Effects of physical activity on behaviour and emotional problems, mental health, and psychosocial well-being in children and adolescents with intellectual disability: A systematic review.

Ross L. Borland[1], Lauren A. Cameron[1], Bruce J. Tonge[1,2], Kylie M. Gray[2,1*],

[1] Centre for Developmental Psychiatry and Psychology, Department of Psychiatry, School of Clinical Sciences at Monash Health, Monash University

[2] Centre for Educational Development, Appraisal and Research, University of Warwick, UK

Corresponding author: Professor Kylie Gray, K.Gray.1@warwick.ac.uk

Mailing address: CEDAR, New Education Building, University of Warwick, Coventry, CV4 7AL, United Kingdom

Running title: Physical activity and intellectual disability

Abstract

Background. This systematic review aimed to explore the effects of sport and physical activity on behaviour and emotional problems, mental health, and psychosocial well-being of children and adolescents with intellectual disability.

Method. Five databases were searched systematically (ERIC, MEDLINE, PsycINFO, SportDISCUS, and SCOPUS), up to 28 February 2021. Thirty-two studies met criteria for inclusion.

Results. Studies in this review included case studies (n=15), treatment trials (n=14), cross sectional studies (n=2), and a cohort study (n=1). Evidence was positive, though high risk of bias in treatment trials (7 of 14 rated high) meant generalisability of results was limited.

Conclusions. The available evidence suggests a positive relationship between physical activity and improved behaviour and emotional problems, mental health, and psychosocial well-being; however, more robust randomised controlled trials are required to confirm this.

Keywords: sport, intellectual disability, physical activity, behaviour problems, mental health

1. Introduction

Many health problems present at higher rates in individuals with intellectual disability than in the typically developing population (Allerton et al., 2011; Van Schrojenstein Lantman-de Valk et al., 1997). While some are associated with specific syndromes, for example congenital heart defects in individuals with Down syndrome (Barr & Shields, 2011; Freeman et al., 1998), others occur at higher rates generally for individuals with intellectual disability (e.g. asthma, epilepsy, ADHD, etc.; (Barr & Shields, 2011; Dekker et al., 2002)). Problems with behaviour, mental health, and psychosocial well-being are also seen at increased rates (Cooper et al., 2007; Einfeld et al., 2006; Einfeld & Tonge, 1996a, 1996b). The effect physical activity has on fitness and physical health of children and adolescents with intellectual disability has been well documented (Chanias et al., 1998; Golubović et al., 2012; Pitchford et al., 2018; Stanish & Temple, 2012), however the effect it can have on behaviour and emotional problems, mental health, and psychosocial well-being has been largely overlooked by research (Matson et al., 2012; Pitchford et al., 2018).

Physical activity is associated with health benefits in typically developing children and adolescents (Janssen & Leblanc, 2010; Wiles et al., 2008). In typically developing populations a number of studies have also demonstrated positive effects of physical activity on behaviour and emotional problems (Ash et al., 2017), as well as mental health (Biddle & Asare, 2011; Eime et al., 2013; Fedewa & Ahn, 2011; Parfitt et al., 2009; Penedo & Dahn, 2005). Reductions in anxiety and depression, along with improved memory, self-concept, and academic performance have all been demonstrated through engagement with physical activity (Ahn & Fedewa, 2011; Fedewa & Ahn, 2011).

Minimum recommended levels of physical activity for health benefits are well established (World Health Organisation, 2002, 2003). These guidelines suggest a minimum of 60 minutes of moderate to vigorous physical activity for children every day, however many fail

to reach this benchmark. A cohort study in the UK (Griffiths et al., 2013) estimated that only 51% of children were meeting these minimum guidelines, while lower rates of participation have been reported in Canada (7%: (Colley et al., 2013; Colley et al., 2011) and Australia (20%: (Kremer et al., 2014).

For populations with disabilities, including intellectual disability, participation in physical activity is reported at lower rates when compared to their typically developing peers (Australian Bureau of Statistics, 2010, 2012; Frey et al., 2008; Hinckson & Curtis, 2013). There is also evidence that physical activity declines and sedentary behaviour increases with age in children with syndromes associated with intellectual disability such as autism spectrum disorder (hereafter referred to as autism) (Jones et al., 2017). This trend continues through adolescence into adulthood, with studies showing adults with intellectual disability participate in less physical activity than the general population (Borland et al., 2020; Temple, 2009; Temple & Walkley, 2003). Previous studies point to a number of barriers to participation such as lack of access to facilities, lack of information on appropriate activities, the specific nature of the disability, or lack of community support (Shields et al., 2012), as well as reduced capacity to complete physical activity to the same extent as their typically developing peers (Boonman et al., 2019).

The majority of research on benefits of physical activity for individuals with intellectual disability has focused on the physical health benefit (physical fitness and body composition) with information lacking on the benefits to behaviour and emotional problems, mental health, and psychosocial well-being (Pitchford et al, 2018). Past studies have also concentrated on specific syndromes (e.g. Down syndrome) or conditions that often co-occur with intellectual disability (e.g. autism, ADHD) (Dykens et al., 1998), however these studies often fail to report on degree of intellectual disability, or intellectual disability is not reported in the cohort studied. This is an important factor to consider, as degree of intellectual disability can

impact participation in physical activity (Wouters et al., 2019). Both adults and children with a severe degree of intellectual disability participate at lower rates, often due to reduced physical capacity, behavioural problems, or lack of appropriate programs (Barr & Shields, 2011; Borland et al., 2020; Hilgenkamp et al., 2012; McGarty & Melville, 2018; Shields et al., 2012; Wouters et al., 2019).

The need for systematic reviews to evaluate the quality of evidence about specific outcomes of physical activity in individuals with intellectual disability has been identified (Pitchford et al. (2018). Previous systematic reviews have examined a variety of outcomes of physical activity participation for children, from barriers to participation for children with intellectual disability (McGarty et al., 2018) to behavioural outcomes for children with autism (Bremer et al., 2016; Sowa & Meulenbroek, 2012). There has been no focus on the potential benefits of physical activity on behaviour and emotional problems within populations of children and adolescents with intellectual disabilities. This review aims to understand whether physical activity has a positive effect on behaviour and emotional problems, mental health, and psychosocial well-being in children and adolescents with intellectual disabilities.

2. Method

This study was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines (Moher et al., 2009; Rethlefsen et al., 2021).

2.1. Search strategy

A literature search was conducted to identify studies that addressed behaviour and emotional problems, mental health, and psychosocial well-being outcomes for children and adolescents with intellectual disability as a result of participation in physical activity. Five databases were searched (Ovid MEDLINE, PsycINFO, ERIC, SportDISCUS and SCOPUS) from conception of each database up to February 28th, 2021. A systematic search strategy was developed

based on truncated key terms. The search was limited to English language studies. Reference lists of included studies and relevant identified systematic reviews were also hand searched for relevant studies, however no additional eligible papers were identified.

2.2. Search Terms

Search terms included were based on sport and physical activity, behaviour and emotional problems, mental health, psychosocial well-being, intellectual disability, and children. For intellectual disability, terms relating to autism were included to capture participants with co-occurring intellectual disability. Search terms were combined with 'and' between domains, and 'or' within domains, with conventions adapted based on each database. The full list of search terms are provided in Table 1.

[Insert Table 1 about here]

2.3. Eligibility criteria

To be included in this review, studies had to have: (a) outcomes relating to behaviour and emotional problems, mental health, or psychosocial well-being; (b) include and report separately on, children and/or adolescents (between 2 and 18 years) with intellectual disability; and (c) physical activity was the intervention or moderator of outcomes. Both cross-sectional and experimental studies were included. Studies were excluded if: (a) participants were aged 19 years or older; (b) if there was no diagnosis of intellectual disability; or (c) the intervention was not focused on physical activity.

2.4. Study selection process

Duplicate studies were removed, and all retrieved records were electronically imported into Covidence (www.covidence.org), and online tool for managing systematic reviews. Title and abstract screen were completed by the first author (RLB). Following this, full-text screening was completed by two authors (RLB and LAC). In cases where uncertainty remained, it was

discussed with a third author (KMG). Risk of bias was assessed by three authors (RLB, LAC, KMG), through consensus discussion using pre-developed proformas based on the Cochrane risk of bias tool (Monash Centre for Health Research and Implementation, 2014) and the Newcastle-Ottawa Scale, a widely used tool for assessing the quality of non-randomised studies (Wells et al., 2015). Each study was given a rating of low, moderate, or high risk of bias (see Tables 2, 3 and 4).

After completing the screening process, information on (a) study characteristics (study design, country, year of publication), (b) participant group (age, degree of intellectual disability), (c) type of physical activity (type, frequency, duration), (d) outcome measures (observation method, measurement tool), and (e) results were extracted. Table 2 summarises each case study, Table 3 summaries each cross-sectional and cohort study, and Table 4 summarises each treatment trial.

3. Results

Overall, 3069 references were retrieved. After 844 duplicates were removed, 2225 references remained for title and abstract screening. Two hundred and forty-seven (247) articles were included in the full text review, from which 36 articles met inclusion criteria. Two pairs of articles were based on the same cohort and reported the same outcomes. From the first pair, the thesis (Broadhead, 1969) was included rather than the government report (Rarick & Broadhead, 1968) due to more detail on participants, including detailed information on degree of intellectual disability. Of the second pair the earlier report, Crain et al. (1983), was included rather than Crain et al. (1984) as reporting of participants and outcomes relating to this review were similar.

Two articles were only available as abstracts (Ioannou & Papadopoulou, 2002; Rommel & Anderson, 2013). Online searches were conducted, and contact made with authors in an

attempt to find published literature on these however none was forthcoming, therefore these were not included in the systematic review.

This left 32 articles for extraction. The full search and selection strategy is presented in Figure 1.

[Insert Figure 1 about here]

3.1. Risk of Bias

Almost half of studies (46.9%) were assessed as having low risk of bias (15 studies rated low, 7 studies rated moderate, and 10 studies rated high). However, when study design was considered, the breakdown appeared more skewed. Experimental case design studies were mostly assessed as having low risk of bias (11 of 15 studies rated low, 78.6%; 3 rated moderate, 1 rated high). Most other studies were assessed as having high or moderate risk of bias (9 of 17 studies rated high, 52.9%; 4 studies rated moderate, 4 studies rated low).

