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Systematic Review

Lifestyle modification interventions for adults with intellectual disabilities: systematic review and meta-analysis at intervention and component levels

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Abstract

Background Adults with intellectual disabilities (IDs) are susceptible to multiple health risk behaviours such as alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet. Lifestyle modification interventions can prevent or reduce negative health consequences caused by these behaviours. We aim to determine the effectiveness of lifestyle modification interventions and their components in targeting health risk behaviours in adults with IDs.

Methods A systematic review and meta-analysis were conducted. Electronic databases, clinical trial registries, grey literature and citations of systematic reviews and included studies were searched in January 2021 (updated February 2022). Randomised controlled trials and non-randomised controlled trials targeting alcohol consumption, smoking, low physical activity, sedentary behaviours and poor diet in adults (aged ≥ 18 years) with ID were included. Meta-analysis was conducted at the intervention level (pairwise and network meta-analysis) and the component-level (component network meta-analysis). Studies were coded using Michie's 19-item theory coding scheme and 94-item behaviour change taxonomies. Risk of bias was assessed using the Cochrane Risk of Bias (ROB) Version 2 and Risk of Bias in Non-randomised Studies of Interventions (ROBINS-I). The study involved a patient and public involvement (PPI) group, including people with lived experience, who contributed extensively by shaping the methodology, providing valuable insights in interpreting results and organising of dissemination events.

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Results Our literature search identified 12 180 articles, of which 80 studies with 4805 participants were included in the review. The complexity of lifestyle modification intervention was dismantled by identifying six core components that influenced outcomes. Interventions targeting single or multiple health risk behaviours could have a single or combination of multiple core-components. Interventions (2 RCTS; 4 non-RCTs; 228 participants) targeting alcohol consumption and smoking behaviour were effective but based on limited evidence. Similarly, interventions targeting low physical activity only (16 RCTs; 17 non-RCTs; 1413 participants) or multiple behaviours (low physical activity only, sedentary behaviours and poor diet) (17 RCTs; 24 non-RCTs; 3164 participants) yielded mixed effectiveness in outcomes. Most interventions targeting low physical activity only or multiple behaviours generated positive effects on various outcomes while some interventions led to no change or worsened outcomes, which could be attributed to the presence of a single core-component or a combination of similar core components in interventions. The intervention-level meta-analysis for weight management outcomes showed that none of the interventions were associated with a statistically significant change in outcomes when compared with treatment-as-usual and each other. Interventions with core-components combination of energy deficit diet, aerobic exercise and behaviour change techniques showed the highest weight loss [mean difference (MD) = −3.61, 95% credible interval (CrI) −9.68 to 1.95] and those with core-components combination dietary advice and aerobic exercise showed a weight gain (MD 0.94, 95% CrI −3.93 to 4.91). Similar findings were found with the component network meta-analysis for which additional components were identified. Most studies had a high and moderate risk of bias. Various theories and behaviour change techniques were used in intervention development and adaptation.
Conclusion Our systematic review is the first to comprehensively explore lifestyle modification interventions targeting a range of single and multiple health risk behaviours in adults with ID, co-produced with people with lived experience. It has practical implications for future research as it highlights the importance of mixed-methods research in understanding lifestyle modification interventions and the need for population-specific improvements in the field (e.g., tailored interventions, development of evaluation instruments or tools, use of rigorous research methodologies and comprehensive reporting frameworks). Wide dissemination of related knowledge and the involvement of PPI groups, including people with lived experience, will help future researchers design interventions that consider the unique needs, desires and abilities of people with ID.

Keywords intellectual disability, lifestyle interventions, systematic review, network meta-analysis, component network meta-analysis, patient and public involvement

Introduction

Adults with intellectual disabilities (ID) are susceptible to health risk behaviours that may adversely impact their health and well-being. Examples of such behaviours include alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet (Robertson *et al.* 2014; Banks 2016). Evidence shows that the prevalence of health risk behaviours among adults with ID differs from the general population. The prevalence rates also vary across the different levels of ID severity, typically classified as mild, moderate, severe and profound based on IQ scores or level of required support (NICE 2023). Studies on the prevalence of alcohol consumption and smoking in adults with ID compared with the general population without ID have produced mixed findings. Some studies indicate that adults with mild ID may be more vulnerable to these behaviours than adults with severe ID (Emerson & Turnbull 2005; Huxley *et al.* 2019). Moreover, adults with ID have low levels of physical activity (Dairo *et al.* 2016; Westrop *et al.* 2019), lead sedentary lifestyles (Hsieh *et al.* 2014; Dairo *et al.* 2016) and have poor diets with low fruit and vegetable intake (Dairo *et al.* 2016). Only about 9% of adults with ID meet the recommended physical activity levels for maintaining a healthy lifestyle (Temple *et al.* 2017).

