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REVIEW

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Conventional exercise interventions for adults with intellectual disabilities: A systematic review and meta-analysis

Lucia Cugusi[1] | Mauro Giovanni Carta[2]

[1]Department of Biomedical Sciences, University of Sassari, Italy

[2]Department of Medical Sciences and Public Health, University of Cagliari, Italy

Correspondence
Lucia Cugusi, Department of Biomedical Sciences, University of Sassari, Viale San Pietro 43/B, 07100, Sassari (SS), Italy.
Email: lucia.cugusi@uniss.it

Exercise is a well-established therapeutic component in the management of a wide range of intellectual disabilities (IDs). Our aim was to appraise the effects of conventional forms of exercise on anthropometric, cardiovascular, and motor-functional profiles of adults with IDs. Four databases (PubMed/Scopus/PEDro/Cochrane) were searched to detect any randomized controlled trial (RCT) pertinent to conventional exercise trainings for adults with ID. Meta-analyses were being performed for studies reported results on the same outcome measures employing RevMan 5.3. Thirteen RCTs involving 556 participants (56.7% men) entered the qualitative synthesis and eleven the meta-analyses. The effect of exercise was superior to controls (no exercise prescription) on several cardiovascular variables (peak oxygen uptake, MD 2.89, 95%CI 0.35;5.42, I^2 = 69%; heart rate peak, MD 4.64, 95%CI 2.15;7.14, I^2 = 7%; maximal exercise capacity, SMD 0.55, 95%CI 0.03;1.08, I^2 = 67%; systolic blood pressure, MD −9.62, 95%CI −17.07;-2.18, I^2 = 40%), without differences in diastolic blood pressure and total cholesterol. None of the anthropometric and body composition variables, six-minute walking test distance and handgrip strength values revealed significant changes at the follow-up. In adults with IDs, conventional exercise training substantially improves cardiovascular fitness and exercise capacity, while it seems of limited effectiveness on anthropometric and body composition variables.

KEYWORDS
exercise-based intervention, health, intellectual disability, rehabilitation

1 | INTRODUCTION

Intellectual disability (ID) is a multisystem and complex disorder characterized by significant impairments in intellectual functioning with the presence of delays or deficits in the development of adaptive behavior comprising conceptual, social, and motor skills.[1] The World Health Organization (WHO) defines ID a "significantly reduced ability to understand new or complex information and to learn and apply new skills (impaired intelligence). This results in a reduced ability to cope independently (impaired social functioning), and begins before adulthood, with a lasting effect on development."[2] Such definition covers multiple pathological conditions; therefore, ID is an umbrella term for various cognitive-neurological diagnoses (eg, Down syndrome, autism spectrum disorder, Fragile X syndrome, etc). Within this multifaceted clinical picture, it is now well established that adults with ID exhibit suboptimal levels of physical fitness.[3] This deficiency has been attributed to common sedentary habits as well

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as some syndrome-specific pathophysiological features of this population, such as muscle weakness, hypotonia, and increased susceptibility to cardiovascular diseases.[4] As a result, this population additionally has an increased risk for obesity, hypertension, and diabetes.[5] Relatedly, a balanced diet and regular physical activity have been proposed as additional elements to be incorporated and monitored in the prevention and management of this increased risk profile.

Several health benefits associated with maintaining adequate levels of physical activity have been documented both in general and special populations, including ID.[6-8] The WHO[9] and the American College of Sport Medicine (ACSM)[6] recommend that adults engage in "moderate-intensity cardiorespiratory exercise training for at least 30 min/day on ≥ 5 days/week for a total of ≥ 150 min/week, or vigorous intensity cardiorespiratory exercise training for at least 20 min/day on ≥ 3 days/week (≥75 min/week). Additionally, on 2-3 days/week, adults should also perform resistance exercises targeting the major muscle groups, and neuromotor exercise involving balance, agility, and coordination." However, it is widely recognized that adults with ID do not meet these minimum recommendations due to a number of issues besides each specific ID-related characteristic,[10] such as psychopharmacological usage, disordered sleep, unhealthy eating patterns, social anxiety, physical barriers and frequent lack of active social support committed to help people with ID to plan, organize, travel to and participate in physical activities and sports.[11] Such key aspects are constantly highlighted and put forward by the Special Olympics International, a worldwide organization which mission is to "help people with ID participate as productive and respected members of society at large, by offering them a fair opportunity to develop and demonstrate their skills and talents through sports training and competition, and by increasing the public's awareness of their capabilities and needs."[12]

Previous systematic reviews have highlighted the prominent role played by exercise-based interventions in improving both the cardiovascular and motor-functional profile and quality of life of adults with IDs,[13-16] with a particular focus on Down syndrome.[15,16] While these studies generally reported beneficial (ie, on cardiovascular fitness, balance and quality of life) following several types of structured exercise, many questions remain on which type, when and how often exercise should be provided to obtain significant and clinically relevant improvements that impact individual functioning. To address these relevant issues and optimize the prescription of exercise activities aimed at improving both physical fitness and psychological health of participants, we set out to conduct a systematic review and meta-analysis of randomized controlled trials (RCTs) that tested the anthropometric, cardiovascular, and motor-functional effects of conventional exercise interventions in adults with ID. More specifically, by doing so, we aimed at identifying and examining the basic descriptors of those forms of exercise (ie, type of exercise, length of intervention, duration, frequency, intensity, etc) that are employed in the research conducted so far in the management of adults with ID.

1.1 | Aims

The main purposes of this study were: (a) to systematically map the research done on conventional exercise interventions in adults with ID; (b) to evaluate the overall quality of the included studies; (c) to gather data into pooled estimates of effect via meta-analysis; (d) to detect any existing gaps in the research methods, design, and planning of studies in this area; and (e) to provide scoping lines for future research aimed at establishing a common methodological platform and enhance the comparability of studies that investigate the effects of exercise on anthropometric, cardiovascular, and motor-functional profile in adults with ID.

2 | METHODS

2.1 | Study design and protocol

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) were followed.[17] The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) on June 2019 (registration number: CRD42020138972).

2.2 | Search strategy

An extensive literature search of the evidence was conducted on the following four databases: PubMed/MEDLINE, Physiotherapy Evidence Database (PEDro), Scopus and the Cochrane Central Register of Controlled Trials (CENTRAL). All the search terms and filters were modified for their adaptation to each database and comprised common keywords and selected Medical Subject Headings related to ID and exercise. Each database was searched from the earliest record up to June, 2019. The detailed search strategy can be found in Supplementary file 1. Only RCTs published in English[18] were considered and, additionally, the full texts of all the included studies and the reference lists were manually screened for any relevant trials.