Increased risk of bias in studies was due to several factors. Physical activity interventions are often prone to higher risk of bias due to the difficulty of blinding participants. In some cases, testing of outcomes was done by the same people running the intervention (nos.20,27), was unblinded (nos.25,32) or it was unclear who completed measures (nos.22,23). In a number of studies there was a lack of accurate reporting on who was completing measures (nos.11,15,19,22,23,29), and many studies did not report the intensity at which physical activity was being performed (nos.2,3,4,6,9,10,11,12,13,14,15,16,17,19,20,22,23,24,25,26,27,28,29,30,31,32). Many studies did not report on degree of intellectual disability (nos.1,11,19,24,25,28,29,31), or any comorbidities or co-occurring disabilities participants may have (nos.1,11,12,13,15,16,18,19,22,26,27,28,29,30,31,32) which could have affected participation or outcomes. Controlled trials were not always randomised

(nos.22,23,24,25,26), and when they were, this process was not always detailed (nos.28,29,30,32). Two studies only provided descriptive data, and did not undertake any statistical analyses (nos.2,19). Two studies did not clearly report numbers of participants, with contradictory data in text and tables (nos.21,22).

3.2. Study and participant characteristics

Studies were published between 1968 and 2019. Twenty-seven studies were published in peer-reviewed journals, while the remaining five were unpublished theses (nos. 7,8,24,27,28). Sixteen studies (50%) were conducted in the United States of America, with the remainder undertaken in China (n=3), Turkey (n=3), Canada (n=2), India (n=2), Italy (n=2), Israel, Czech Republic, Japan, and Kuwait (all n=1) (see Tables 2, 3 & 4).

3.2.1. Physical activities

The included studies reported on a wide variety of sports and physical activities undertaken in different settings as interventions and moderators of outcomes (see Tables 2, 3 and 4). Four studies used in-school physical education classes, eight studied the effects of jogging, and another ten examined different forms of generic aerobic exercise (exercise bike, calisthenics, play activities etc.). Other activities included soccer, basketball, track & field, yoga, judo, swimming, and dancing. One study measured general levels of daily activity using accelerometers. Types of physical activity examined in each study could be broadly categorised into six distinct groups: aerobic exercise (18 studies; e.g. jogging, cycling, yoga, calisthenics), play activities (3 studies; e.g. ball playing), team sports (3 studies; e.g. basketball, soccer), individual sports (4 studies; e.g. swimming, judo, dancing, track and field), varied sport/activities (5 studies; e.g. physical education classes, Special Olympics where not otherwise specified), and daily activity (1 study; overall daily activity measured via accelerometer).

Duration and scope of physical activity varied, with bouts of physical activity as short as 10 minutes in some studies (nos.3,7,8,10,11,14). Other studies included 2-hour sessions of exercise (no.16), or a weekend-long sporting carnival (no.30). The regularity of activity also varied, including lifetime participation (nos.16,17), multiple bouts per week over an extended period (nos.2,15,19,20,21,23,24,26,27,28,29,31,32), or exercise immediately before the observation period (nos.1,3,4,5,6,7,8,9,10,11,12,13,14,25). One study did not report on duration of activity (no.22).

Intensity of physical activity was examined in six studies (18.8%). Accelerometers were used in just two of the 32 (6.3%) studies included in this review (nos.8,18). One (no.18) had participants wear the devices for seven days to track daily activity, while the other (no.8) had participants only wear the devices during the intervention activities. Three studies (nos.5,7,21) measured intensity of activity using heart rate (HR) monitors. One study (no.7) had participants wear a chest-belt and watch receiver to track HR during exercise. Another study (no.5) used the inbuilt HR monitor (hand grips) on the exercise bike participants rode; however, readings were taken only on the first use of the exercise bike. The third study (no.21) ensured activities were completed between 50-75% of maximum HR, assessed using wrist worn sensors; however, the observers wore the monitors rather than the participants. The sixth study measured HR by periodically taking the pulse rate at the child's radial artery during activity (no.1).

3.2.2. Outcomes

Nineteen different measures were used to assess outcomes across fourteen studies (43.8% of included studies). The only measure used by multiple studies to assess outcomes was the Vineland Social Maturity Scale (VSMS: (Doll, 1947); nos.24,32), while other measures were used in single studies (see Tables 2, 3 and 4 for full list of measures). Observation schedules were used to assess outcomes in the experimental case studies (fifteen studies), as well as in

three treatment trials (nos.19,23,29) (18 of 32 studies overall, 56.3%). These reported on behaviour during activity and/or in a classroom or separate non-activity setting after the activity had been completed. They were completed either by a member of the research team (all studies) or a teacher (nos.19,23). Format of the observation schedule, number of observers, and frequency of observations differed across all studies. Parent report of behaviour at home was used in one study (no.29).

3.2.3. Sample sizes

In total, 995 individuals with intellectual disability were included in the review. Individual studies ranged from one participant to 275 participants. Six studies also included children without intellectual disability (nos.5,6,8,10,14,27). In these cases, only results from the groups or individuals with intellectual disability were examined in this review. Two studies reported different sample sizes in text compared to what was reported in tables and figures (nos.21,22; see Table 4, Note).

3.2.4. Age

The age range across studies was three to 18 years. All controlled trials included reported that there were no significant age differences between the intervention group/s and control group at baseline.

3.2.5. Degree of intellectual disability

Degree of intellectual disability ranged from mild to severe across studies where reported. Fourteen (43.8%) studies reported scores based on IQ or another standardised measure of intellectual functioning (nos.3,5,6,7,8,13,14,15,16,17,22,25,27,30), while nine (28.1%) provided a general report on degree of intellectual disability, identifying the presence of mild, moderate or severe intellectual disability (nos.4,9,10,12,18,20,23,26,32). Two further studies reported on ‘mental age’ or ‘developmental age’, which could be used to provide an estimate

of degree of intellectual disability (nos.2,21). Seven studies (21.9%) did not report degree of intellectual disability. Six of these noted the presence of “mental retardation” or “intellectual disability” in the study sample based on their attendance at a special school for children with intellectual disabilities (nos.1,19,24,28,29) or participation in Special Olympics (no.31). The seventh was an experimental case study where the source of intellectual disability diagnosis was not provided (no.11).

3.2.6. Comorbidities and co-occurring disabilities

Ten studies (31.3%) were interventions for children with autism (nos.2,3,4,5,7,8,10,14,21,25), and one for children with Down syndrome (no.17). One study focused on children with intellectual disability who also had visual impairments (no.20, five blind, two visually impaired). Two additional studies included participants with autism (no.23, 60% with autism; no.9, 1 of 4 participants with autism), and one additional study included a participant with Down syndrome (no.6, 1 of 3 participants). Other co-occurring disabilities included cerebral palsy (no.20, two participants), Fragile X syndrome (no.6, one participant), foetal alcohol syndrome (no.9, one participant), quadriplegia (no.9, one participant), ataxia (no.20, one participant), and microcephaly (no.9, one participant). Seventeen studies (53.1%) did not report on comorbidities or co-occurring disabilities. Three studies excluded participants with physical disabilities or health problems that would impact their participation in or ability to perform sport and physical activities (nos.21,28,31). Other studies excluded participants who had a co-morbid psychiatric disorder (no.25), complex neurological disorder (nos.21,25,32), or visual and auditory deficits (nos.25,32).

3.3. Study design

3.3.1. Experimental case studies

Nearly half (n=15, 46.9%) of the studies were case studies (see Table 2). All of these were experimental studies that examined the effects of aerobic activities. Sample size ranged from

one to seven participants. Activities were primarily jogging (nos.1,3,4,6,7,13,14,15), but also included swimming (no.2), cycling (no.5), roller skating (no.11), calisthenics (nos.9,12), trampoline jumping (no.10), or aerobic activity completed during recess at school (no.8). The studies relied on observations by researchers or teachers, and examined outcomes including stereotypic and self-stimulatory behaviours, or on- and off-task behaviours in class. All studies included multiple baselines (prior to intervention) or repeated baselines (re-set each day, or before each event).

Duration of activities varied, with some looking at single sessions of activity ranging from six to twenty minutes, and others examining a program of multiple sessions per week for up to twelve weeks. Despite this variation, positive outcomes were reported in all studies. One study noted that the participants with low baseline of inappropriate behaviours saw no change after intervention while the participants with high baseline did (no.1). Three studies observing outcomes immediately after exercise noted that improvements were not maintained when participants were re-observed later in the day (nos.7,9,12).

Eight studies examined children with co-occurring autism and outcomes of behaviour and emotional problems related to autism symptomatology and stereotypy (nos.2,3,4,5,7,8,10,14). While these studies all reported an immediate decrease in stereotypy or improved social interactions after physical activity, one study reported improvements were not maintained when participants were re-observed later in the day (no.7).

[Insert Table 2 about here]

3.3.2. Cohort & cross-sectional studies

Two cross-sectional studies (nos.17,18) and one cohort study (no.16) met inclusion criteria (see Table 3). These studies examined daily physical activity (no.18), individual sport (no.17, swimming as part of Special Olympics), and mixed activities (no.16, participants in Special

Olympics broadly). One study included data on 35 participants with intellectual disability who had not been involved in Special Olympics as a comparison group (no.17).

One study examined the effect of total daily physical activity (measured via accelerometer across the course of seven days) on behaviour regulation (shifting emotions, inhibition, and emotional control) and executive functioning (working memory, planning) as assessed using the BRIEF (Gioia et al., 2000) in 104 participants with intellectual disability, aged 7-18 years (no.18). This was one of only two studies to use accelerometers to measure activity, and was therefore able to distinguish between mild, moderate, and vigorous activity. While minimum wear-time requirements were established by the authors, they did not report how many participants met this criteria. The study reported a positive relationship between moderate and vigorous physical activity and higher working memory and planning skills, but no significant relationship with behavioural regulation.

The other two studies examined years enrolled in Special Olympics programs. One (no.17) reported that improved social skills, and improved behaviour problems as measured by the SDQ (Goodman et al., 1998; Muris et al., 2003), were positively associated with participation in Special Olympics swimming in children with Down syndrome (average of 5 hours per week for 8 years), when compared with a group of adolescents with Down syndrome who did not participate in Special Olympics activities (both groups aged 11-17 years). No difference in emotional symptoms such as anxiety were reported between the two groups. The other study (no.16) measured functional ability using the WHODAS 2.0 (World Health Organization, 2000), and reported a positive association between years involved in Special Olympics and higher concentration and learning, better interactions with unknown people, and better maintenance of friendships for 31 adolescents aged 12 to 18. Data was available when they began school (baseline), when they began their sport participation (repeat baseline), and at time of data collection, however it was not clear whether the data from

earlier time points were collected retrospectively or not. The study also did not provide information on years involved with Special Olympics for the group, how many sessions had been attended during that period, or which sports participants were involved in. It was not clear how the data were analysed. The methods indicated that regression analyses were conducted to determine the effects of active participation and number of years in school on each outcome variable; however, only t-test results were reported. These were reported for each outcome variable, but the groups being compared in the analyses were unclear.

