE = Cardiovascular Endurance. MS = Muscular Strength. ME = Muscular Endurance, * $p < 0.05$

Discussion

The aim of the current investigation study was to determine the effects of exergaming on health-related fitness, skill-related fitness, and motor skill development for children with disabilities. There were a total 20 studies that met inclusion criteria, however, the number of studies measuring each of the outcomes was insufficient to form conclusions. The author has selected to provide statements regarding trends in each of the outcomes reported and make recommendations for future study. Children and adolescents with disabilities are less active when compared to typically developing peers and increasing activity can improve many health-related outcomes (Stanish, 2019). Research has found that exergaming can be engaging and enjoyable under specific circumstances as well as provides additional opportunities to include and increase activity levels in the daily routines (Sween,2014; Fitzgerald,2020).

Health-Related Fitness

According to physical activity guidelines, children should participate in physical activity 7 days a week for at least 60 minutes to improve health-related outcomes (CDC, 2022). There were 15 studies that measured and tracked how exergaming influenced some form of health-related fitness (body composition, cardiovascular endurance, flexibility, and/or muscular strength and endurance). In summary, participants across studies engaged in physical activity through exergaming between 10 minutes to 45 minutes ranging from 2-3 days a week. While each of the studies provided information on how exergaming might contribute to meeting CDC physical activity guidelines, none

of the studies were able to connect how exergaming might help children and adolescents transition to other activities beyond exergaming. The current investigation found positive trends for cardiovascular endurance and flexibility and no improvements in muscular strength and endurance. Research has shown that to improve muscular strength and endurance participants must engage in specifically designed movements that require resistance and force to be applied (Morrissey,1994). The virtual games that subjects were engaged with did not have game components that require continuous or maximal muscular engagement. However, both cardiovascular endurance and flexibility may improve as a result from the types of exergaming activities which included Wii Fit (Wii Sports, Balance Bubble, Super Hula Hoop), Xbox Kinect(Just Dance 3, Kinect Adventures, Kinect Sports I, and Kinect Disneyland Adventures), E-Link System and GaitWayXR. Future research may consider how games are designed by adding activities that include all types of health-related fitness that allow students to achieve physical activity guidelines.

Exergaming provides a way for children and adolescents to engage in physical activity, however, the most popular types of virtual games involve sedentary behavior (Baranowski,2011). Results from the current investigation suggest that specific components of health-related fitness may improve and are connected to how virtual games are designed during the exergaming experience (Del Coral, 2014; Tsu, 2018; Wideman, 2006; Luna-Olivia, 2013). However, an important consideration when using exergaming to increase physical activity involves how virtual experiences connect to physical experiences (Chiu, 2018; Tsu, 2018; Smits-Englsman, 2017; Tzanetakos,2017).

Research has found that connecting learning experiences in different contexts provides positive reinforcement which can facilitate transfer to different and beneficial experiences between virtual and physical activities (Soltani, 2020). Future studies might consider comparing differences between active and sedentary gaming behaviors to develop strategies that will engage children and adolescents in increased activity levels during exergaming to meet the CDC guidelines.

Skill-Related Fitness

Skill related fitness involves agility, balance, coordination, power, reaction time, and speed to successfully achieve the desired outcomes in physical activity contexts (Corbin, 2000). Studies included in the current investigation used exergaming experiences that attempted to develop balance, coordination, power, and speed in disabled participants (Chiu et al, 2018; Pourazar, 2021; Kamel et al, 2021; Smits-Englesman, 2012; Rostami et al, 2012). However, balance and speed were the only outcomes to have a sufficient number of studies with positive results when compared to studies measuring coordination and power outcomes which produced negative results (Chiu et al, 2018; Smits-Englesman, 2012; Rostami et al, 2012; Salem et al,2012). Research has found that both balance and speed improve when activity is specific and modified to engage participants in physical activity (Chiu et al, 2018; Rostami et al, 2012). The types of exergames (E-Link System, Wii-Fit) involved activities specifically designed to improve fitness by receiving real time feedback to target desired fitness goals. Some of activities involved during these virtual experiences involved the use of balance boards or gaming devices which tracked movement and participants

involvement. An important consideration when interpreting these results includes the fitness levels of the disabled participants as well as the comparison groups. Some of the studies involved sedentary populations that when engaged for minimal periods of time will exhibit immediate improvements (Smits-Engelsman, 2017). Another possibility that may have contributed to inconclusive results was that many of the studies did not employ matched group designs permitting accurate comparisons (Barnett et al, 2015; Smits-Engelsman, 2017). Research has found that sedentary populations involved in lower levels (types and intensity) of physical activity will exhibit immediate gains that plateau after short periods of time (Tsu et al, 2018). Future research might consider evaluating how activity/fitness levels contribute to skill-related fitness development as well as the use of longer interventions that track the development and progress.