2.3 | Eligibility criteria: participants, intervention, and comparators

Inclusion criteria based on the participants, intervention, comparisons, outcome (PICO) model[19] were followed. Participants: specific inclusion criteria for adults ≥18 years old diagnosed with ID.[1] Interventions characteristics: conventional exercise-based interventions such as aerobic exercise program, strength exercise program, combined trainings (eg, aerobic *plus* strength exercise). Interventions length: mid- to long-term interventions (defined as ≥2 weeks). Comparisons: conventional exercise-based interventions compared to controls (receiving usual care but without structured supervised exercise-based interventions). Outcomes: anthropometric profile, cardiovascular fitness variables, and motor-functional outcomes were analyzed.

2.4 | Data sources, studies selections, and data extraction

Titles and abstracts of all the identified records were independently evaluated by two of the authors (LC and MGC), and duplicates as well as records clearly outside the aim of this study were removed at this stage. Eligible studies were then included on the basis of the information presented in their full text. Any disagreement was overcome by a mutual discussion to reach consensus.

A customized data extraction form was independently applied by two authors (LC and MGC), containing information such as: study design, characteristics of the samples (eg, average age, gender, sample distribution among groups, ID diagnosis), interventions (eg, type of exercise, length of interventions, frequency of sessions per week, duration of exercise sessions), timing of assessments, training adherence, number of dropouts, and main outcomes and findings of each study. All the included studies were assessed for risk of bias employing the PEDro scale[20] and, when available, ratings from the PEDro database (www.pedro.org.au) were used. RCTs with a score ≤4 were considered as carrying high risk of bias. Again, any disagreement was overcome by a mutual discussion to reach consensus. Finally, the Grading of Recommendation, Assessment, Development and Evaluation (GRADE) system was employed to score the quality level of each body of evidence.[21] According to the GRADE scoring system, the quality of the evidence of each meta-analysis was downgraded/upgraded from the "high" level (set by default for RCTs) according to pre-defined criteria.[21] Quality was downgraded by one place if there was evidence of: Indirectness; substantial heterogeneity (Inconsistency statistic, $I^2 \geq 70\%$); Imprecision; publication bias demonstrated by asymmetry of funnel plots (if ≥10 trials were included in the meta-analysis),[22] or if most trials scored ≤6 on the PEDro scale assessment. Evidence was downgraded two places if most trials scored ≤4 on the PEDro scale assessment or due to very large confidence interval (CI) and Imprecision. Consequently, the evidence was ranked into four levels: very low, low, moderate, and high.[21]

2.5 | Data analysis

Data from each primary study were pooled employing RevMan 5.3[23] and analyzed according to the Cochrane Handbook for Systematic Reviews of Interventions.[24] Meta-analyses were performed if at least three studies reported results for the same outcome measures. Raw data (means and standard deviation, SD) were extracted or calculated from medians, standard errors and 95% CI, P values, t or F values. In case of missing data, a formal request was sent to the corresponding and first author of the considered study. In the case of study that included more than one type of exercise-based intervention, post-training data on continuous aerobic exercise training were used. To allow interpretation of the effect size of these changes, we calculated the weighted mean difference (MD, 95% CI) when data were extracted from the same outcome measures, or the standardized mean difference (SMD, 95% CI) in case homogenous data were extracted from similar outcome measures. A random-effects model was used for all meta-analyses. Heterogeneity between comparable trials was evaluated employing the Chi-square test and the inconsistency I^2 test, where values from 75% to 100% indicated considerable heterogeneity. In case of heterogeneity exceeding this threshold, sensitivity analyses with a *leave-one-out* approach were performed to check whether the findings were driven by a single study. Publication bias was examined through visual inspection of funnel plot asymmetry.[24] If not otherwise specified, values are expressed as mean ± SD.

3 | RESULTS

3.1 | Study selection and qualitative synthesis

The PRISMA flow chart displaying the study selection process is reported in Figure 1.

Thirteen RCTs met all the inclusion criteria and were therefore included in the qualitative synthesis of this review[25-37] (Table 1).

The studies were published between 1995 and 2017 and involved a total of 556 individuals with IDs. These studies enrolled 315 men (56.7%), and 241 women (43.3%). The age of the participants in each study ranged about from 19 to 63 years. Overall, subjects' inclusion criteria were documented diagnoses of ID, for example, Down syndrome,