[Insert Table 3 about here]

3.3.3. Treatment trials

3.3.3.1 Uncontrolled treatment trials

Three uncontrolled treatment trials (nos.19,20,21) examined small groups of individuals (between seven and 24 participants) receiving an intervention multiple times a week (see Table 4). One study (no.19) provided dancing instruction to thirteen adolescents aged 13-15 years, three times a week for 30 minutes, over 10 weeks. Social behaviours (e.g. cooperation, initiating interactions) were assessed during eleven of the thirty dancing sessions though an observation schedule completed by researchers. Disruptive behaviours (e.g. biting, hitting) were assessed using a similar observation schedule, though only in the first and last week of the program. Overall, improvements in social skills and reductions in disruptive behaviours were reported. Evidence was anecdotal and no statistical analysis was applied. Four groups were described; those who improved social behaviours (n=5), those who improved (decreased) disruptive behaviours (n=2), those who improved in both (n=4), and those with no improvement post treatment (n=2).

The second uncontrolled trial (no.20) examined the effects of a judo training program (two 90-minute sessions per week, for six months) on psychosocial functioning and self-help skills

in seven children aged 6-12 years. One author was an advisor at the school from which children were recruited and delivered the judo training program, a potential source of bias. Psychosocial functioning was measured using a scale designed by staff working with the children and not tested for reliability or validity. Participants had moderate to severe intellectual disability and were blind or visually impaired, with other co-occurring conditions including cerebral palsy and epilepsy. The variety and types of co-occurring disabilities in this group were cited as the reason for no control group. The authors reported significant improvements in psychosocial functioning during the training programme; however, functioning reverted to baseline after the training programme ended. No change was reported in self-help skills.

The third uncontrolled study (no.21) included three different activities for eight weeks; walking (60 minutes, three times per week), jogging/jumping (30 minutes, three times per week), and paper plane building and throwing (30 minutes, two times per week). Twenty-four participants with co-occurring autism were included in the study (age range 11-14 year), with results relating to autism specific outcomes (Autism Treatment Evaluation Checklist; ATEC, (Geier et al., 2013). Rather than assessing the impact of each activity separately, participants were involved in all three activities. Baseline data was only provided for six participants, a non-physical activity intervention (paper plane building) was included, and the intensity of exercise was monitored by taking the HR of the researchers accompanying the participants during the activity rather than the participants themselves, resulting in a high risk of bias rating. Outcomes in terms of speech/communication skills, sociability, cognitive awareness, and stereotypic behaviours were measured before and after walking activities and jogging activities. The study reported significant improvements in communication skills, cognitive awareness, and sociability, but no significant change in stereotypic behaviours.

3.3.3.2 Controlled treatment trials

Eleven studies reported on the results of controlled trials (see Table 4). Six of the eleven studies were randomised controlled trials (54.5%; nos.27,28,29,30,31,32). Only two of these detailed the randomisation process (nos.27,31). One study used a cross-over design, with participants acting as their own controls (no.25). Ten of the eleven studies (90.1%) included a non-physical activity control group. Five of these included a control group with no alternate activity (nos.22,23,26,30,31), and five included a control group participating in a non-physical activity (nos.25,32) or regular classroom activities (nos.24,27,28). The control group in the other study allowed children to play with balls for the same period as the intervention, though no instruction or interaction was provided (no.29). Three studies also included comparison groups of an alternate sport activity (nos.22,24,27), as well as the non-physical activity control group.

Three studies looked at team sport activities (nos.22,29,31). One of these studies examined the impact of participation in basketball on behaviour problems at home and in the classroom, (no.29). Results of the preassessment showed that the treatment group had lower rates of problem behaviours at baseline at home compared to the control group. The treatment group had significantly decreased problem behaviours at home immediately after the program finished, and at the 45-day follow-up, while no change was seen across this time in the control group. Problem behaviours in school at baseline were comparable between the two groups. Results showed that immediately after the program and at the 45-day follow-up the treatment group had significantly improved behaviours compared to the control group. The other two studies examined participation in soccer (Special Olympics) (nos.22,31). One study reported positive outcomes in terms of problem behaviours and social competence following participation in integrated activities (with typically developing students) (no.22). This study included a segregated sport group, which also showed improvements in problem

behaviours and social competence compared to the control group. The segregated sport group reported lower happiness than the integrated group after the intervention. The authors did not specify the duration or frequency of the program, and provided inconsistent numbers of participants, and country of origin when reporting results. The other study compared outcomes following participation in an intervention three times a week for eight weeks to a control group who attended an education session at the same time (no.31). Problem behaviours were reduced in the treatment group at post-test; however, there was no difference compared to the control group.

One study examined participation in individual sport (track and field) as part of the Special Olympics (no.30). A group of participants who attended a single weekend event (24 randomly selected from a pool of 376 registered participants) were compared with a group who usually attended but did not on this occasion (24 participants, randomly selected from a list of 66 non-participating children). All participants in both groups were regular attendees at past events. The randomisation process for each group was not detailed. Demographic variables of the participation and control groups were compared to ensure the groups did not differ statistically. The two groups were reported to be ‘similar’, however the statistics used to establish this were not detailed nor were results provided. Compared to the control group of regular attendees, the children who attended the track and field event on this occasion reported improvements in social acceptance and self-confidence after the event.

Four studies examined varied sports and activities in school-based physical education classes (nos.24,26,27,28). Each intervention ran every weekday, with the intervention duration ranging from ten to 24 weeks. One study (no.27) included two physical education classes (group activities, and individual activities) along with an art activity class and a non-participating control group. Participants were randomly assigned to one of the three activity groups, or the non-participating control group. A second study (no.24) also included two

physical education classes as interventions (traditional physical education, and body movement training) as well as a non-participating control group, although no randomisation process was used. The other two studies (nos.26,28) had a single physical education group and a non-participating control group. One (no.28) randomised participants into intervention and control groups, while the other (no.26) divided participants into equal groups based on number, sex and age without randomisation. One randomised controlled trial showed no change in participant self-concept, self-perception, anxiety, or social competency after participation in physical education classes compared to non-participating controls (no.28). Another showed improvement in social behaviours after participation in two different physical education classes (individual and group focused) compared to non-participating controls, although there were no differences in outcomes comparing the physical activity groups to an art activity program (no.27). This study also reported statistically significant improvements in emotional problems in the individualised physical activity program compared to the group physical activity program and non-participating control group; however, this improvement was less than the improvement reported in the art program. The two non-randomised controlled trials examining physical education classes found consistently positive results in outcomes including interpersonal skills, social maturity, and self-regulation, compared to controls after the intervention (nos.24,26). One study (no.26) also measured outcomes 16 weeks after completion of the program to determine whether improvements were maintained after physical activity stopped. While their findings reported improvements in the intervention group being retained at the 16-week follow-up, no statistical comparison was made between the intervention and control groups.

Two further controlled trials used play activities as an intervention to target self-stimulating behaviours of hand flapping and body rocking in individuals with autism (no.25) or emotional self-control and social interactions (no.23). Both included thirty participants. One

study (no.23) included three 45-minute sessions per week for eight weeks, of play activities including running, jumping, and ball play. Outcomes were recorded through systematic observations by teachers of emotional and social behaviours in the classroom. Statistically significant improvements were reported for self-control post-intervention in the physical activity group compared to the control group. No improvement in social interaction with other children was reported. The other study (no.25) had participants engage in 15 minutes of ball play and tapping activities designed to mimic hand flapping movements followed by five minutes of seated stretching, twice a week for twelve weeks. Outcomes were recorded using the repetitive behaviour scale from the Gilliam Autism Rating Scale – 3rd edition (GARS-3; Gilliam, 2014). Participants acted as their own controls, with a placebo condition included where they were read a story for the corresponding time periods. A one-month washout period was used between the experimental and placebo conditions. When compared to the placebo condition, the treatment condition was associated with significantly decreased frequency of hand flapping. There was no change in body rocking behaviours.

The final randomised controlled trial reported on a one-hour yoga program that ran each weekday for 12 months (no.32). Participants were aged 6-15 years and had mild to severe intellectual disabilities. There were 90 participants in total, with n=45 randomised to the intervention group and n=45 to the non-participating control group. Pre- and post-intervention measurements of cognitive ability, visual perception, and social maturity and competence were recorded. Improvements were seen for all outcomes in the physical activity group compared to the control group, with the greatest improvements noted in those with moderate intellectual disability.

[Insert Table 4 about here]

4. Discussion

The aim of this review was to understand whether physical activity has a positive effect on behaviour and emotional problems, mental health, and psychosocial well-being in children and adolescents with intellectual disabilities. Thirty-two studies reporting on effects of participation in sport and physical activity by children and adolescents with intellectual disability on behaviour and emotional problems, mental health, and psychosocial well-being were included. While the type, duration, and setting of activity varied greatly, outcomes were generally positive, with improvements reported in 93.8% of studies.

The experimental case studies (n=15) reported benefits to stereotypical behaviours, social behaviours, and on-/off-task behaviours in the classroom, through following participation in a variety of different aerobic activities, and were generally rated as having a low risk of bias (11 of 15; 73%). These studies demonstrate the short-term effects physical activity can have, although there was no evidence for maintenance of effects. The larger cohort and cross-sectional studies (n=3, including 31 to 104 participants) provided a broader view of the potential impact physical activity participation can have, though methodological limitations make conclusions difficult to draw. The cross-sectional study design used in two studies (nos.17,18) meant it was impossible to determine the direction of effect; whether improvements in behaviour and social skills were an outcome of participation in sport and physical activity, or whether low rates of behaviour problems and higher levels of social skills were a facilitator for participation. Behaviour problems and poor social skills have been highlighted as barriers to participation in sport and physical activity (Bossink et al., 2017; Trost et al., 2002).

The treatment trials included in this review had a range of methodological problems, limiting the conclusions that could be drawn. Two studies included potential conflicts of interest (nos.19,20). Randomisation of treatment and control groups was done in only six studies.