In recent times, adults with ID have transitioned from residing in centralised institutional settings, characterised by controlled and structured environments, to embracing community living that

promotes social integration, independence and active participation in community life. However, this shift has not been without consequences. It has exposed them to various social and environmental pressures, potentially leading to the adoption of health risk behaviours (Melville *et al.* 2008). These behaviours frequently occur together and can have detrimental effects on an individual's overall health (Schuit *et al.* 2002; Hale *et al.* 2014) leading to chronic diseases such as obesity, type-2 diabetes, cardiovascular diseases and certain cancers (Melville *et al.* 2008; Myint *et al.* 2009; Hsieh *et al.* 2014; Hatton & Emerson 2015; Banks 2016). Moreover, these behaviours can aggravate secondary conditions, contribute to mental health issues and impact personal safety and interpersonal relationships (Taggart *et al.* 2008). Consequently, adults with ID experience higher rates of comorbidity and premature mortality compared with the general population without ID (Krahn & Fox 2014; Hatton & Emerson 2015).

Lifestyle modification interventions or programmes designed to address health risk behaviours have the potential to prevent or reduce their resulting negative health consequences. Several literature reviews have synthesised the effectiveness of existing lifestyle modification interventions for adults with ID (Rotatori *et al.* 1981; Hamilton *et al.* 2007; Bartlo & Klein 2011; Heller *et al.* 2011; Jinks *et al.* 2011; Kerr *et al.* 2013; Spanos *et al.* 2013; Spanos *et al.* 2014; Temple *et al.* 2017; Doherty *et al.* 2018; Harris *et al.* 2018; Willems *et al.* 2018; van Duijvenbode & VanDerNagel 2019; Hassan *et al.* 2019; Bondár *et al.* 2020), but they tend to be imbalanced in their focus on health risk behaviours. They often focus on interventions targeting either low physical activity (Bartlo & Klein 2011; Temple *et al.* 2017; Hassan *et al.* 2019; Bondár *et al.* 2020) or a combination of low physical activity and poor diet (Rotatori *et al.* 1981; Hamilton *et al.* 2007; Heller *et al.* 2011; Jinks *et al.* 2011; Spanos *et al.* 2013; Spanos *et al.* 2014; Doherty *et al.* 2018; Harris *et al.* 2018; Willems *et al.* 2018), where the effectiveness was typically assessed using multiple broad outcomes related to physical activity (Bartlo & Klein 2011; Temple *et al.* 2017; Hassan *et al.* 2019) or weight management (Rotatori *et al.* 1981; Hamilton *et al.* 2007; Spanos *et al.* 2013; Spanos *et al.* 2014; Harris *et al.* 2018). Notably, there are fewer reviews on lifestyle modification interventions targeting alcohol consumption and smoking behaviour, which can be attributed to the limited studies in this area (Kerr *et al.* 2013; van Duijvenbode & VanDerNagel 2019).

Moreover, existing reviews lack an assessment of intervention design, including the extent to which behaviour change theories or techniques have been applied to develop interventions. Importantly, lifestyle modification interventions are complex interventions with inter-connected component structures (Skivington *et al.* 2021), regardless of whether they target single or multiple health risk behaviours. The process of behaviour modification itself is also multi-faceted. Although these reviews acknowledge the complexity of lifestyle modification interventions, they do not endeavour to deconstruct the interventions' structure to determine how they influence health risk behaviours. Thus far, only one review on weight management interventions has attempted to identify intervention components (Spanos *et al.* 2013; Spanos *et al.* 2014). Determining the individual contributions of each component to the overall effect of the lifestyle modification intervention can be challenging due to intervention characteristics, setting or context, implementation processes and participant characteristics (Skivington *et al.* 2021). Nevertheless, its complexity demands methodological consideration, especially when conducting quantitative synthesis. Quantitative synthesis of evidence on the effectiveness of lifestyle modification intervention remains limited; only a review (Harris et al. 2018) has quantitatively assessed weight management interventions but it adopts a lumped approach, treating lifestyle modification interventions as homogenous entities to facilitate comparison with usual care in pairwise meta-analysis.

Therefore, a comprehensive synthesis of the literature on the effectiveness of lifestyle modification interventions is needed for all health risk behaviours to enrich our understanding of how to effectively improve the health and well-being of adults with ID. We aim to determine the effectiveness of lifestyle modification interventions and their components in targeting health risk behaviours in adults with IDs.