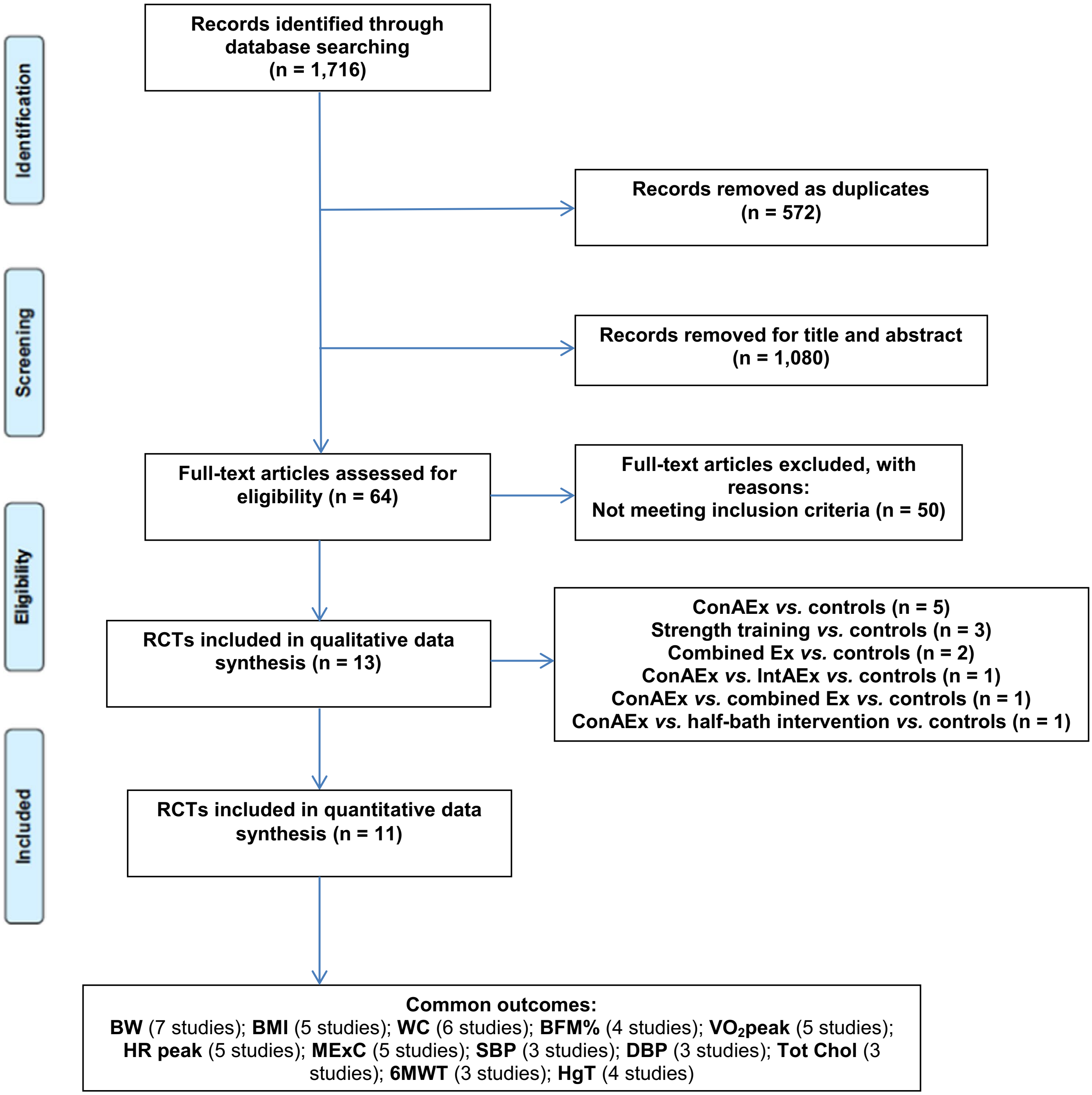

FIGURE 1 PRISMA flow chart for study selection

autism spectrum disorder, and Fragile X syndrome. Among these, eight out of thirteen studies involved individuals with Down syndrome only.[26-29,31,32,34,35] In general, intelligence quotients were determined using the Stanford Binet Scale and were reported (by means or range) in six of the included studies.[25-27,30-32] All the studies investigated the health effects of a mid- to long-term conventional exercise program (training lengths from 8 to 32 weeks, mean 14.8 ± 6.9). Weekly frequencies and training session durations tested in the studies ranged from 2 to 5 times/week (mean 3 ± 0.7), and from 30 to 70 minutes/session (mean 52.7 ± 10.9 minutes). Eight trials[26,27,30,32-35,37] assessed the effects of aerobic exercise, three studies[25,29,31] evaluated the effects of a strength training program, other three trials[28,30,36] assessed the effects of a combined exercise training (eg, aerobic exercise *plus* strength training). Among the eight trials where the effects of a continuous aerobic exercise were assessed, three studies presented other arms of intervention comprising combined exercise training,[30] interval aerobic exercise,[35] and a half-bath program.[37] In all the thirteen studies, the intervention groups were compared to a control group undergoing usual medical therapy and daily activities without any exercise

TABLE 1 Main characteristics of the included studies

Trial/ Publication year/Country	Participants	Experimental interventions	Controls	Main outcome measures	Dropout/ Adherence	PEDro score
Suomi et al 1995[25] USA	N = 22 Age *(y)* = 30.1 Gender = 22M, 0F IQ = 57.8 Diagnosis = Mild to moderate MR	N = 11 *Strength training* 60 min, 3/week, 12 wk Intensity = 4 to 20 reps *per* set for 2 to 5 sets	N = 11 Recreational activities (card playing, dart throwing, etc)	• Right/Left knee extension • Right/Left hip abduction(total work and peak torque)	DO = 0 AD ≥ 67%	6/10
Varela et al 2001[26] Portugal	N = 16 Age *(y)* = 21.4 Gender = 16M, 0F IQ = 38.8 Diagnosis = DS	N = 8 *Aerobic exercise* 45 min, 3/week, 16 wk Intensity = 55%-70% VO_2 peak	N = 8 No change to usual exercise routine	• BW • BFM% • VO_2 peak • RER • HR peak • VE peak • Maximal time and distance at CPET	DO = 0 AD = NR	5/10
Carmeli et al 2002[27] Israel	N = 26 Age *(y)* = 63 Gender = 10M, 16F IQ = 56 to 75 Diagnosis = DS	N = 16 *Aerobic exercise* 45 min, 3/week, 25 wk Intensity = treadmill walking speed below the threshold of breathlessness	N = 10 No change to usual exercise routine	• Knee extension/flection (the greatest single value for average work and peak torque) • TUG	DO = 0 AD = NR	6/10
Rimmer et al 2004[28] USA	N = 52 Age *(y)* = 39.4 Gender = 23M, 29F IQ = NR Diagnosis = DS	N = 30 *Combined exercise* 30 to 45 min aerobic *plus* 15 to 20 min strength, 12-week, 3/week Aerobic intensity = 50%-70% VO_2 peak Strength intensity = 70%-80% of the participants' 1-RM for 1 set of 10 to 20 reps	N = 22 No change to usual exercise routine	• BW • BMI • VO_2 peak • HR peak • RER • Maximal time and work at CPET • Handgrip test • Total skinfolds • Bench press • Leg press	DO = 0 AD = NR	5/10
Shields et al 2008[29] Australia	N = 20 Age *(y)* = 26.8 Gender = 13M, 7F IQ = NR Diagnosis = DS	N = 9 *Strength training* 60 min, 2/week, 10 wk Intensity = progressive resistance training as recommended by the ACSM	N = 11 No change to usual exercise routine	• Chest press • Leg press • Timed up and down stairs test • Grocery shelving task	DO = 0 AD = 92.8%	8/10

(Continues)

prescription. To sum up, each session consisted of a supervised group class involving 5-10 minutes of warm-up period, a central main phase of about 30-40 minutes (eg, continuous aerobic exercise; strength training; combined training), and a brief cool-down period (5-10 minutes). Anthropometric and body composition variables were analyzed in all the included studies except three,[25,27,29] cardiovascular and fitness parameters were assessed in all the studies except four,[25,27,29,31] functional and motor variables were estimated in seven studies,[27,29-31,34-36] muscular strength parameters by other seven studies,[25,27-30,35,36] and hematic variables by five trials.[30-32,35,36]

None of the studies declared adverse events during the trainings, but three studies reported 37 dropouts cumulatively following the interventions.[33,35,36] Adherence of participants was clearly reported in all the included studies (from 67% to 96%), except four.[26-28,37] The PEDro score of the included studies ranged from 4 to 8 (median 6). Of

TABLE 1 (Continued)