Further complicating interpretation, blinding of investigators was not achieved in some studies (nos.20,22,23,25,27,32). Many of the studies were poorly reported, including inconsistencies in information as fundamental as participant numbers (nos.21,22). Control groups varied; some studies had non-participating controls, and some had alternate activity participation (e.g. classroom activities, art activity). The effect of exclusion and lack of social interaction from those non-participating groups creates potential confounders, as the social aspect of sport and the attention an intervention provides may impact outcomes. Of the three controlled trials with a low risk of bias, two were published in 1970 (nos.24,28) and the other was published in 1989 (no.32), highlighting the lack of recent quality research in this field.

Three controlled trials made additional comparisons, examining the difference between individual and group designed activities (no.27), and comparing unified/integrated sport (participating with non-disabled athletes) and segregated sport (athletes with intellectual disability only) (no.22). While there were positive outcomes reported across all activity groups, improved emotional behaviour was observed only in the individually tailored activity group and increased happiness was reported only for the integrated athletes. Further exploration of these differences is warranted, as they reflect findings from studies on groups without intellectual disability which have demonstrated different outcomes of physical activity programs based on variations in type, duration, frequency and intensity of activity (Pluhar et al., 2019; Sowa & Meulenbroek, 2012; Steptoe & Bolton, 1988).

Stereotypical behaviour and autism symptomatology were examined in ten of the included studies (31.3%). Eight of these studies (80%) were experimental case studies which showed improvements in behaviours immediately after exercise. Of the other two studies, one was an uncontrolled trial with high risk of bias (no.21) and the other was a controlled trial that looked at very specific stereotypical self-stimulatory behaviours (hand-flapping and body rocking; no.25) making it difficult to draw generalisable conclusions. The study that followed

up behaviours at a later time point, reported that improvements were not maintained (no.7). While results of these studies suggest that physical activity can decrease stereotypical and self-stimulatory behaviours in children and adolescents with intellectual disability and co-occurring autism, they do not consider the broader impacts physical activity could have on other behaviour and emotional problems, mental health, or psychosocial well-being. In cases where activities are designed to mimic behavioural outcomes, findings may be specific to the behaviour and the disability (no.25).

A limitation of the included studies was inconsistency in how physical activity participation was recorded. More widespread use of objective measurement devices such as accelerometers (two studies) and HR monitors (three studies) would have allowed for more consistent reporting of activity between studies regardless of type of activity. ActiGraph accelerometers have been tested for validity for use with individuals with intellectual disability (McGarty et al., 2016; Zhu et al., 2020). These require diary or questionnaire usage to fill in gaps where these devices can't be used such as during aquatic activities or contact sports, or to collect data about activity type. This was not done in the studies included in this review. Only one study used chest-belt HR monitors (no.7), which are currently the best option to provide an accurate indication of HR outside of controlled laboratory conditions and are a suitable tool for assessing exercise intensity during activity (Gillinov et al., 2017). Proper use of these tools in physical activity research is important, as they record duration of activity and intensity of activity, which can have an effect on outcomes (Parfitt et al., 2009).

Another limitation of studies was missing information on both usual levels of physical activity participation and intellectual disability. Measurement of physical activity outside of the intervention was missing in all treatment studies. External physical activity outside the scope of the intervention may have affected willingness and ability to participate in the interventions, as well as outcomes. Seven studies (22%) did not report on participants' degree

of intellectual disability. This makes it impossible to draw conclusions for sub-groups within the population of individuals with intellectual disabilities. There are significant differences in the characteristics and capabilities of individuals with a more severe intellectual disability, and individuals with a mild/moderate intellectual disability. These can include decreased working memory function (Schuchardt et al., 2010), decreased social abilities (Nota et al., 2007), and higher rates of physical disabilities and mobility issues (Borland et al., 2020; Kobe et al., 1994) which could effect an individual's ability to engage with and participate in physical and sport activities. Thorough reporting of participants is important to support a better understanding of how particular types of physical activity interventions might be appropriate for different children and adolescents with intellectual disability.

A limitation of this systematic review is that older studies may have been missed, due to differences in terminology used to define intellectual disability in the past. The hand-searching of reference lists that was conducted would likely have identified any papers missed.

4.1. Conclusions

The generally positive results reported throughout the studies included in this review provide some indication that physical activity may have benefits for behaviour and emotional problems, mental health, and psychosocial well-being for children and adolescents with intellectual disability. However, this review highlights the lack of quality research in this area. These outcomes are under-represented in the existing literature, with the focus of past studies being primarily physical health outcomes (Pitchford et al., 2018), or stereotypical or repetitive behaviours corresponding with a syndrome diagnosis (most commonly autism) (Sowa & Meulenbroek, 2012).

Case study designs have demonstrated the effects of exercise on improving the short-term behaviour and emotional problems and mental health outcomes of individuals with intellectual disability, however their generalisability is limited. Larger studies conducted to date have numerous methodological limitations. To ensure effects are related to physical activity participation and the intervention being studied, and to differentiate between short-term, long-term, and sustained effects, several recommendations can be made. Control groups should be participating in an alternate social or interactive activity. Participation in physical activity undertaken outside of the intervention needs to be recorded, and varying levels of physical activity participation need to be accounted for. Measurement of physical activity needs be as consistent and non-biased as possible, including frequency, duration, intensity, and type. Long-term follow-up should be conducted to determine whether short-term benefits are sustained. Accurate recording of degree of intellectual disability is essential to understand who interventions might be best for. The different impact of individual activities, group activities, and team activities, as well as the different impact of segregated and integrated activities also deserve further exploration than what has been covered in this review.

Rigorous, well-designed randomised controlled trials, examining the effects of sport and physical activity on behaviour and emotional problems, mental health, and psychosocial well-being of children and adolescents with intellectual disabilities should be a focus of future research.

5. Registration and Protocol

This review was registered with PROSPERO, registration number CRD42018112934. The protocol can be accessed at https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018112934.

6. References

*studies included in the systematic review

Ahn, S., & Fedewa, A. L. (2011). A meta-analysis of the relationship between children's physical activity and mental health. *Journal of Pediatric Psychology, 36*(4), 385-397. doi:10.1093/jpepsy/jsq107

Allerton, L. A., Welch, V., & Emerson, E. (2011). Health inequalities experienced by children and young people with intellectual disabilities: A review of literature from the United Kingdom. *Journal of Intellectual Disabilities, 15*(4), 269-278. doi: 10.1177/1744629511430772

*Alruwaih, M. E. (2015). Effects of soccer unified program on adaptive behavioural for children with mental retardation. *Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health, 15*(2), 436-441.

Ash, T., Bowling, A., Davison, K., & Garcia, J. (2017). Physical activity interventions for children with social, emotional, and behavioral disabilities—A systematic review. *Journal of Developmental & Behavioral Pediatrics, 38*(6), 431-445. doi: 10.1097/DBP.0000000000000452

Australian Bureau of Statistics. (2010). *Disability, ageing and carers, Australia: Summary of findings 2009*. Retrieved from Australian Bureau of Statistics, Canberra: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4430.0Main+Features12009?OpenDocument

Australian Bureau of Statistics. (2012). *Sport and recreation: A statistical overview*. Retrieved from Australian Bureau of Statistics, Canberra: http://www.abs.gov.au/ausstats/abs@.nsf/Products/552FD3C2C5C75EC1CA257AD9000E25D0?opendocument

*Bachman, J. E., & Fuqua, R. W. (1983). Management of inappropriate behaviors of trainable mentally impaired students using antecedent exercise. *Journal of Applied Behavior Analysis, 16*(4), 477-484. doi: 10.1901/jaba.1983.16-477

Barr, M., & Shields, N. (2011). Identifying the barriers and facilitators to participation in physical activity for children with Down syndrome. *Journal of Intellectual Disability Research, 55*(11), 1020-1033. doi: 10.1111/j.1365-2788.2011.01425.x

*Battaglia, G., Agrò, G., Cataldo, P., Palma, A., & Alesi, M. (2019). Influence of a specific aquatic program on social and gross motor skills in adolescents with autism spectrum disorders: Three case reports. *Journal of Functional Morphology and Kinesiology, 4*(2), 27. doi: 10.3390/jfmk4020027

Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine, 45*(11), 886-895. doi: 10.1136/bjsports-2011-090185

Boonman, A. J. N., Schroeder, E. C., Hopman, M. T. E., Fernhall, B., & Hilgenkamp, T. I. M. (2019). Cardiopulmonary Profile of Individuals with Intellectual Disability. *Medicine & Science in Sports & Exercise, 51*(9), 1802-1808. doi: 10.1249/MSS.0000000000001995

Borland, R., Hu, N., Tonge, B., Einfeld, S., & Gray, K. (2020). Participation in sport and physical activity in adults with intellectual disabilities. *Journal of Intellectual Disability Research, 64*(12), 908-922. doi: 10.1111/jir.12782

Bossink, L. W., van der Putten, A. A., & Vlaskamp, C. (2017). Understanding low levels of physical activity in people with intellectual disabilities: A systematic review to identify barriers and facilitators. *Research in Developmental Disabilities, 68*, 95-110. doi: 10.1016/j.ridd.2017.06.008

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. doi: 10.1177/1362361315616002

*Broadhead, G. D. (1969). The role of educational physical activity programs in the modification of selected parameters of the behavior of educable mentally retarded children and minimally brain injured children of elementary school age. *Dissertation Abstracts International, 29*(12-A), 4305-4306.

Chanias, A. K., Reid, G., & Hoover, M. L. (1998). Exercise effects on health-related physical fitness of individuals with an intellectual disability: A meta-analysis. *Adapted Physical Activity Quarterly, 15*(2), 119-140. doi: 10.1123/apaq.15.2.119

*Choi, P. H. N., & Cheung, S. Y. (2016). Effects of an 8-week structured physical activity program on psychosocial behaviors of children with intellectual disabilities. *Adapted Physical Activity Quarterly, 33*(1), 1-14. doi: 10.1123/apaq.2014-0213

Colley, R. C., Garriguet, D., Adamo, K. B., Carson, V., Janssen, I., Timmons, B. W., et al. (2013). Physical activity and sedentary behavior during the early years in Canada: A cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 54. doi: 10.1186/1479-5868-10-54

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 15-23.