Methods

The systematic review and meta-analysis adheres to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA), its extension on incorporating network meta-analysis (NMA) and reporting literature searches and the International Society for Pharmacoeconomics Outcomes Research (ISPOR) Taskforce (Hoaglin *et al.* 2011; Jansen *et al.* 2011; Hutton *et al.* 2016; Page *et al.* 2021; Rethlefsen *et al.* 2021).

Eligibility criteria

Eligible studies included the following:

- Adults (18 years and above) with ID.
- Lifestyle modification interventions targeting one or multiple health risk behaviours [alcohol consumption, smoking (cigarettes or tobacco), low physical activity, sedentary behaviour and poor diet] to change any related primary or secondary outcomes.
- Study designs consisting of parallel-group, individual or cluster RCTs and non-RCTs such as pre–post controlled or uncontrolled studies and case–control studies.

Our review follows the American Association of Intellectual and Developmental Disabilities (AIDD) definition of ID, which involves a limitation in intellectual functioning (intelligence quotient <70) and adaptive behaviour onset before age 18 years (Schalock *et al.* 2010). The AIDD updated the criterion to intelligent quotient <75 and adaptive onset before age 22 years after the publication of our study protocol and commencement of the search results screening process (AIDD 2021). This update does not impact our selection of relevant studies because our inclusion criteria would have captured studies adhering to the previous definition, which inherently includes participants meeting the updated definition. Additionally, our updated search in February 2022 would capture studies adhering to the new definition.

We included studies on people with Down syndrome, given the diversity in their severity level of ID and evidence suggesting that generic behaviour change programmes work for people with Down syndrome. There were no restrictions related to intervention settings. We acknowledge that the definitions of usual care (routine care participants are expected to receive as part of standard practice) may differ across studies.

Information sources, search strategy and selection process

Five electronic databases were searched from inception until 14 January 2021: Applied Social Sciences Index and Abstracts (ASSIA), Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE, MEDLINE and PsycINFO. Registered and ongoing clinical trials registries were also searched: Cochrane Central Register of Controlled Trials (CENTRAL), US National Library of Medicine ClinicalTrials.gov, International Standard Randomised Controlled Trials Number (ISRCTN) and Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre). Additionally, we identified grey literature via Google Scholar and hand-searched the citations of existing systematic reviews and final included studies. The full search strategy, broadly developed to capture studies for a simultaneous realist synthesis, was adapted for each database (Supporting information, section A). Clinical trial registries were filtered using search filters to include studies with adult participants. The main search was updated in February 2022. We sought translations of studies in languages other than English and pre-print versions of newer studies when necessary.

Selection process

Two researchers independently performed the literature search and used reference management software Covidence and EndNote X9 to collate search results, remove duplicates and screen studies using explicit eligibility criteria. A third reviewer was consulted to resolve conflicts.

Data collection process and items

A comprehensive data extraction form was designed in Microsoft Excel using the Cochrane Handbook (Higgins *et al.* 2019) and existing reviews (Kerr *et al.* 2013; Harris *et al.* 2018; Willems *et al.* 2018). This form was pre-piloted before use. Three independent reviewers performed the data extraction.

The extracted information included details on study design, population, intervention characteristics and outcomes. Primary outcomes were directly related to lifestyle modification while secondary outcomes were additional outcomes explored, such as quality of life. Studies on the same population or follow-up publications were combined under a single identification number. Extracted data were double-checked. The extent of theory use (Michie & Prestwich 2010) and behaviour change taxonomy (Michie *et al*. 2013) coding were undertaken only when the studies provided detailed descriptions that matched the coding item definition. Study authors were contacted via email if further information was needed.

Study risk of bias assessment

Three authors independently evaluated the risk of bias at the study level using the Cochrane Risk of Bias (ROB) Version 2 (Higgins *et al*. 2016) and Risk of Bias in Non-randomised Studies-of Interventions (ROBINS-I) (Jüni *et al*. 2016). RCTs were assessed as low, high, or with some concerns in the bias domains while non-RCTs were assessed as low, moderate, serious, critical or with no information. The overall assessment was made following the tools' guidance and reviewed by all three authors. All studies meeting the eligibility criteria were included in the review regardless of their risk of bias.

Synthesis methods

All included studies were synthesised narratively according to the health risk behaviours targeted by the interventions. We identified intervention core components based on the description provided by the study authors. Core components are inter-connected structures of a complex intervention that influences health risk behaviours. Dismantling core components allowed us to evaluate the intervention and compare it with other interventions.