Trial/ Publication year/Country	Participants	Experimental interventions	Controls	Main outcome measures	Dropout/ Adherence	PEDro score
Calders et al 2011[30] Belgium	N = 45 Age *(y)* = 42 Gender = 18M, 27F IQ = 56 Diagnosis: Mild to moderate MR	N = 15 *Aerobic exercise* 70 min, 2/week, 20 wk Intensity = 90%-110% of the VAT N = 15 *Combined exercise* 70 min, 2/week, 20 wk aerobic (intensity as above) *plus* strength (intensity calculated from the 1-RM values)	N = 15 No change to usual exercise routine	• BW • BMI • WC • VO_2 peak • HR peak • Maximal work at CPET • 6MWT • Handgrip test • BFM (kg) • BFFM (kg) • SBP • DBP • Total cholesterol • HDL • LDL • IRM UL • IRM LL • Muscle fatigue resistance • CSST	DO = 0 AD ≥ 90%	6/10
Rosety-Rodriguez et al 2013[31] Spain	N = 40 Age *(y)* = 23.7 Gender = 40M, 0F IQ = 60-69 Diagnosis = DS	N = 24 *Strength training* 60 min, 3/week, 12 wk Intensity = 40%-65% of the participants' 8-RM assessments	N = 16 No change to usual exercise routine	• Leptin • Adiponectin • IL-6 • TNF-α • TUG • WC • BFFM%	DO = 0 AD ≥ 90%	4/10
Ordonez et al 2014[32] Spain	N = 20 Age *(y)* = 25 Gender = 0M, 20F IQ = 50-69 Diagnosis = DS	N = 11 *Aerobic exercise* 60 min, 3/week, 10 wk Intensity = 55%-65% of HR peak	N = 9 No change to usual exercise routine	• BMI • WC • BFM% • WHR • VO_2 peak • α1-antitrypsin • IL-6 • hs-CRP • Fibrinogen • TNF-α	DO = 0 AD ≥ 90%	5/10
Melville et al 2015[33] UK	N = 102 Age *(y)* = 47 Gender = 57M, 45F IQ = NR Diagnosis = Mild to severe ID	N = 54 *Aerobic exercise* 30 min, 3/week, 12 wk Intensity = individualized walking program	N = 48 No change to usual exercise routine (waiting list control group)	• BMI • WC • Steps/day • Time spent in PA (%) • Time spent in MVPA (%) • Time spent seating (%) • METs/min/week	DO = 14 AD = 71%	7/10
Shields & Taylor, 2015[34] Australia	N = 16 Age *(y)* = 21.4 Gender = 8M, 8F IQ = NR Diagnosis = DS	N = 8 *Aerobic exercise* 50 min, 3/week, 8 wk Intensity = individualized walking program	N = 8 Social activities	• WC • BW • 6MWT • PA counts • Self-selected speed • Fast walking speed	DO = 0 AD = 96%	8/10

(Continues)

TABLE 1 (Continued)

Trial/ Publication year/Country	Participants	Experimental interventions	Controls	Main outcome measures	Dropout/ Adherence	PEDro score
Boer et al 2016[35] South Africa	N = 42 Age *(y)* = 33.8 Gender = 25M, 17F IQ = NR Diagnosis: DS	N = 15 *Continuous aerobic exercise* 45 min, 3/week, 12 wk Intensity = 70-85% of VO_2 peak N = 15 *Interval aerobic exercise* 45 min, 3/week, 12 wk Intensity = 'all out'	N = 16 No change to usual exercise routine	• BW • BMI • WC • HC • BFM (%; Kg) • SBP • DBP • Total cholesterol • Glucose • VO_2 peak • VE peak • HR peak • Maximal time at CPET • 6MWT • Handgrip test • 8-foot up and go • CSST	DO = 4 AD = 96%	7/10
Van Schijndel-Speet et al 2017[36] The Netherlands	N = 131 Age *(y)* = 58 Gender = 59M, 72F IQ = NR Diagnosis: Mild to moderate ID	N = 66 *Combined exercise (endurance, strength, balance and flexibility)* 45 min, 3/week, 32 wk Intensity = NR	N = 65 No change to usual exercise routine	• BW • WC • Total cholesterol • Glucose • Steps/day • Handgrip test • BBS • Self-selected speed • Fast walking speed • DBP • SBP • Maximal time at incremental shuttle walking test	DO = 19 AD = 78%	4/10
Kim et al 2017[37] Republic of Korea	N = 24 Age *(y)* = 19 Gender = 24M, 0F IQ = NR Diagnosis: ID (not specified)	N = 8 *Aerobic exercise* 50 min, 5/week, 12 wk Intensity = 50%-70% HR max N = 8 *Half-bath* (39-40°C) 30 min/day (3 × 10 min), 5/week, 12 wk	N = 8 No change to usual exercise routine	• BW • BFM% • VO_2 peak • HR peak • Pulse wave velocity	DO = 0 AD = NR	4/10

Note: Age and IQ are reported as means or ranges.

Abbreviations: 6MWT, six-minute walking test; ACSM, American College of Sport Medicine; AD, adherence; BBS, Berg balance scale; BFFM, body fat-free mass; BFM, body fat mass; BMI, body mass index; BW, body weight; CPET, cardiopulmonary exercise incremental test; CSST, chair sit-to-stand test; DBP, diastolic blood pressure; DO, dropout; DS, Down Syndrome; F, females; HC, hip circumference; HDL, high-density lipoprotein; HR, heart rate; hs-CRP, high sensitive C-reactive protein; ID, intellectual disability; IL-6, interleukin-6; IQ, intelligence quotient; IRM LL, maximal strength lower limb; IRM UL, maximal strength upper limb; LDL, low-density lipoprotein; M, males; MET, metabolic equivalent; MR, mental retardation; MVPA, moderate-vigorous physical activity; NR, not reported; PA, physical activity; RER, respiratory exchange ratio; RM, repetition-maximum; SBP, systolic blood pressure; TNF, tumor necrosis factor; TUG, timed up-and-go test; VAT, ventilatory anaerobic threshold; VE peak, peak minute ventilation; VO_2 peak, peak oxygen uptake; WC, waist circumference; WHR, waist hip ratio; y, years.

the thirteen studies examined, eleven trials reported data on at least three shared outcome measures, that is, body weight in kilograms (BW); body mass index in Kg/m^2 (BMI); waist circumference in centimeters (WC); body fat mass in percentage or kilograms (BFM); heart rate peak in bpm (HR_{peak}) registered at cardiopulmonary exercise test (CPET); peak oxygen uptake in mL/Kg/min (VO_{2peak}) at CPET; maximal exercise capacity (MExC) in watts, minutes or distance reached at CPET or at incremental shuttle walking test; total cholesterol in mg/dl or mmol/l (Tot Chol); systolic and diastolic blood pressure (BP) at rest in mmHg; six-minute walking test in meters (6MWT); handgrip strength test in kilograms (HgT), and were therefore included in our meta-analyses (Figure 1).

3.2 | Quantitative synthesis

3.2.1 | Effects of conventional exercise on anthropometric and body composition profile

Data pooling from the studies that evaluated the anthropometric profile and body composition outcomes revealed no significant differences between groups in BW (seven studies, 260 participants, MD −1.03, 95% CI −4.56 to 2.51, I^2 = 49%)[26,28,30,34-37] (Figure 2.1), BMI (five studies, 217 participants, MD −0.38, 95% CI −1.68 to 0.92, I^2 = 28%)[28,30,32,33,35] (Figure 2.2), and WC (six studies, 284 participants, MD −0.12, 95% CI −3.71 to 3.47, I^2 = 53%)[30,32-36] (Figure 2.3). Data pooling from the four studies[26,32,35,37] that reported BFM% measures showed a considerable heterogeneity (I^2 = 80%) across the trials. Sensitivity analyses were therefore conducted, which revealed that the pooled estimate was highly influenced by the study by Kim and colleagues (16 participants)[37] (Supplementary file 2). This study was removed employing a *leave-one-out* approach, resulting in a low heterogeneity (I^2 = 33%) without any significant difference between groups (three studies, 65 subjects after sensitivity analyses; MD −0.48, 95% CI −3.79 to 2.84)[26,32,35] (Figure 2.4).