Cooper, S. A., Smiley, E., Morrison, J., Williamson, A., & Allan, L. (2007). Mental ill-health in adults with intellectual disabilities: Prevalence and associated factors. *British Journal of Psychiatry, 190*, 27-35. doi: 10.1192/bjp.bp.106.022483

Crain, C., Eisenhart, M., & McLaughlin, J. (1984). The application of a multiple measurement approach to investigate the effects of a dance program on educable

mentally retarded adolescents. *Research Quarterly for Exercise and Sport, 55*(3), 231-236. doi: 10.1080/02701367.1984.10609357

*Crain, C., McLaughlin, J. A., & Eisenhart, M. A. (1983). The social and physical effects of a 10-week dance program on educable mentally retarded adolescents. *Education & Training of the Mentally Retarded, 18*(4), 308-312.

Dekker, M. C., Koot, H. M., van der Ende, J., & Verhulst, F. C. (2002). Emotional and behavioral problems in children and adolescents with and without intellectual disability. *Journal of Child Psychology and Psychiatry, 43*(8), 1087-1098. doi: 10.1111/1469-7610.00235

Doll, E. A. (1947). Vineland Social Maturity Scale. *Minneapolis: Educational Test Bureau*.

Dykens, E. M., Rosner, B. A., & Butterbaugh, G. (1998). Exercise and sports in children and adolescents with developmental disabilities. Positive physical and psychosocial effects. *Child and Adolescent Psychiatric Clinics of North America,* 7(4), 757–771.

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: Informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 98. doi: 10.1186/1479-5868-10-98

Einfeld, S. L., Piccinin, A. M., Mackinnon, A., Hofer, S. M., Taffe, J., Gray, K. M., et al. (2006). Psychopathology in young people with intellectual disability. *Jama, 296*(16), 1981-1989. doi: 10.1001/jama.296.16.1981

Einfeld, S. L., & Tonge, B. T. (1996a). Population prevalence of psychopathology in children and adolescents with intellectual disability: I Rationale and methods. *Journal of Intellectual Disability Research, 40*(2), 91-98. doi: 10.1046/j.1365-2788.1996.767767.x

Einfeld, S. L., & Tonge, B. T. (1996b). Population prevalence of psychopathology in children and adolescents with intellectual disability: II Epidemiological findings. *Journal of Intellectual Disability Research, 40*(2), 99-109. doi: 10.1046/j.1365-2788.1996.768768.x

Fedewa, A. L., & Ahn, S. (2011). The effects of physical activity and physical fitness on children's achievement and cognitive outcomes: a meta-analysis. *Research Quarterly for Exercise and Sport, 82*(3), 521-535. doi: 10.1080/02701367.2011.10599785

*Fiorilli, G., di Cagno, A., Iuliano, E., Aquino, G., Calcagnile, G., & Calcagno, G. (2016). Special Olympics swimming: Positive effects on young people with Down syndrome. *Sport Sciences for Health, 12*(3), 339-346. doi: 10.1007/s11332-016-0293-x

Freeman, S. B., Taft, L. F., Dooley, K. J., Allran, K., Sherman, S. L., Hassold, T. J., et al. (1998). Population-based study of congenital heart defects in Down syndrome. *American Journal of Medical Genetics, 80*(3), 213-217.

Frey, G. C., Stanish, H. I., & Temple, V. A. (2008). Physical activity of youth with intellectual disability: Review and research agenda. *Adapted Physical Activity Quarterly, 25*(2), 95-117. doi: 10.1123/apaq.25.2.95

*Funk, D. C. (1970). The effects of a physical education program on the educational improvement of trainable mentally retarded children. *Dissertation Abstracts International, 30*(11-A), 4810.

Geier, D. A., Kern, J. K., & Geier, M. R. (2013). A comparison of the Autism Treatment Evaluation Checklist (ATEC) and the Childhood Autism Rating Scale (CARS) for the quantitative evaluation of autism. *Journal of Mental Health Research in Intellectual Disabilities, 6*(4), 255-267. doi: 10.1080/19315864.2012.681340

*Gençöz, F. (1997). The effects of basketball training on the maladaptive behaviors of trainable mentally retarded children. *Research in Developmental Disabilities, 18*(1), 1-10. doi: 10.1016/S0891-4222(96)00029-7

*Ghosh, D., & Datta, T. K. (2012). Functional improvement and social participation through sports activity for children with mental retardation: A field study from a developing nation. *Prosthetics and Orthotics International, 36*(3), 339-347. doi: 10.1177/0309364612451206

*Gibbons, S. L., & Bushakra, F. B. (1989). Effects of Special Olympics participation on the perceived competence and social acceptance of mentally retarded children. *Adapted Physical Activity Quarterly, 6*(1), 40-51. doi: 10.1123/apaq.6.1.40

Gilliam, J. E. (2014). GARS-3: Gilliam Autism Rating Scale - Third Edition.

Gillinov, S., Etiwy, M., Wang, R., Blackburn, G., Phelan, D., Gillinov, A. M., et al. (2017). Variable accuracy of wearable heart rate monitors during aerobic exercise. *Med Sci Sports Exerc, 49*(8), 1697-1703. doi: 10.1249/MSS.0000000000001284

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *Behavior rating inventory of executive function: BRIEF*: Psychological Assessment Resources Odessa, FL.

*Gleser, J. M., Margulies, J. Y., Nyska, M., Porat, S., Mendelberg, H., & Wertman, E. (1992). Physical and psychosocial benefits of modified judo practice for blind, mentally retarded children: A pilot study. *Perceptual and Motor Skills, 74*(3 Pt 1), 915-925. doi: 10.2466/pms.1992.74.3.915

Golubović, Š., Maksimović, J., Golubović, B., & Glumbić, N. (2012). Effects of exercise on physical fitness in children with intellectual disability. *Research in Developmental Disabilities, 33*(2), 608-614. doi: 10.1016/j.ridd.2011.11.003

Goodman, R., Meltzer, H., & Bailey, V. (1998). The Strengths and Difficulties Questionnaire: A pilot study on the validity of the self-report version. *European Child & Adolescent Psychiatry, 7*(3), 125-130. doi: 10.1007/s007870050057

*Goodwin, L. A. (1971). The effects of two selected physical education programs on trainable mentally retarded children. *Dissertation Abstracts International, 31*(8-A), 3933.

Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., et al. (2013). How active are our children? Findings from the Millennium Cohort Study. *BMJ Open, 3*(8), e002893. doi: 10.1136/bmjopen-2013-002893

Hilgenkamp, T. I., Reis, D., van Wijck, R., & Evenhuis, H. M. (2012). Physical activity levels in older adults with intellectual disabilities are extremely low. *Research in Developmental Disabilities, 33*(2), 477-483. doi: 10.1016/j.ridd.2011.10.011

Hinckson, E. A., & Curtis, A. (2013). Measuring physical activity in children and youth living with intellectual disabilities: A systematic review. *Research in developmental disabilities, 34*(1), 72-86. doi: 10.1016/j.ridd.2012.07.022

Ioannou, I. D., & Papadopoulou, S. K. (2002). *The effect of mild physical exercise on the behavior of adolescents with autism. (Abstract)*. Paper presented at the European College of Sport Science, Proceedings of the 7th annual congress of the European College of Sport Science, Athens, Greece.

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 40. doi: 10.1186/1479-5868-7-40

Jones, R. A., Downing, K., Rinehart, N. J., Barnett, L. M., May, T., McGillivray, J. A., et al. (2017). Physical activity, sedentary behavior and their correlates in children with

autism spectrum disorder: A systematic review. *PloS One, 12*(2), e0172482. doi: 10.1371/journal.pone.0172482

*Kern, L., Koegel, R. L., & Dunlap, G. (1984). The influence of vigorous versus mild exercise on autistic stereotyped behaviors. *Journal of Autism & Developmental Disorders, 14*(1), 57-67. doi: 10.1007/BF02408555

*Kern, L., Koegel, R. L., Dyer, K., Blew, P. A., & Fenton, L. R. (1982). Effects of physical exercise on self-stimulation and appropriate responding in autistic children. *Journal of Autism & Developmental Disorders, 12*(4), 399-419. doi: 10.1007/BF01538327

Kobe, F. H., Mulick, J. A., Rash, T. A., & Martin, J. (1994). Nonambulatory persons with profound mental retardation: Physical, developmental, and behavioral characteristics. *Research in Developmental Disabilities, 15*(6), 413-423. doi: 10.1016/0891-4222(94)90026-4

Kremer, P., Elshaug, C., Leslie, E., Toumbourou, J. W., Patton, G. C., & Williams, J. (2014). Physical activity, leisure-time screen use and depression among children and young adolescents. *J Sci Med Sport, 17*(2), 183-187. doi: 10.1016/j.jsams.2013.03.012

*Losinski, M., Cook, K., Hirsch, S., & Sanders, S. (2017). The effects of deep pressure therapies and antecedent exercise on stereotypical behaviors of students with autism spectrum disorders. *Behavioral Disorders, 42*(4), 196-208. doi: 10.1177/0198742917715873

*Luke, S., Vail, C. O., & Ayres, K. M. (2014). Using antecedent physical activity to increase on-task behavior in young children. *Exceptional Children, 80*(4), 489-503. doi: 10.1177/0014402914527241

Matson, J. L., Belva, B. C., Hattier, M. A., & Matson, M. L. (2012). Scaling methods to measure psychopathology in persons with intellectual disabilities. *Research in Developmental Disabilities, 33*(2), 549-562. doi: 10.1016/j.ridd.2011.10.023

*Mays, M. N. M. (2015). Using antecedent aerobic exercise to decrease stereotypic and self-stimulatory behavior in children with autism. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 76*(1-B(E)).

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. doi: 10.1111/jir.12467

McGarty, A. M., & Melville, C. A. (2018). Parental perceptions of facilitators and barriers to physical activity for children with intellectual disabilities: A mixed methods systematic review. *Research in Developmental Disabilities, 73*, 40-57. doi: 10.1016/j.ridd.2017.12.007

McGarty, A. M., Penpraze, V., & Melville, C. A. (2016). Calibration and cross-validation of the ActiGraph wGT3X+ accelerometer for the estimation of physical activity intensity in children with intellectual disabilities. *PloS One, 11*(10), e0164928. doi: 10.1371/journal.pone.0164928

*McLaughlin, C. A. H. (2011). Decreasing stereotypy in preschoolers with autism spectrum disorder: The role of increased physical activity and function. *Dissertation Abstracts International: Section A: Humanities and Social Sciences, 71*(10-A), 3619.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med, 6*(7), e1000097. doi: 10.1371/journal.pmed.1000097

Monash Centre for Health Research and Implementation. (2014). *Evidence synthesis program template for critical appraisal of a cohort study*. Melbourne: Monash Centre for Health Research and Implementation.