Meta-analysis was conducted at the intervention and component levels. Studies without key statistics or adequate data for calculations outlined in the Cochrane Handbook (Higgins *et al*. 2019) were excluded. We contacted the study authors via email for further information on the reported outcome, if needed. Intervention-level meta-analysis was conducted in two ways using R statistical computing software (Version 4.1) (Hoaglin *et al*. 2011; Jansen *et al*. 2011). This included: (1) a frequentist pairwise meta-analysis which compared the effectiveness of all lifestyle modification interventions to usual care or treatment as usual (TAU) using a random effects model. It was performed using the intervention 'lumping' approach, which allowed us to compare our results with existing systematic reviews and meta-analyses. The results were reported as MDs with 95% CIs; (2) a Bayesian NMA, which compared the effectiveness of various lifestyle interventions with each other and TAU. A random effects model was employed, and the Bayesian Markov Chain Monte Carlo method was fitted using the Just Another Gibbs Samplers (JAGS) software within the BUGSnet and Gemtc packages. The results were reported as MDs with 95% credible intervals (CrIs). At the component level, we conducted a component NMA (CNMA) (Welton *et al*. 2009; Freeman *et al*. 2018) in WinBugs (Version 1.4.3) (Lunn *et al*. 2000) to determine the effectiveness of core components of various lifestyle interventions. We expanded the core components by adding additional components such as mode of delivery, support mechanisms and living status. CNMA was based on the additive model, which assumes the effect of a multicomponent intervention is the sum of the individual effects of each component (Welton *et al*. 2009; Freeman *et al*. 2018). All meta-analysis models were assessed for parsimony (model's simplicity) and adequacy (model's ability to represent data adequately) using various statistics such as the deviance information criteria (DIC), model complexity (pD) and residual deviances (Dres) via leverage plot (DJs *et al*. 2002). Posterior mean deviance of the individual data points in the inconsistency model was compared against the consistency model (Lu & Ades 2006).

Patient and public involvement

Our research actively engaged people with lived experience through People First Scotland, a user-led non-profit organisation dedicated to empowering and advocating for people with ID. Our diverse PPI group comprised four members (two males and two