3.2.2 | Effects of conventional exercise on cardiovascular, fitness and hematic parameters

Data pooling from the five studies (143 participants)[26,28,30,35,37] that reported VO_{2peak} and HR_{peak} results registered at CPET revealed significant between-groups differences in favor of exercise for both the variables (VO_{2peak}, MD 2.89, 95% CI 0.35 to 5.42, I^2 = 69%) (Figure 3.1) (HR_{peak}, MD 4.64, 95% CI 2.15 to 7.14, I^2 = 7%) (Figure 3.2). In the meta-analysis of the five studies[26,28,30,35,36] evaluating the effects of exercise programs on MExC, pooled data revealed a significant between-groups difference in favor of exercise (213 participants, SMD 0.55, 95% CI 0.03 to 1.08, I^2 = 67%) (Figure 3.3). Data pooling from the three studies (121 participants)[30,35,36] that analyzed both systolic and diastolic BP values at rest revealed a significant decrease in favor of exercise for the first (MD −9.62, 95% CI −17.07 to −2.18, I^2 = 40%) (Figure 3.4), and any significant between-groups difference for the latter (MD −2.90, 95% CI −7.24 to 1.44, I^2 = 0%) (Figure 3.5). In the meta-analysis of the total cholesterol levels, data pooling from the same three studies did not reveal any significant difference between groups (107 participants, SMD −0.02, 95% CI −0.40 to 0.36, I^2 = 0%)[30,35,36] (Figure 3.6).

3.2.3 | Effects of conventional exercise on motor-functional and strength variables

Data pooling from the studies evaluating the effects of exercise compared to controls on 6MWT distance and handgrip strength results revealed no significant between-groups differences in both meta-analyses (6MWT, three studies, 75 participants, MD 13.51, 95% CI −47.58 to 74.6, I^2 = 60%)[30,34,35] (Figure 4.1) (HgT, four studies, 207 participants, MD 0.27 95% CI −2.26 to 2.80, I^2 = 4%)[28,30,35,36] (Figure 4.2).

4 | DISCUSSION

The purposes of this study were manifold: (a) to systematically map the research done on conventional exercise interventions in adults with ID; (b) evaluate the overall quality of the included studies; (c) gather data into pooled estimates of effect via meta-analysis; (d) detect any existing gaps in the research methods, design, and planning of studies in this area; and (e) provide scoping lines for future research to establish a common methodological platform and enhance the comparability of studies that investigate the effects of exercise on anthropometric, cardiovascular, and motor-functional profile in adults with ID.

Firstly, in relation to the different kinds of IDs here analyzed, individuals with Down syndrome showed to be the population most frequently investigated (eight out of thirteen studies included)[26-29,31,32,34,35] and with outcomes of intervention supported by the highest methodological quality.[29,34,35] Secondly, although our inclusion criteria comprised different forms of conventional training (eg, aerobic exercise, strength training and combined training programs), a predominance of continuous aerobic over the other types of training was detected. In the last years, however, researchers' attention is shifting toward new forms of conventional exercise, for example, the combination of endurance, strength, balance and flexibility training,[36] and interval aerobic training.[35]

This systematic review and meta-analysis highlighted the benefits of conventional exercise trainings pertaining especially to cardiovascular fitness variables, as demonstrated by the results of the four meta-analyses carried out for VO_{2peak}, SBP, MExC, and HR_{peak} (although this last variable is partly determined by age and heredity). Data pooling on VO_{2peak} values of adults with ID revealed an improvement by 6.4% after 14 weeks, on average, (12-20 weeks) of aerobic and

Figure 2.1: Body weight

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	69.2	14.6	13	74.1	8.4	16	10.8%	-4.90 [-13.84, 4.04]
Kim 2017	61.3	1.6	8	66.1	0.5	8	33.4%	-4.80 [-5.96, -3.64]
Van Schijndel-Speet 2017	72.3	14	54	72.2	14.3	47	18.7%	0.10 [-5.44, 5.64]
Rimmer 2004	79.5	19.9	30	78.5	17.9	22	8.8%	1.00 [-9.33, 11.33]
Varela 2001	62	9.6	8	59.9	10.6	8	9.3%	2.10 [-7.81, 12.01]
Shields & Taylor 2015	70.3	10.5	8	67.4	10.8	8	8.6%	2.90 [-7.54, 13.34]
Calders 2011	70.4	14.7	15	65.1	10.6	15	10.4%	5.30 [-3.87, 14.47]
Total (95% CI)			**136**			**124**	**100.0%**	**-1.03 [-4.56, 2.51]**

Heterogeneity: Tau² = 9.38; Chi² = 11.79, df = 6 (P = 0.07); I² = 49%
Test for overall effect: Z = 0.57 (P = 0.57)

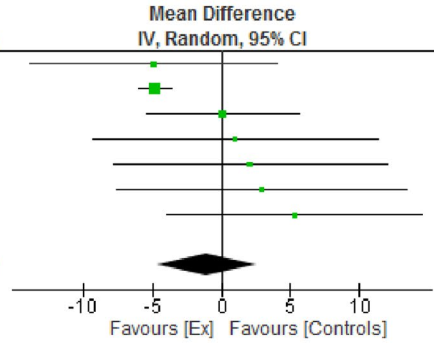

Figure 2.2: Body mass index

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	30.2	6.3	13	30.9	4.2	16	9.1%	-0.70 [-4.70, 3.30]
Calders 2011	25.3	4.7	15	22.9	3.3	15	15.3%	2.40 [-0.51, 5.31]
Melville 2015	32.1	7.7	43	32.9	7.5	43	13.1%	-0.80 [-4.01, 2.41]
Ordonez 2014	29.8	0.7	11	30.9	0.8	9	55.0%	-1.10 [-1.77, -0.43]
Rimmer 2004	34.7	9.2	30	34.4	7.1	22	7.6%	0.30 [-4.13, 4.73]
Total (95% CI)			**112**			**105**	**100.0%**	**-0.38 [-1.68, 0.92]**

Heterogeneity: Tau² = 0.69; Chi² = 5.59, df = 4 (P = 0.23); I² = 28%
Test for overall effect: Z = 0.58 (P = 0.56)