*Morrissey, P. A., Franzini, L. R., & Karen, R. L. (1992). The salutary effects of light calisthenics and relaxation training on self-stimulation in the developmentally disabled. *Behavioral Residential Treatment, 7*(5), 373-389. doi: 10.1002/bin.2360070505

Muris, P., Meesters, C., & van den Berg, F. (2003). The strengths and difficulties questionnaire (SDQ). *European child & adolescent psychiatry, 12*(1), 1-8.

*Neely, L., Rispoli, M., Gerow, S., & Ninci, J. (2015). Effects of antecedent exercise on academic engagement and stereotypy during instruction. *Behavior Modification, 39*(1), 98-116. doi: 10.1177/0145445514552891

Nota, L., Ferrari, L., Soresi, S., & Wehmeyer, M. (2007). Self-determination, social abilities and the quality of life of people with intellectual disability. *Journal of Intellectual Disability Research, 51*(11), 850-865. doi: 10.1111/j.1365-2788.2006.00939.x

*Özer, D., Baran, F., Aktop, A., Nalbant, S., Aĝlamiş, E., & Hutzler, Y. (2012). Effects of a Special Olympics Unified Sports soccer program on psycho-social attributes of youth with and without intellectual disability. *Research in Developmental Disabilities, 33*(1), 229-239. doi: 10.1016/j.ridd.2011.09.011

Parfitt, G., Pavey, T., & Rowlands, A. V. (2009). Children's physical activity and psychological health: The relevance of intensity. *Acta Paediatrica, 98*(6), 1037-1043. doi: 10.1111/j.1651-2227.2009.01255.x

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189-193. doi: 10.1097/00001504-200503000-00013

Pitchford, E. A., Dixon-Ibarra, A., & Hauck, J. L. (2018). Physical activity research in intellectual disability: A scoping review using the behavioral epidemiological

framework. *American Journal on Intellectual and Developmental Disabilities, 123*(2), 140-163. doi: 10.1352/1944-7558-123.2.140

Pluhar, E., McCracken, C., Griffith, K. L., Christino, M. A., Sugimoto, D., & Meehan III, W. P. (2019). Team sport athletes may be less likely to suffer anxiety or depression than individual sport athletes. *Journal of Sports Science & Medicine, 18*(3), 490.

*Powers, S., Thibadeau, S., & Rose, K. (1992). Antecedent exercise and its effects on self-stimulation. *Behavioral Residential Treatment, 7*(1), 15-22. doi: 10.1002/bin.2360070103

*Protic, M., & Válková, H. (2018). The relationship between executive functions and physical activity in children with an intellectual disability. *Journal of Physical Education and Sport, 18*(2), 844-852. doi: 10.7752/jpes.2018.02125

Rarick, G. L., & Broadhead, G. A. (1968). *The Effects of Individualized Versus Group Oriented Physical Education Programs on Selected Parameters of Development of Educable Mentally Retarded and Minimally Brain Injured Children. Final Report*. Retrieved from Wisconsin Univ., Madison.

*Reid, P. D., Factor, D. C., Freeman, N. L., & Sherman, J. (1988). The effects of physical exercise on three autistic and developmentally disordered adolescents. *Therapeutic Recreation Journal, 22*(2), 47-56.

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. *Systematic reviews*, 10(1), 1-19. https://doi.org/10.1186/s13643-020-01542-z

Rommel, T. M., & Anderson, C. J. (2013). Benefits of yoga as an intervention for those with intellectual disabilities. *Therapeutic Recreation Journal, 47*(3), 212-212.

*Rosenthal-Malek, A., & Mitchell, S. (1997). Brief report: The effects of exercise on the self-stimulatory behaviors and positive responding of adolescents with autism. *Journal of Autism and Developmental Disorders, 27*(2), 193-202. doi: 10.1023/a:1025848009248

Schuchardt, K., Gebhardt, M., & Mäehler, C. (2010). Working memory functions in children with different degrees of intellectual disability. *Journal of Intellectual Disability Research, 54*(4), 346-353. doi: 10.1111/j.1365-2788.2010.01265.x

Shields, N., Synnot, A. J., & Barr, M. (2012). Perceived barriers and facilitators to physical activity for children with disability: A systematic review. *British Journal of Sports Medicine, 46*(14), 989-997. doi: 10.1136/bjsports-2011-090236

Sowa, M., & Meulenbroek, R. (2012). Effects of physical exercise on autism spectrum disorders: A meta-analysis. *Research in Autism Spectrum Disorders, 6*(1), 46-57. doi: 10.1016/j.rasd.2011.09.001

Stanish, H. I., & Temple, V. A. (2012). Efficacy of a peer-guided exercise programme for adolescents with intellectual disability. *Journal of Applied Research in Intellectual Disabilities, 25*(4), 319-328. doi: 10.1111/j.1468-3148.2011.00668.x

Steptoe, A., & Bolton, J. (1988). The short-term influence of high and low intensity physical exercise on mood. *Psychology and Health, 2*(2), 91-106. doi: 10.1080/08870448808400346

Temple, V. A. (2009). Factors associated with high levels of physical activity among adults with intellectual disability. *International Journal of Rehabilitation Research, 32*(1), 89-92. doi: 10.1097/MRR.0b013e328307f5a0

Temple, V. A., & Walkley, J. W. (2003). Physical activity of adults with intellectual disability. *Journal of Intellectual & Developmental Disability, 28*(4), 342-353. doi: 10.1080/13668250310001616380

Trost, S. G., Owen, N., Bauman, A. E., Sallis, J. F., & Brown, W. (2002). Correlates of adults' participation in physical activity: Review and update. *Medicine & Science in Sports & Exercise, 34*(12), 1996-2001. doi: 10.1097/00005768-200212000-00020

*Tse, C. A., Pang, C., & Lee, P. H. (2018). Choosing an appropriate physical exercise to reduce stereotypic behavior in children with autism spectrum disorders: A non-randomized crossover study. *Journal of Autism and Developmental Disorders, 48*(5), 1666-1672. doi: 10.1007/s10803-017-3419-3.

*Uma, K., Nagendra, H. R., Nagarathna, R., Vaidehi, S., & Seethalakshmi, R. (1989). The integrated approach of yoga: A therapeutic tool for mentally retarded children: A one-year controlled study. *Journal of Intellectual Disability Research, 33*(5), 415-421. doi: 10.1111/j.1365-2788.1989.tb01496.x

Van Schrojenstein Lantman-de Valk, H., Van den Akker, M., Maaskant, M., Haveman, M., Urlings, H., Kessels, A. G., et al. (1997). Prevalence and incidence of health problems in people with intellectual disability. *Journal of Intellectual Disability Research, 41*(1), 42-51. doi: 10.1111/j.1365-2788.1997.tb00675.x

*Watters, R. G., & Watters, W. E. (1980). Decreasing self-stimulatory behavior with physical exercise in a group of autistic boys. *Journal of Autism and Developmental Disorders, 10*(4), 379-387. doi: 10.1007/BF02414814

Wells, G. A., Tugwell, P., O'Connell, D., Welch, V., Peterson, J., Shea, B., et al. (2015). The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses.

Wiles, N. J., Jones, G. T., Haase, A. M., Lawlor, D. A., Macfarlane, G. J., & Lewis, G. (2008). Physical activity and emotional problems amongst adolescents: A longitudinal study. *Soc Psychiatry Psychiatr Epidemiol, 43*(10), 765-772. doi: 10.1007/s00127-008-0362-9

World Health Organisation. (2002). *The world health report 2002: Reducing risks, promoting healthy life*. Retrieved from https://www.who.int/whr/2002/en/

World Health Organisation. (2003). *Health and development through physical activity and sport*. Retrieved from https://apps.who.int/iris/handle/10665/67796

World Health Organization. (2000). World Health Organization disabilty assessment schedule: WHODAS II. Phase 2 field trials. Health services research.

Wouters, M., Evenhuis, H. M., & Hilgenkamp, T. I. M. (2019). Physical activity levels of children and adolescents with moderate-to-severe intellectual disability. *Journal of Applied Research in Intellectual Disabilities, 32*(1), 131-142. doi: 10.1111/jar.12515

*Yamanaka, T., Furuya, T., & Shibbagaki, M. (1994). Use of running exercises for preschoolers with mental retardation as a means of improving play or school activity. *Perceptual and Motor Skills, 78*(2), 571-578. doi: 10.2466/pms.1994.78.2.571

*Ye, Q., Hu, G., Cai, Y., Zhang, G., Xu, K., Qu, T., et al. (2019). Structural exercise-based intervention for health problems in individuals with autism spectrum disorders: A pilot study. *European Review for Medical and Pharmacological Sciences, 23*(10), 4313-4320. doi: 10.26355/eurrev_201905_17937

*Yilmaz, A., & Soyer, F. (2018). Effect of physical education and play applications on school social behaviors of mild-level intellectually disabled children. *Education Sciences, 8*(2), 89. doi: 10.3390/educsci8020089

Zhu, X., Haegele, J., Wang, D., Zhang, L., & Wu, X. (2020). Reactivity to accelerometer measurement of youth with moderate and severe intellectual disabilities. *Journal of Intellectual Disability Research, 64*(9), 667-672. doi: 10.1111/jir.12757

7. Tables

Table 1: Search Terms

Sport and physical activity	Outcomes	Population (diagnosis)	Population (age range)
sport*, “physical activ*”, “physical educat*”, exercis*	depress*, stress*, anxi*, mood*, “social funct*”, “mental health”, behav*, psychosoci*, emotion*	“intellect* disab*”, “mental* retard*”, “development* disab*”, “developmental delay”, “learning disab*”, autis*, asperg*, PDD*, “pervasive developmental disorder”	child*, adolesc*, youth*, teenage*, kid*, pediatric*