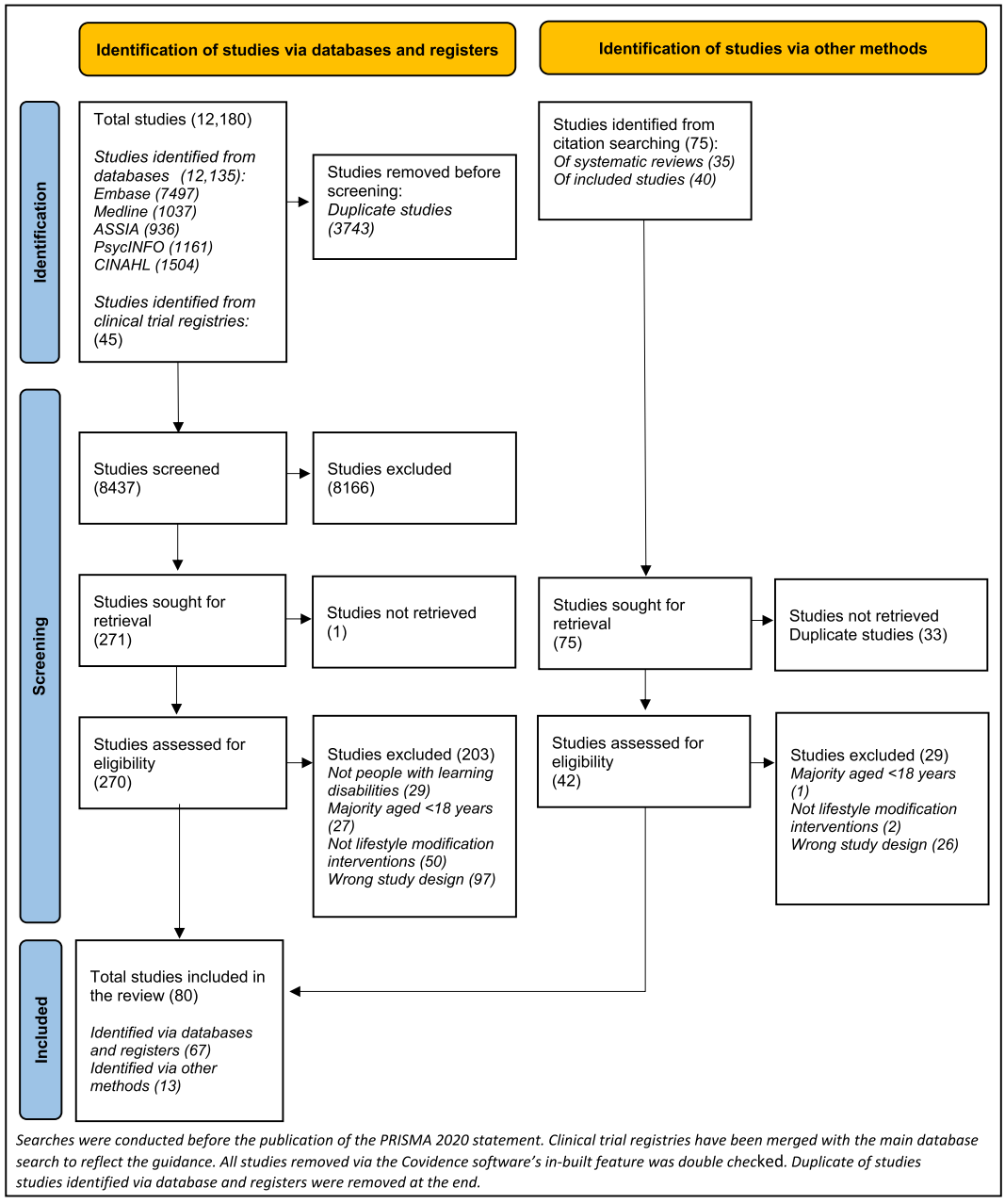

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

females) with mild IDs, a PPI co-applicant (male) and a staff member (female) who provided support to the group throughout the study. We frequently interacted with the PPI group, conducting four online meetings due to COVID-19 pandemic restrictions. We developed easy-read presentations using photo symbols as visual aids to enhance and facilitate discussions. The PPI group's contribution guided various aspects of our mixed-methods study. Specifically, they played a vital role in shaping the

methodology of our systematic review, including forming and validating search strategies, selecting key data extraction items, and identifying core components. Furthermore, they provided invaluable insights for interpreting results and organising dissemination events. Their involvement ensured our study adopted a population-centred approach, augmenting the relevance and applicability of our findings to individuals with ID and their communities. Our steering group also included a member with ID and professionals who worked directly with people with ID, with expertise in developing and implementing lifestyle modification interventions.

Results

Literature search

There were 12 180 studies identified, of which 3743 duplicates were eliminated, 8437 titles and abstracts were screened, and 271 full texts were obtained. One study was not retrieved due to limited language translation, and 203 were excluded for not meeting the inclusion criteria. Simultaneously, the additional search of citations in systematic reviews and final included studies resulted in the retrieval of 75 studies and the assessment of 42 full texts against our inclusion criteria. In total, 80 studies were identified as eligible for inclusion in the systematic review, of which 67 were from databases and clinical registries and 13 from additional searches. Three fully published versions of study protocols that had been identified in the initial search were retrieved after the updated search in February 2022 (Neumeier *et al.* 2021; Niemeier *et al.* 2021; Lally *et al.* 2022). The process is summarised in a flow diagram using PRISMA guidelines (Figure 1). A list of excluded studies with reasons is available in Supporting information, section B.

Identification of core intervention and comparator components

Six core components were identified systematically using definitions formulated by the project team (see Figure 2). Interventions and comparators included various combinations of core components which influenced different health risk behaviour outcomes, such as behaviour change techniques (BCTs) combined with an energy deficit diet and aerobic exercise. BCTs were only identified as present if explicitly mentioned. Instead of defining health education as a separate core component, we have considered it to be a part of the BCT core component consistent with Michie's behaviour change taxonomy item 5.1: 'Information about health consequences' (Michie *et al.* 2013). Diet advice is treated as distinct from energy deficit diets. Core components for comparators were only defined if they were active in nature or provided adequate information about usual care/TAU. Examples of core components in studies are available in Supporting information, section C.