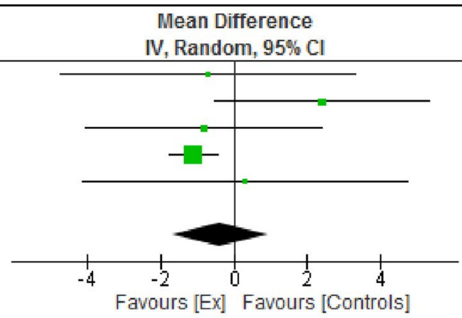

Figure 2.3: Waist circumference

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	93.7	11.9	13	98	10.6	16	12.2%	-4.30 [-12.60, 4.00]
Calders 2011	91	12.7	15	83	8.2	15	13.5%	8.00 [0.35, 15.65]
Melville 2015	104.9	16.9	45	107.8	17.8	42	14.3%	-2.90 [-10.20, 4.40]
Ordonez 2014	91.5	3.1	11	93.7	3.2	9	28.8%	-2.20 [-4.98, 0.58]
Shields & Taylor 2015	90.1	12.1	8	94.1	7.4	8	9.7%	-4.00 [-13.83, 5.83]
Van Schijndel-Speet 2017	94.6	13.7	55	91.1	10.8	47	21.6%	3.50 [-1.26, 8.26]
Total (95% CI)			**147**			**137**	**100.0%**	**-0.12 [-3.71, 3.47]**

Heterogeneity: Tau² = 9.66; Chi² = 10.58, df = 5 (P = 0.06); I² = 53%
Test for overall effect: Z = 0.07 (P = 0.95)

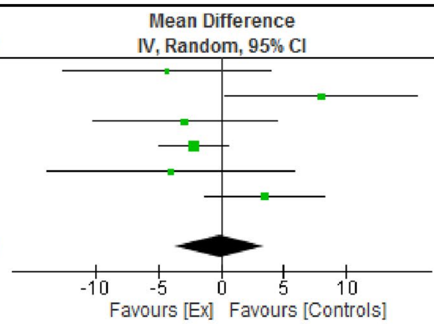

Figure 2.4: Body fat mass (%)

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	29.6	10.2	13	27.1	11.8	16	14.6%	2.50 [-5.51, 10.51]
Kim 2017	27.5	1.1	8	33.1	1	8		Not estimable
Ordonez 2014	35	3.8	11	37.8	3.9	9	48.5%	-2.80 [-6.20, 0.60]
Varela 2001	22.8	4.7	8	21.4	4.1	8	36.9%	1.40 [-2.92, 5.72]
Total (95% CI)			**32**			**33**	**100.0%**	**-0.48 [-3.79, 2.84]**

Heterogeneity: Tau² = 2.91; Chi² = 2.98, df = 2 (P = 0.23); I² = 33%
Test for overall effect: Z = 0.28 (P = 0.78)

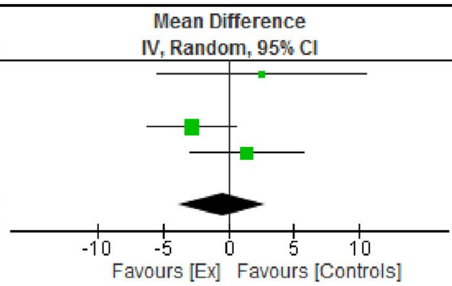

FIGURE 2 2.1 to 2.4—Forest plots showing the effects of conventional exercise on anthropometric and body composition profile

combined training sustained for 50 minutes (45-70 minutes/session), three times/week (2-5 times/week). Therefore, to elicit cardiovascular adaptations in participants with ID, a maintenance exercise program should be of sufficient

TABLE 2 Grades of Recommendation, Assessment, Development and Evaluation (GRADE) quality of evidence

Outcome	Design	Risk of bias (PEDro scale)	Indirectness	Inconsistency	Imprecision	Publication bias	Effect size	GRADE quality
Body weight $I^2 = 49\%$, MD −1.03, 95%CI −4.56 to 2.51	RCT x 7	−1[a]	0	0	−2[b]	0	0	Very low
Body mass index $I^2 = 28\%$, MD −0.38, 95% CI −1.68 to 0.92	RCT x 5	0	0	0	−1[c]	0	0	Moderate
Waist circumference $I^2 = 53\%$, MD −0.12, 95% CI −3.71 to 3.47	RCT x 6	0	0	0	−1[c]	0	0	Moderate
Body fat mass (%) $I^2 = 33\%$, MD −0.48, 95% CI −3.79 to 2.84	RCT x 3	−1[a]	0	0	−2[b]	0	0	Very low
Peak oxygen uptake $I^2 = 69\%$, MD 2.89, 95% CI 0.35 to 5.42	RCT x 5	−1[a]	0	0	−1[d]	0	0	Low
Heart rate peak $I^2 = 7\%$, MD 4.64, 95% CI 2.15 to 7.14	RCT x 5	−1[a]	0	0	−1[d]	0	0	Low
Maximal exercise capacity $I^2 = 67\%$, SMD 0.55, 95% CI 0.03 to 1.08	RCT x 5	−1[a]	0	0	−1[d]	0	0	Low
Systolic blood pressure $I^2 = 40\%$, MD −9.62, 95% CI −17.07 to −2.18	RCT x 3	−1[a]	0	0	0	0	0	Moderate
Diastolic blood pressure $I^2 = 0\%$, MD −2.90, 95% CI: −7.24 to 1.44	RCT x 3	−1[a]	0	0	−1[c]	0	0	Low
Total cholesterol $I^2 = 0\%$, SMD −0.02, 95% CI −0.40 to 0.36	RCT x 3	−1[a]	0	0	−1[c]	0	0	Low
Six-minute walking test $I^2 = 60\%$, MD 13.51, 95% CI −47.58 to 74.6	RCT x 3	0	0	0	−2[b]	0	0	Low
Handgrip test $I^2 = 4\%$, MD 0.27 95% CI −2.26 to 2.80	RCT x 4	−1[a]	0	0	−1[c]	0	0	Low

Abbreviations: CI, Confidence Interval; I^2, Inconsistency Statistic; MD, Weighted Mean Difference; PEDro, Physiotherapy Evidence Database scale; RCT, Randomized Controlled Trial; SMD, Standardized Mean Difference.

[a]Downgraded one place as most of the trials scored ≤ 6 on the PEDro scale.

[b]Downgraded two places due to very large confidence interval and imprecision.

[c]Downgraded one place due to imprecision.

[d]Downgraded one place due to very large confidence interval.