Table 2: Experimental Case Studies

#	Author (year), Country	Type of physical activity	Description of intervention and baseline / control condition	Participant characteristics			Outcomes	Key Findings	Risk of bias
				N	Age	Intellectual disability diagnosis			
1	Bachman & Fuqua (1983), USA	Jogging	All jogging completed in the morning before classes, intensity measured by taking radial pulse rate of participants. Exercise started as 1-mile of moderate jogging every second day, progressing to 1.5 miles of vigorous jogging every day. One participant with lower baseline saw no improvement, so progressed to 2-miles of vigorous jogging. Intervention lasted for approximately 30-40 days. Baseline observations recorded prior to intervention over 10-15 days.	4	6-16 years	"Trainable mentally impaired"	Observation of inappropriate in-class behaviours up to 2-hours after intervention.	Inappropriate behaviour appeared to decrease in 3 of 4 students across all exercise conditions. Inappropriate behaviours decreased further as intensity of activity increased. During alternate exercise day periods, lower rates of inappropriate behaviours were recorded on exercise days. No improvement was seen in the student with lower baseline, even after additional vigorous activity.	Low
2	Battaglia et al (2019), Italy	Swimming / Aquatic Therapy	45–50-minute Aquatic Therapy program. 2x per week for 12 weeks. Baseline observations recorded across 6x 1-hour sessions.	3	11-15 years	Mental age considerably lower than chronological age (estimated IQ range 34-46)	Observation of Interaction (joint attention, joint play, searching others' presence, comply ones turn) and Contact (sensitivity to other's presence, loneliness, eye contact, observation of other's behaviours)	No statistical analyses were undertaken. All subjects appeared to show some improvement in social behaviours at the end of the 12-week intervention compared to baseline. Specific areas of improvement varied amongst subjects.	High
3	Kern et al (1982), USA	Jogging	15 minutes prior to observation period every second day for 45 days. Baseline observations recorded on alternating days.	7	4-14 years	IQ=48-59 or untestable due to degree of intellectual disability	Observation of self-stimulatory behaviours and academic responding immediately after intervention.	Decrease in self-stimulatory behaviour and increased academic responding/appropriate play following jogging sessions compared to baseline.	Low
4	Kern et al (1984), USA	Jogging & Ball playing	15 minutes of jogging prior to observation period on alternate days (total 3 days) 15 minutes of ball play prior to observation on alternate days (total 3 days) Baseline observations recorded on a non-exercise day prior to intervention, and again after the first 3 days of intervention.	3	7-11 years	"Formally untestable on standardized tests"	Observation of stereotypical behaviours immediately after intervention.	Decrease in stereotypical behaviour compared to baseline after vigorous jogging sessions. No change in behaviours compared to baseline after ball playing sessions.	Low
5	Losinski et al (2017), USA	Exercise bike	Intensity of physical activity measured with HR monitors.	3	7-11 years	IQ=50, 54 & unavailable IQ	Observation of stereotypical behaviours	Reduced stereotypical behaviours in post-exercise sessions for all participants.	Low

			10 minutes at pace that had brought HR above 100 beats per minute for 5 minutes in first session (HR not measured after this), prior to observation period, 5x across 5 days. Baseline observations recorded across 5 consecutive days before starting intervention.			with extremely low communication	immediately after intervention.		
6	Luke et al (2014), USA	Aerobic exercise – e.g. running, jumping as play activities	20 minutes prior to observed period for 9 days. Baseline observations recorded for 6 days prior to intervention, and again for 5 days halfway through the intervention.	3	3-5 years	2-3SD below the mean on Mullen Scales of Early Learning (scores of 62, 55 & 70)	Observations of on- and off-task behaviours immediately after intervention.	Greater on-task behaviour was observed after physical activity sessions compared to baseline periods.	Low
7	Mays (2015), USA	Jogging	Intensity of physical activity measured with HR monitors. Jogging for 10 minutes, HR 60-80% of maximum HR on 5-separate days. Baseline observations recorded prior to intervention. Baseline and intervention were repeated three times.	2	10 & 11 years	IQ=38 & 45	Observation of stereotypical behaviours immediately after intervention, and later in the day (time not specified).	Stereotypic behaviours decreased 10-12% compared to baseline in classes immediately following physical activity. This effect was not maintained in sessions later in the same day.	Low
8	McLaughlin (2011), USA	Play activities during recess (aerobic activities)	Intensity and duration of activity measured with accelerometer. 5 continuous minutes vigorous activity in the last 15 minutes of recess, immediately prior to observation period (5 or 6 sessions) 5 1-minute intervals of vigorous activity in the last 10 minutes of recess, immediately prior to observation (4 or 6 sessions) Baseline observations recorded prior to intervention, and re-established between continuous activity, and interval activity conditions.	2	3-5 years	1.5-3SD below mean on Battelle Developmental Inventory: Cognitive	Observation of stereotypical behaviours immediately after intervention.	Decreased stereotypical behaviours following both physical activity conditions when compared to baseline for both students.	Low
9	Morrissey et al (1992), USA	Light calisthenics	15 minutes of calisthenics (intensity estimated as light) prior to observation periods for 21 days. Two alternate conditions were included: 15 minutes of free time or 15 minutes of relaxation session. During intervention, all three conditions were tested each day, separated by at least 1 hour. Baseline observations recorded prior to intervention across 5 days.	4	8-13 years	"Untestable IQ" estimated moderate-severe intellectual disability	Observation of self-stimulatory behaviour and on-task / attending-to-task behaviour immediately after intervention, and in regular living conditions later in the afternoon.	Decreased self-stimulatory behaviour and attention-to-task was observed after calisthenics sessions compared to baseline and free-time conditions. Effects were matched in the relaxation condition. Effects were not maintained later in the day.	Low
10	Neely et al (2015), USA	Trampoline jumping	Trampoline jumping until bored, average 6min 18sec, prior to instructional session. Brief trampoline jumping (20% of previous time, 1min 38sec) prior to instructional session. Instructional sessions were conducted 2-3 times per week for 10-12 weeks. Baseline observations recorded prior to intervention and re-recorded periodically across the intervention period.	1	7 years	Severe intellectual disability	Observation of stereotypy and academic engagement immediately after intervention.	Reduction in stereotypy and improved academic engagement after both exercise activities. Greater improvements seen after exercise until bored.	Low

11	Powers et al (1992), USA	Roller skating	10 minutes prior to observation period for 17 days. Baseline observations recorded for 9 days prior to intervention and re-recorded for 11 days after 6 days of intervention.	1	8 years	Intellectual disability with autistic-like behaviours	Observation of self-stimulatory behaviour and on-task performance immediately after intervention.	Decrease in self-stimulatory behaviour and increase in on-task behaviour was observed after exercise when compared to baseline.	Mod
12	Reid et al (1988), Canada	Calisthenics	20 minutes prior to observation period for 20 days. Baseline observations recorded for 8 days prior to observation period. An 8-day follow-up period of no exercise after the intervention was also included.	3	12-17 years	IQ in severe intellectual disability range	Observation of on- and off-task behaviour, prosocial behaviour, and inappropriate vocalisations immediately after intervention.	Improvement in on- and off-task behaviour was observed post exercise compared to baseline. Behaviours returned to baseline during follow-up. No changes to prosocial behaviour and inappropriate vocalisations.	Low
13	Rosenthal-Malek & Mitchell (1997), USA	Jogging	Mildly strenuous (flushing and increased breathing, but not discomforted/out of breath) for 20 minutes prior to observation period. An academic condition, where participants spent 20 minutes in a normal classroom prior to observation period was used to establish baseline. 10 academic and 10 exercise sessions were conducted (one each day for 4 weeks) in randomised order.	5	14-15 years	Mean IQ=42.2 (SD=4.9)	Observation of self-stimulatory behaviour and academic responding immediately after intervention.	Self-stimulatory behaviour decreased following physical activity compared to academic condition. Number of correct responses and completed tasks increased after physical activity compared to academic condition.	Mod
14	Watters & Watters (1980), Canada	Jogging	8-10 minutes prior to observation period on 11 days. Alternate conditions included the same time spent watching TV (5 days) or completing regular academic work (11 days) prior to observation period. Order of physical activity and alternate conditions was randomised.	4	9-11 years	IQ=34-48	Observation of self-stimulatory behaviour and academic responding immediately after intervention.	Observed self-stimulation decreased following physical activity compared to alternate conditions. No change in academic responding was observed after physical activity.	Low
15	Yamanaka et al (1994), Japan	Jogging	20 minutes, 3x per week for 11 weeks. Baseline observations were made 3x per week for 4 weeks, prior to the intervention.	4	4-5 years	IQ=40-56	Observation of behaviour and social interaction in school and play activities across the entire school day that the intervention took place, for the last 4 weeks of the intervention	2 of 4 participants with intellectual disability showed improvements in observed social interaction and behaviours in the last 4 weeks of intervention compared to baseline.	Mod

Table 3: Cohort & Cross-Sectional Studies

#	Author (year), Country	Type of physical activity	Description of physical activity	Participant characteristics			Outcomes	Key findings	Risk of bias
				N	Age	Intellectual disability diagnosis			
Cohort Study									
16	Ghosh & Datta (2012), India	Special Olympics - general	Number of years enrolled in Special Olympics was recorded but not reported	31	12-18 years	IQ=45-70	Functional ability measured using the World Health Organisation Disability Assessment Schedule (WHODAS) 2.0	More years involved with sport was associated with improved concentration and learning, improved interactions with unknown people, maintaining friendships, and better day-to-day work at school.	High
Cross Sectional Studies									
17	Fiorilli et al (2016), Italy	Special Olympics - Swimming	Participants in Special Olympics (average 5hrs per week for 8 years) Comparison group of adolescents who had never done Special Olympics.	93 (58 in Special Olympics, 35 in comparison group)	11-17 years	IQ=43-52	Behaviour and emotional problems measured by the SDQ (self-report and parent versions)	Participation in sport activity was associated with improved well-being, behaviours, and social skills. No difference in emotional symptoms.	Low
18	Protic & Valkova (2018), Czech Republic	Daily activity measured by accelerometer	All daily activity (accelerometer), for 7 consecutive days	104	7-18 years	49 with mild intellectual disability 55 with moderate intellectual disability	Behaviour Rating Inventory of Executive Functions	Positive relationship between moderate and vigorous physical activity, and working memory and planning. No significant relationship with behavioural regulation.	High