The skill-related fitness outcomes that favored control conditions (pretest) or control groups were power and coordination (See table 2). Research defines power as muscular output from the subject to an object (Knudson,2019) and has found that the development of power requires activity using maximal force to be exerted (Sarabia et al, 2017). Research included in the current investigation used video games geared towards the needs of the specific participant, exergames such as Wii Fit's Basic Run or Hula Hoop games did not incorporate or require maximal force to complete the task. To see significant effects in coordination, research suggests that greater effects require at least 16 hours of engagement (Rafiei, et al 2021). Coordination development requires mindful movements of the upper and lower bilateral limbs (Barnett et al, 2016). While coordination involves the use of bilateral movements of both the upper and lower limbs,

activities were specifically prescribed to strengthen the participants abilities, some participants excluded from the study that may have been limited by exergame itself and the extent of their participant in that certain activity. Depending on the participants' abilities, profiles were made to prescribe interventions that were individualized and based on the child's interest (Salem et al, 2012). Future research should consider using exergames that receive feedback from all parts of the body, rather than just a platform or a device that is used unilaterally.

Motor Skills

Motor skills were evaluated in three studies meeting inclusion criteria using the the Test of Gross Motor Functional Measure, the Movement Assessment Battery for Children-2, and the Test of Gross Motor Development-2 (Regaieg et al, 2021; Cho et al, 2016; Ferguson et al, 2013). There were not enough studies to draw conclusions on how exergames influence locomotor skills development, however, the trend for included studies showed a moderate positive effect. Research suggests that the ideal conditions to development locomotor skills include games that motivate participants and use task orientated games that require lower cognitive demand (Regaieg et al, 2021; Cho et al, 2016; Ferguson et al, 2013). Studies included in the current investigation used virtual reality treadmill training, Xbox Kinect Adventures, and Wii-Fit training and the design of these activities meet the criteria that exergaming include motivating factors and tasks that understandable to the participant (Regaieg et al, 2021; Cho et al, 2016; Ferguson et al, 2013)). Future research should consider using games that are specific to the participant's interest and is specific to the participants cognitive and physical abilities.

Object control skills were only measured in two studies meeting inclusion criteria and as a result no conclusions can be formulated. Object control skills include both health-related and skill-related fitness outcomes to perform throwing, catching/collecting, striking, kicking, punting, dribbling, and volleying. Research suggests that the development of manipulative skills should include games that are structured and supervised that allow participants to use their skills such as kicking and throwing during games (Regaieg et al, 2021; Refiei et al, 2021).

Study Characteristics

The primary exergaming devices used to conduct research included the Wii-Fit and Xbox Kinect which connected to either increase strength and balance (Wii-Fit) or target overall fitness (Xbox). Most articles that were included in this meta-analysis using the Wii-Fit (k = 6 of 11) and Xbox Kinect (k = 4 of 5) were focused on skill-related fitness outcomes. While the use of specific exergames collected skill-related fitness data there were some studies in which the activities and use of a specific exergame did not align with how the game/activity was designed. Additionally, the context (location) in which the study was conducted may have also influenced the outcomes results in children with disabilities. Studies were conducted in either a therapeutic setting (k = 8), a school setting (k =11) , and/or within a community setting (k =1). 11 of the 20 studies were found in the school setting which is the least restrictive setting for the participants. The focus and participant in activities in each of these types of settings may differ, therefore, the type and amount of activity, activity goals, and evaluation of achievement levels will differ in each of these settings/contexts. For example, in a school-based setting, children

with disabilities have individualized educational plans (IEP) that designate structured activity and learning goals. Given the very different contexts in which exergames combined with types of exergames, participant outcomes and performance may differ given the focus of each of these variables.

Another factor that may have influenced outcomes in children with disabilities was the training administered to participants administering the studies. In the therapeutic setting, test administrators were trained on how to set up and start the exergaming activity for the participant, whereas at the school or the community, there were little, or no details related to if and how teachers or community members were trained. Correct training allows all the administrators to follow the same protocol and method to uniformly administer the exergaming activity and this information was absent in many studies. Training to use exergames is also different than training required to work with children and adolescents who have disabilities. There are many types of disabilities and children with disabilities typically do not have the same physical, mental, or emotional skills required to function, and accommodations need to be made for the specific needs of the child (Salem et al, 2012). Understanding and collecting the appropriate types of information related to baseline skill for each of the children who are at different levels requires specific training to ensure that outcomes are met (Acar et al, 2016; Tsu et al, 2018), Future research should work with individuals with disabilities and use specific exergaming interventions that will target the participant's area of needs as well as ensure administrators follow the same protocol when determining how exergames will be used to ensure accurate and consistent evaluation of progress.

This meta-analysis focus was determining the effects of exergaming on health-related fitness. All the studies used objective measures to determine the effectiveness of exergaming, which allowed the researchers to use the data they collected to make their conclusion. 5 out of the 20 studies used a combination of objective and subjective measurements. The 5 studies were able to gain feedback on how exergaming affected their mood, but the focus was geared toward health-related fitness and exergaming.

Conclusions, Summary, or Recommendations

When analyzing the effects of exergaming, more data is needed students with disabilities to provide a conclusive statement on exergames effect on health-related fitness, skill related fitness, and motor skills. The authors understand that there are several factors to consider when collecting data from students with disabilities. However, we would suggest that future quantitative studies discover more articles that are conducted in school settings, to further understand exergaming's effect on student's fitness outcomes in connection to physical education. The most important consideration when determining the effects of exergaming is gathering more studies that focus on cardiovascular fitness, muscular strength/endurance, flexibility, coordination, power, gross/locomotor skills, and object manipulation. This will widen the scope of how exergaming can affect students with disabilities. The overall summary of the meta-analytic findings indicated that the factors of lacking studies to analyze exergaming's effect, prevents the author from stating conclusive results.

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