Figure 3.1: Peak oxygen uptake

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	23.1	4.5	13	22.7	5	16	19.8%	0.40 [-3.06, 3.86]
Calders 2011	26.9	6.9	15	26.3	9.7	15	11.3%	0.60 [-5.42, 6.62]
Kim 2017	33.1	2.4	8	27.1	1	8	27.1%	6.00 [4.20, 7.80]
Rimmer 2004	17.8	4.6	30	13.6	4.5	22	24.1%	4.20 [1.70, 6.70]
Varela 2001	31.7	4	8	31.1	4.1	8	17.7%	0.60 [-3.37, 4.57]
Total (95% CI)			**74**			**69**	**100.0%**	**2.89 [0.35, 5.42]**

Heterogeneity: Tau² = 5.33; Chi² = 12.95, df = 4 (P = 0.01); I² = 69%
Test for overall effect: Z = 2.23 (P = 0.03)

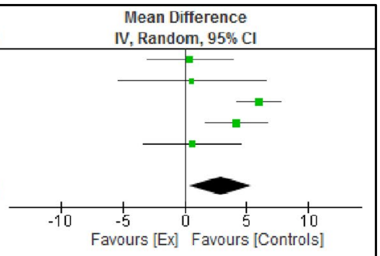

Figure 3.2: Heart rate peak

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	162	11.2	13	159.4	10.4	16	9.3%	2.60 [-5.34, 10.54]
Calders 2011	158	18.3	15	158	16.6	15	3.9%	0.00 [-12.50, 12.50]
Kim 2017	171.2	2.8	8	166.8	1	8	74.9%	4.40 [2.34, 6.46]
Rimmer 2004	144	18	30	129	21	22	5.1%	15.00 [4.11, 25.89]
Varela 2001	171	10	8	166	9	8	6.8%	5.00 [-4.32, 14.32]
Total (95% CI)			**74**			**69**	**100.0%**	**4.64 [2.15, 7.14]**

Heterogeneity: Tau² = 1.06; Chi² = 4.31, df = 4 (P = 0.37); I² = 7%
Test for overall effect: Z = 3.65 (P = 0.0003)

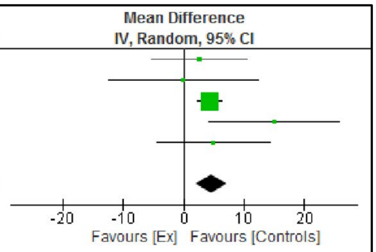

Figure 3.3: Maximal exercise capacity

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
Boer 2016	13.5	1.3	13	11.6	2.2	16	18.5%	1.00 [0.21, 1.78]
Calders 2011	132	42.9	15	133	43.7	15	19.8%	-0.02 [-0.74, 0.69]
Rimmer 2004	89	20	30	70	23	22	22.7%	0.88 [0.30, 1.46]
Van Schijndel-Speet 2017	5.4	2.2	49	5.4	2.1	37	25.9%	0.00 [-0.43, 0.43]
Varela 2001	16	1.3	8	12.9	2.8	8	13.0%	1.34 [0.23, 2.46]
Total (95% CI)			**115**			**98**	**100.0%**	**0.55 [0.03, 1.08]**

Heterogeneity: Tau² = 0.23; Chi² = 12.30, df = 4 (P = 0.02); I² = 67%
Test for overall effect: Z = 2.06 (P = 0.04)

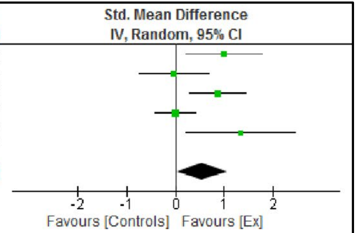

Figure 3.4: Systolic blood pressure

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	103.3	16.9	13	117.3	16.1	16	26.0%	-14.00 [-26.11, -1.89]
Calders 2011	120	14	15	134	14.7	15	32.3%	-14.00 [-24.27, -3.73]
Van Schijndel-Speet 2017	120.1	14.4	33	123.6	17.9	29	41.7%	-3.50 [-11.66, 4.66]
Total (95% CI)			**61**			**60**	**100.0%**	**-9.62 [-17.07, -2.18]**

Heterogeneity: Tau² = 17.26; Chi² = 3.31, df = 2 (P = 0.19); I² = 40%
Test for overall effect: Z = 2.53 (P = 0.01)

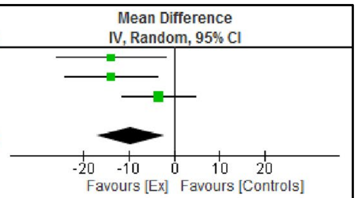

Figure 3.5: Diastolic blood pressure

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Mean Difference IV, Random, 95% CI
Boer 2016	61.3	10.6	13	66.7	11.7	16	28.5%	-5.40 [-13.53, 2.73]
Calders 2011	80	20	15	73	24.8	15	7.2%	7.00 [-9.12, 23.12]
Van Schijndel-Speet 2017	75.7	10.2	33	78.6	11.4	29	64.2%	-2.90 [-8.32, 2.52]
Total (95% CI)			**61**			**60**	**100.0%**	**-2.90 [-7.24, 1.44]**

Heterogeneity: Tau² = 0.00; Chi² = 1.81, df = 2 (P = 0.40); I² = 0%
Test for overall effect: Z = 1.31 (P = 0.19)

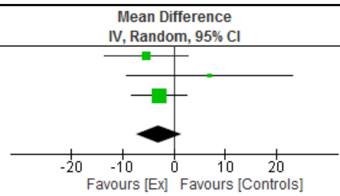

Figure 3.6: Total cholesterol

Study or Subgroup	Exercise Mean	Exercise SD	Exercise Total	Controls Mean	Controls SD	Controls Total	Weight	Std. Mean Difference IV, Random, 95% CI
Boer 2016	216.2	48.4	13	222.9	30.6	16	26.9%	-0.16 [-0.90, 0.57]
Calders 2011	193	34.9	15	199	27	15	28.1%	-0.19 [-0.90, 0.53]
Van Schijndel-Speet 2017	5.6	1.2	23	5.4	1.1	25	45.0%	0.17 [-0.40, 0.74]
Total (95% CI)			**51**			**56**	**100.0%**	**-0.02 [-0.40, 0.36]**

Heterogeneity: Tau² = 0.00; Chi² = 0.79, df = 2 (P = 0.67); I² = 0%
Test for overall effect: Z = 0.10 (P = 0.92)

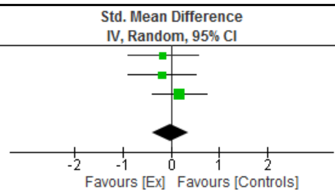

FIGURE 3 3.1 to 3.6 - Forest plots showing the effects of conventional exercise on cardiovascular, fitness and hematic parameters

Figure 4.1: Six-minute walking test

	Exercise			Controls				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Boer 2016	563.2	74.9	13	495.9	85.2	16	37.1%	67.30 [8.99, 125.61]
Calders 2011	545	83.1	15	545	71.7	15	38.4%	0.00 [-55.54, 55.54]
Shields & Taylor 2015	432.3	85.9	8	479.2	102.5	8	24.5%	-46.90 [-139.57, 45.77]
Total (95% CI)			**36**			**39**	**100.0%**	**13.51 [-47.58, 74.60]**

Heterogeneity: Tau² = 1729.87; Chi² = 5.03, df = 2 (P = 0.08); I² = 60%
Test for overall effect: Z = 0.43 (P = 0.66)