Narrative synthesis of studies

Studies published between 1980 and 2022 have been summarised according to the target health behaviour of the interventions, that is, alcohol consumption, smoking and both behaviours [6 studies; 2 RCTs (Singh *et al.* 2014; Kouimtsidis *et al.* 2017), 3 uncontrolled pre–post (Tracy & Hosken 1997; Forbat 1999; Mendel & Hipkins 2002) and 1 controlled pre–post (Lindsay *et al.* 1998) in design; 228 participants], low physical activity [33 studies; 16 RCTs (Heller *et al.* 2004; Rimmer *et al.* 2004; Shields *et al.* 2008; Carmeli *et al.* 2009; Calders *et al.* 2011; Carraro & Gobbi 2012; Rosety-Rodriguez *et al.* 2013; Ordonez *et al.* 2014; Shields & Taylor 2015; Melville *et al.* 2015; Boer *et al.* 2016; Bossink *et al.* 2017; Pérez-Cruzado & Cuesta-Vargas 2017; Silva *et al.* 2017; van Schijndel-Speet *et al.* 2017; Boer 2018), 2 controlled pre–post (Carmeli *et al.* 2004; Oviedo *et al.* 2014), 13 uncontrolled pre–post (Pitetti & Tan 1991; Pommering *et al.* 1994; Messent *et al.* 1998; Stanish *et al.* 2001; Podgorski *et al.* 2004; Jones *et al.* 2007; Moss 2009; Wu *et al.* 2010; Yen *et al.* 2012; Yan *et al.* 2015; Pérez-Cruzado & Cuesta-Vargas 2016; Przysucha *et al.* 2020; Zurita-Ortega *et al.* 2020) and 2 case–control (Giagkoudaki *et al.* 2010; Mendonca *et al.* 2011) in design; 1413 participants] and multiple behaviours, that is, low physical activity, sedentary behaviour and poor diet [41 studies; 17 RCTs (Rotatori *et al.* 1980; Jackson & Thorbecke 1982; Fox *et al.* 1984; Fisher 1986; Rotatori *et al.* 1986; McDermott *et al.* 2012; Bergström *et al.* 2013; Curtin *et al.* 2013; Marks *et al.* 2013; Pett *et al.* 2013; Harris *et al.* 2017; House A *et al.* 2018a; Ptomey *et al.* 2018a, b; Kovačič *et al.* 2020; Neumeier *et al.* 2021; Lally

Figure 2. Core components of interventions and comparators.

et al. 2022), 8 controlled pre–post (Fox *et al.* 1985; Norvell & Ahern 1987; McCarran & Andrasik 1990; Chapman *et al.* 2005; Chapman *et al.* 2008; Bodde *et al.* 2012; San Mauro-Martín *et al.* 2016; Niemeier *et al.* 2021), 12 uncontrolled pre–post (Harris & Bloom 1984; Wilson & Parkinson 1993; Marshall *et al.* 2003; Mann *et al.* 2006; Bazzano *et al.* 2009; Geller & Crowley 2009; Melville *et al.* 2011; Saunders et al., 2011; Yilmaz *et al.* 2014; Spanos *et al.* 2016; Croot *et al.* 2018; Marks *et al.* 2019), and 4 case–control (Ewing *et al.* 2004; Spanos *et al.* 2014; Martínez-Zaragoza *et al.* 2016; Ptomey *et al.* 2020) in design; 3164 participants]. Most studies on alcohol consumption and smoking behaviour were conducted in the United Kingdom. In contrast, studies on low physical activity only or multiple behaviours were primarily conducted in the United States, followed by the United Kingdom.

Participant characteristics

Participants were recruited from residential facilities, community support groups, sheltered workshops, vocational training centres, schools, hospitals, medium secure services, local Special Olympics programmes and disability networks via referrals from families, practitioners/specialists, other key workers and research investigators. Most participants were White and had mild-to-moderate level of ID. Few studies included adults with severe (Tracy & Hosken 1997; Stanish *et al.* 2001; Podgorski *et al.* 2004; Shields *et al.* 2008; Wu *et al.* 2010; Yen