Table 4: Treatment Trials

#	Author (year), Country	Type of physical activity	Description of physical activity and control groups	Participant characteristics			Outcomes	Key Findings	Risk of bias
				N	Age	Intellectual disability diagnosis			
Uncontrolled Trials									
19	Crain et al (1983), USA	Dancing	30 minutes, 3x per week for 10 weeks	13	13-15 years	"Educable mentally retarded"	Physical and social behaviours during exercise (observations) and changes outside this (interview)	No statistical analyses undertaken. Some gain in social skills reported. Four groups described: Improved physically; improved socially; improved both; no improvement.	High
20	Gleser et al (1992), Israel	Judo	90 minutes, 2x per week for 6 months	7	6-12 years	Moderate to severe intellectual disability	Brigance Diagnostic Inventory of Early Development, staff-designed scale measuring overall psychosocial functioning	Psychosocial functioning improved during training, but declined to baseline after activity stopped. No change to self-help skills. Minimal change to body part comprehension which was lost at follow-up.	High
21[a]	Ye et al (2019), China	Outdoor walking, jogging & jumping, and paper plane building & throwing	Intensity of physical activity measured with HR monitors worn by observers. Walking 3x per week (60 mins @ 50-75% maximum HR). Jogging/jumping 3x per week (30mins, 4 sets of 2-3min intervals). Building/throwing paper planes 2x per week (30mins @ 50-75% maximum HR) for 8 weeks.	24	11-14 years	Developmental age considerably lower than chronological age (estimated IQ range 33-68)	Autism Treatment Evaluation Checklist (ATEC). Autism related behaviours in areas of communication, sociability, sensory and cognitive awareness, health & physical behaviour, + total score	Significant improvement in communication, sociability, and sensory/cognitive awareness. Physical behaviour problems did not improve.	High
Non-Randomised Controlled Trials									
22[a]	Alruwaih (2015), Kuwait	Special Olympics - Soccer	Participation in unified/integrated sport and participation in segregated sport, based on Special Olympics. Duration and intensity unknown. Control group did not participate in any activity.	40 (12 unified, 10 segregated, 18 control)	11-18 years	Mean IQ: Unified=58.29 Segregated=57.09 Control=58.11	Piers-Harris Self-Concept Scale (self-concept, behavioural adjustment, anxiety, popularity, happiness & satisfaction)	Significant improvement in both sport groups versus control. Significant increase in happiness in unified sport compared to segregated sport.	High
23	Choi et al (2016), China	Play activities – e.g. jumping, ball play	45 minutes, 3x per week for 8 weeks. Control group did not participate in any activity.	30 (18 intervention, 12 control)	7-8 years	Mild intellectual disability	Observation and interviews detailing emotional self-control and social interaction	Significant improvements were reported for self-control. No change was seen in social interaction.	High

24	Goodwin (1970), USA	Physical education class & body movement training	30 minutes, 5x per week for 10 weeks for both physical activity groups. Control group attended regular classroom activities during these periods.	33 (11 in traditional PE, 11 in movement exploration, 11 control)	10-15 years	"Trainable mentally retarded"	Vineland Social Maturity Scale	Social maturity improved significantly in both physical activity groups compared to control.	Low
25	Tse et al (2018), China	Ball tapping & throwing	15 minutes of tapping/throwing followed by 5 minutes of seated stretching, 2x per week for 12 weeks. Control condition was 20 minutes of story time, 2x per week for 12 weeks.	30	9-12 years	Intellectual disability, non-verbal IQ over 40	GARS-3 Repetitive Behaviour Subscale. Observation of stereotypical behaviours – hand flapping (matching physical activity) and body rocking (other)	Observed hand flapping (matched exercise) decreased significantly post exercise while body rocking remained unchanged.	Mod
26	Yilmaz & Soyer (2018), Turkey	Physical Education class	2 hours, 5x per week for 24 weeks. Control group did not participate in any activity.	20 (10 intervention, 10 control)	7-9 years	Mild intellectual disability'	School Social Behaviour Scales (Interpersonal relations, self-regulation, academic skills, aggressive-nervous, antisocial-aggressive, destructive-demanding)	Significant improvements noted in all domains for experimental group after intervention. However, no difference in interpersonal, self-regulation or academic skills when compared to control. Improvements mostly retained at 16-week follow-up (but no analyses were done to compare with control)	High
<u>Randomised Controlled Trials</u>									
27	Broadhead (1968), USA	Physical Education class	35 minutes, 5x per week for 20 weeks for both physical activity groups, and the art activity group. Control group attended regular classroom activities during these periods.	275 (73 individual PE, 70 group PE, 66 art class, 66 control	6-13 years	Mean IQ=65.3	Bender Motor Gestalt Test, Cattell Personality Questionnaires (intellectual, social & emotional behaviour)	Intellectual behaviour improved in the physical activity programs compared to control, but not compared to the art program. Improved emotional behaviours were observed in the individual physical activity program compared to the group physical activity program or control, however these improvements were lower than improvements in the art program.	Mod
28	Funk (1970), USA	Physical Education class	30 minutes, 5x per week for 12 weeks. Control group attended regular classroom activities during these periods.	40 (20 intervention, 20 control)	8-18 years	"Trainable mentally retarded"	Cain-Levine Social Competency Scale, Goodenough-Harris draw-a-person test	No differences found in psychological tests or social competency.	Low
29	Gencoz (1997), Turkey	Basketball	40 minutes, 3x per week for 7 weeks. Control group could play with balls in any manner during this time but received no instruction.	20 (10 intervention, 10 control)	10-14 years	"Trainable mental retardation"	Adaptive behaviours (American Association on Mental Deficiency Adaptive Behavior Scale, ABS and Classroom Behaviour Checklist, CBC)	Significant reduction in problem behaviours in the classroom and at home after intervention and at 45-day follow-up, compared to the control group.	Mod
30	Gibbons & Bushakra (1989), USA	Special Olympics – Track & Field	1.5-day Special Olympics meet (Friday evening, all day Saturday). Min 4 events participated, max 6.	48 (24 participation, 24 control)	9-13 years	IQ=48-70 (mean 58.5)	Pictorial Scale of Perceived Competence and Social Acceptance for Young Children	Significant increase in peer acceptance, cognitive competence and maternal acceptance compared to non-participatory group	High

			Control group of children who normally participate but did not on this occasion.						
31	Ozer et al (2012), Turkey	Special Olympics - Soccer	1.5-hour session 3x per week for 8 weeks. Control group did not participate in any activity.	38 (23 intervention, 15 control)	12-15 years	Intellectual Disability	Child Behaviour Checklist (Parent & Teacher report), Friendship Activity Scale, Adjective Checklist	Significant increase in social competence and attitude to social activity compared to control group. Reduction in problem behaviour was matched by control group.	Mod
32	Uma et al (1989), India	Yoga	1 hour, 5x per week for a school year. Control group attended regular school activities during these periods.	90 (45 intervention, 45 control)	6-15 years	Mild to Severe Intellectual Disability	Seguin Form Board, Vineland Social Maturity Scale	Significant improvement in both measures after yoga when compared to the control group. Individuals with moderate intellectual disability saw greatest improvements.	Low

Note. [a] Study 22 specified 40 participants in the results tables, however in-text it was stated that 30 participants were included in the study. Study 21 only provided demographic data on six participants, however in-text it was stated analyses were completed using 24 participants. In discussing these two studies, the sample sizes referred to in analyses were reported.

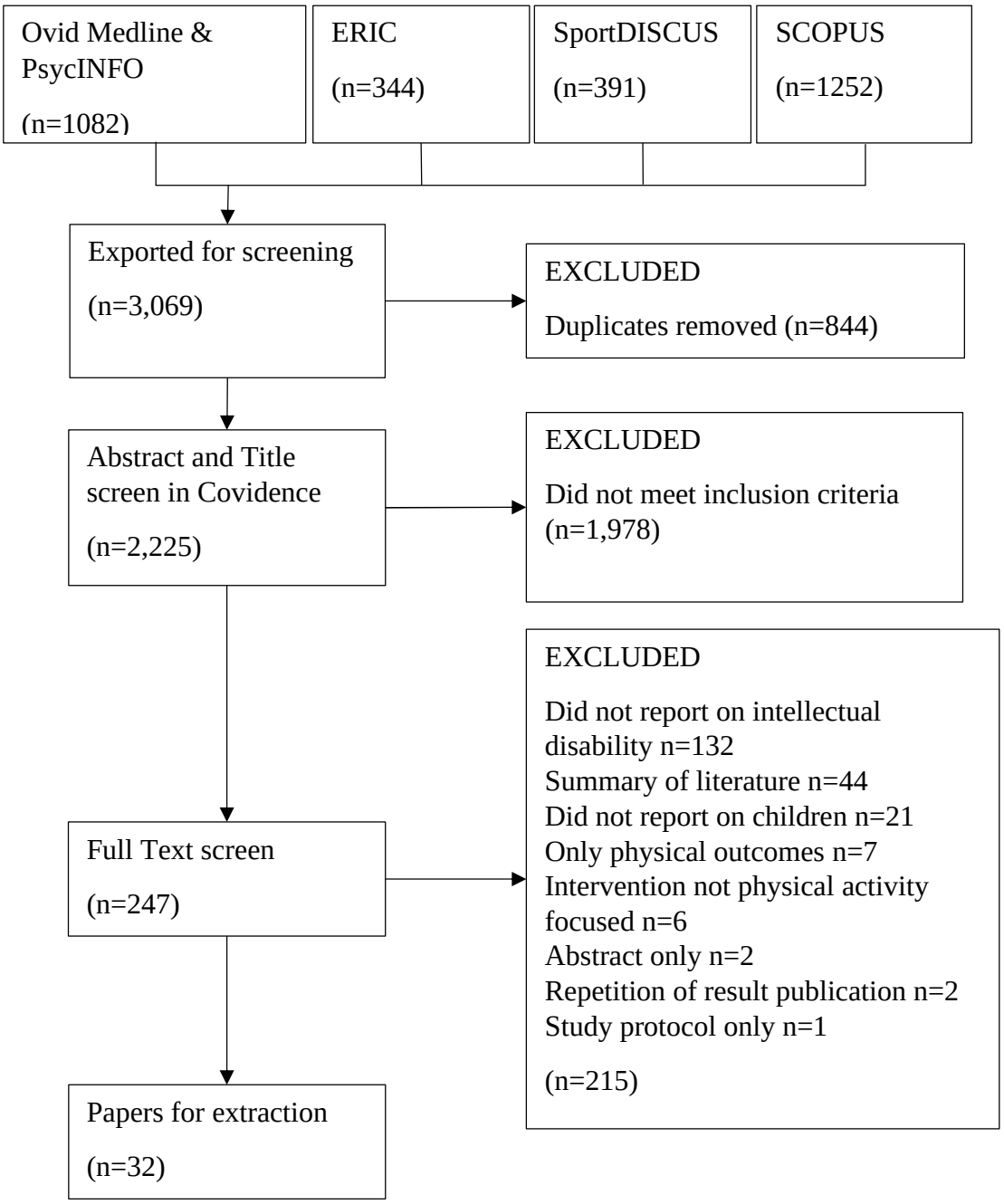

Figure 1. PRISMA flow diagram