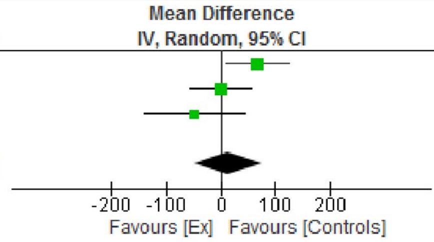

Figure 4.2: Handgrip test

	Exercise			Controls				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Boer 2016	26.1	7.9	13	25.5	9.1	16	16.2%	0.60 [-5.59, 6.79]
Calders 2011	27	23.2	15	23	23.2	15	2.3%	4.00 [-12.60, 20.60]
Rimmer 2004	22	8.1	30	19	7.7	22	32.2%	3.00 [-1.33, 7.33]
Van Schijndel-Speet 2017	21.8	9	53	23.6	8.2	43	49.2%	-1.80 [-5.25, 1.65]
Total (95% CI)			**111**			**96**	**100.0%**	**0.27 [-2.26, 2.80]**

Heterogeneity: Tau² = 0.29; Chi² = 3.12, df = 3 (P = 0.37); I² = 4%
Test for overall effect: Z = 0.21 (P = 0.83)

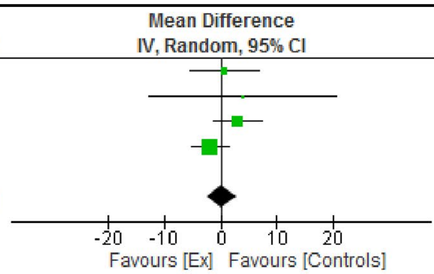

FIGURE 4 4.1 to 4.2—Forest plots showing the effects of conventional exercise on motor-functional and strength variables

length (at least 12 weeks), intensity (≥50 VO_{2peak}), duration (≥45 minutes), and frequency (≥2 times/week). Although the diastolic BP levels showed a not significant decrease, our findings registered a significant improvement in systolic BP levels with a moderate quality of the evidence after a mean of 21 weeks of training, suggesting that this cardiovascular parameter can be positively changed through exercise, but may require a longer conditioning to determine a noticeable change. These results are of particular interest considering that, compared to healthy populations, individuals with ID have a higher prevalence of hypertension (from 25% to 41% compared with 29% of the general population).[38] In summary, our findings indicate that regular exercise can improve cardiovascular fitness and exercise capacity, which can prevent cardiovascular disease promoting cardiovascular health. However, despite the relatively consistent and positive results on cardiovascular fitness (ie, VO_{2peak} and SBP) and exercise capacity (ie, MExC and HR_{peak}), data pooling of the available evidence on anthropometric and body composition variables evidenced that the conventional exercise programs here reviewed seem of limited effectiveness to elicit a significant impact on BW, BMI, WC, and BFM%. Our findings are in agreement with previous research conducted in healthy populations[39] and in individuals with Down syndrome,[15] which found limited effectiveness of aerobic exercise alone to significantly reduce BW and improve body composition variables. On the contrary, when exercise and nutrition interventions are combined together into a more comprehensive health behavior education program, stronger evidence exists for reductions in BW and in different body composition variables.[15,40,41] We offer that the unimodal nature of the studies here reviewed (ie, focusing on one single intervention) may have contributed to the findings outlined here. Moreover, the aggregation of anthropometric and body composition data from quite different subpopulations (eg, individuals with mental retardation, persons with Down syndrome), as well as the employment of different exercise regimens across the studies may have led to conflict attributions of effects, making difficult to evaluate the role played by the exercise on these morphologic variables.

With regard to functional and motor variables, based on the relatively small sample of adults here investigated (five RCTs entered the meta-analyses), no significant differences emerged for 6MWT distance and handgrip strength values. Undoubtedly, due to the limited statistical power for the meta-analyses conducted for these outcome measures, such findings need confirmation in the near future through properly planned investigations incorporating functional, strength, and balance trainings supported by their specific assessments. Comprehensive exercise programs, in fact, have been reported to play a key role in enhancing mobility and contribute to prevent the onset of functional decline also in adults with IDs.[36]

None of the studies declared adverse events during the programs indicating that conventional exercise trainings are safe, feasible, and high-adherence approaches for the adults with different IDs. Moreover, supervision by exercise professionals and caregivers was well documented in all the included studies and might have played a role in the observed effects, especially for those outcome measures that are more closely related to the physical activity habits of the participants.[41]

4.1 | Study limitations and quality of the evidence

Limitations of this quantitative analysis are mainly related to the small number of studies included that prevents us to plan useful subgroup-analyses both for each specific form of ID described by the studies and the different types of exercise trainings performed. Indeed, only a few studies have investigated the effects of strength or combined trainings. Moreover, the quality level of each scored body of evidence employing the GRADE assessment was ranked as very low (BW, BFM%), low (HR_{peak}, $VO2_{peak}$, MExC, DBP, Tot Chol, 6MWT, HgT), and moderate (BMI, WC, SBP) (Table 2), warranting cautious interpretation of findings, particularly for those trials with a higher risk of bias (PEDro score ≤4).[31,36,37] These studies lacked important methodological issues such as "blinding of assessors" and "intention-to-treat analyses," which may have biased the present estimates. With reference to the gaps in the research design and methods across the trials, although very informative for several anthropometric and cardiovascular parameters, the findings of the studies here reviewed are lacking to draw firm conclusions about fundamental key outcomes predictive of individual functional capacity. Indeed, our study selection showed that a small number of trials planned functional and motor assessments for example, instrumented appraisals of muscular strength, assessment of dynamic and static balance, measurement of muscle flexibility; thus preventing us from analyzing such relevant variables also quantitatively. In addition, even when similar variables were considered, the study protocols differed for the modalities of assessment which prevented data pooling across larger samples.

4.2 | Perspectives

Although conventional and well-established forms of exercise-based interventions for adults with ID may be helpful to improve cardiovascular fitness and exercise capacity in the short term, their effectiveness in the long term could be enhanced by adding stable community-based programs. In this view, programs focused on promoting social inclusion through popular sport activities (eg, soccer, tennis, volleyball, gymnastics, etc)[42,43] or alternative and unconventional trainings (eg, dancing, Nordic walking, and water-based exercise)[44-47] may represent a good opportunity to augment the long-term adherence to exercise-based interventions.

5 | CONCLUSIONS

Based on the available evidence, in adults with ID conventional exercise training of sufficient length (≥12 weeks), intensity (≥50 VO_{2peak}), duration (≥45 minutes), and frequency (≥ 2 times/week) substantially improve cardiovascular fitness (ie, VO_{2peak}; SBP) and exercise capacity (ie, MExC; HR_{peak}), while it seems of limited effectiveness for anthropometric and body composition variables. Although very informative for several anthropometric and cardiovascular parameters, our findings prevent to draw firm conclusions about relevant key outcomes predictive of individual functional capacity, such as functional and motor outcomes. Further primary and secondary studies are needed, with interventions tailored and analyzed by population and exercise form.

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CONFLICT OF INTEREST

The authors report no relationships that could be construed as a conflict of interest.

ORCID

Lucia Cugusi https://orcid.org/0000-0001-7650-0640
Mauro Giovanni Carta https://orcid.org/0000-0003-0706-9687

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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