et al. 2012; Melville et al. 2015; Bossink et al. 2017; van Schijndel-Speet et al. 2017; Zurita-Ortega et al. 2020) and profound (Podgorski et al. 2004; Jones et al. 2007; Wu et al. 2010; Melville et al. 2011; Yen et al. 2012; Spanos et al. 2014; Melville et al. 2015; Bossink et al. 2017; Harris et al. 2017) ID while some studies did not provide information on the level of ID or only reported the IQ levels (Harris & Bloom 1984; McCarran & Andrasik 1990; Pommering et al. 1994; Mann et al. 2006; Curtin et al. 2013; Ordonez et al. 2014; Martínez-Zaragoza et al. 2016; Silva et al. 2017). Other ethnic groups such as Black (Heller et al. 2004; Rimmer et al. 2004; Mann et al. 2006; Bazzano et al. 2009; McDermott et al. 2012; Marks et al. 2013; Pett et al. 2013; Ptomey et al. 2018b; Marks et al. 2019; Niemeier et al. 2021), Hispanic (Heller et al. 2004; Rimmer et al. 2004; McDermott et al. 2012; Curtin et al. 2013; Marks et al. 2013; Pett et al. 2013; Ptomey et al. 2018b), Asian (Pommering et al. 1992; Bazzano et al. 2009; House A et al. 2018a; Ptomey et al. 2018b; Niemeier et al. 2021), Native American (Heller et al. 2004; McDermott et al. 2012; Marks et al. 2013; Pett et al. 2013; House A et al. 2018a; Ptomey et al. 2018b; Niemeier et al. 2021) and mixed ethnic groups (McDermott et al. 2012; House A et al. 2018a; Ptomey et al. 2018b) were under-represented by the studies. Participants were nearly equally represented in terms of gender, but some studies focused on a single gender (Jackson & Thorbecke 1982; Fisher 1986; Rosety-Rodriguez et al. 2013; Ordonez et al. 2014; Boer et al. 2016; Bossink et al. 2017; Boer 2018; Niemeier et al. 2021). Few studies reported on socioeconomic backgrounds —participants either came from similar socioeconomic backgrounds (Niemeier et al. 2021), belonged to well-educated (Pett et al. 2013) and employed (Neumeier et al. 2021) middle-class families (Martínez-Zaragoza et al. 2016), or from low-income backgrounds with little formal education (Jackson & Thorbecke 1982; Harris et al. 2017). Participants resided at home with family and carers, in community centres, in dispersed housing provided by public or private providers, medium secure services or lived independently. Physical and mental health problems, including those of sensory, mobility and incontinence nature caused by genetic disorders such as Down syndrome, autism and cerebral palsy were also reported.

Interventions and comparators characteristics

Table 1 presents details about participants, interventions and outcomes. Given the vast number of outcomes utilised to measure intervention effects, we have devised a stop-light system to summarise the overall effect direction and its strength based on the reported study results and their level of statistical significance. Additional information, including Michie's theory coding scheme and behaviour change taxonomy, are available in Supporting information, sections D and E.

Alcohol consumption and smoking. Alcohol consumption and smoking interventions included BCT (Tracy & Hosken 1997; Lindsay et al. 1998; Forbat 1999; Mendel & Hipkins 2002; Singh et al. 2014; Kouimtsidis et al. 2017) and mindfulness (Forbat 1999; Mendel & Hipkins 2002; Singh et al. 2014) as core components. Comparator groups received usual care involving information leaflets, therapeutic interventions (e.g., talking therapy, behaviour and motivational therapy, nicotine replacement therapy, and pharmacotherapy), and an alcohol awareness course covering legal aspects of drinking, drinking units/strengths and psychological effects of alcohol. The interventions were based on the existing literature (Lindsay et al. 1998; Forbat 1999; Singh et al. 2014; Kouimtsidis et al. 2017) including previous works by authors, manuals (Kouimtsidis et al. 2017), guidelines (Tracy & Hosken 1997) and publications by service user groups (Kouimtsidis et al. 2017). The intervention adaptations included a greater number of longer sessions, the use of various materials in its delivery (Kouimtsidis et al. 2017) and skill-building contents (Forbat 1999). They were also tailored to consider the forensic status of the participants in offending behaviour and the nature of their current residence. Smoking interventions focused on cognitive challenges like attention control, information analysis, planning and foresight (Tracy & Hosken 1997).

Participant involvement in the study design was absent. Some interventions were theory based or utilised therapeutic techniques such as cognitive behaviour therapy and motivational enhancement therapy (Kouimtsidis et al. 2017). A few explicitly mentioned the transtheoretical (stages of change)

model (Mendel & Hipkins 2002) and biopsychosocial model (Forbat 1999). BCTs included goals and planning, feedback and monitoring, social support, antecedents, self-belief, shaping knowledge, natural consequences, repetition and substitution, regulation, antecedents, identity, social support, reward and threat, and comparison of outcomes and behaviour. Interventions were administered individually (Forbat 1999) and in groups (Tracy & Hosken 1997; Mendel & Hipkins 2002) by the investigators (Forbat 1999; Mendel & Hipkins 2002), with varying personalisation levels and no reported social support. Figure 3 highlights strategies employed by the studies to enhance intervention accessibility.

Low physical activity only. Most interventions consisted of aerobic exercise only as a core component (Pitetti & Tan 1991; Pommering *et al.* 1994; Messent *et al.* 1998; Carmeli *et al.* 2004; Jones *et al.* 2007; Carmeli *et al.* 2009; Giagkoudaki *et al.* 2010; Wu *et al.* 2010; Calders *et al.* 2011; Yen *et al.* 2012; Ordonez *et al.* 2014; Boer *et al.* 2016; Boer 2018) or a combination of aerobic exercise + resistance exercise component (Stanish *et al.* 2001; Podgorski *et al.* 2004; Rimmer *et al.* 2004; Moss 2009; Calders *et al.* 2011; Mendonca *et al.* 2011; Rosety-Rodriguez *et al.* 2013; Oviedo *et al.* 2014; Yan *et al.* 2015; Silva *et al.* 2017; Przysucha *et al.* 2020; Zurita-Ortega *et al.* 2020). Core components combinations also included mindfulness (Carraro & Gobbi 2012) and BCTs (Heller *et al.* 2004; Shields & Taylor 2015; Melville *et al.* 2015; Pérez-Cruzado & Cuesta-Vargas 2016; Pérez-Cruzado & Cuesta-Vargas 2017; van Schijndel-Speet *et al.* 2017). Interventions were also based on single core-components (Shields *et al.* 2008; Bossink *et al.* 2017; Pérez-Cruzado & Cuesta-Vargas 2017; Silva *et al.* 2017). Comparator groups received no interventions, only vocational activities with low-level social interaction and physical involvement without training effect, or usual care (Carmeli *et al.* 2009; Shields & Taylor 2015). Usual care typically involved a significant amount of inactive time (Bossink *et al.* 2017), no smartphone reminders (Pérez-Cruzado & Cuesta-Vargas 2017), and daily activities such as employment, leisure, art and sporting activities (Shields *et al.* 2008; Silva *et al.* 2017).

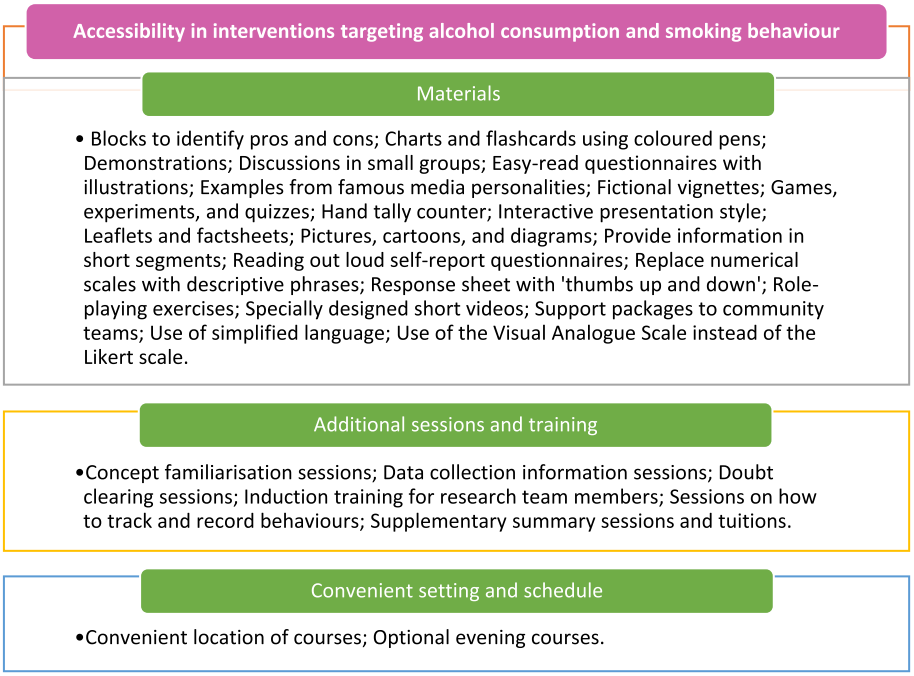

Figure 3. Various ways accessibility was improved in interventions targeting alcohol consumption and smoking behaviours.

Intervention development or adaptation involved consulting existing guidelines (Stanish *et al.* 2001; Podgorski *et al.* 2004; Moss 2009; Wu *et al.* 2010; Yen *et al.* 2012; Yan *et al.* 2015) and literature on exercise and nutrition (Heller *et al.* 2004; van Schijndel-Speet *et al.* 2017), on chronically ill population over 65 years (Carmeli *et al.* 2004; Rimmer *et al.* 2004; Oviedo *et al.* 2014; Melville *et al.* 2015; Bossink *et al.* 2017; van Schijndel-Speet *et al.* 2017), strategies for increasing physical activity (Ordonez *et al.* 2014; Shields & Taylor 2015; Boer *et al.* 2016; Boer 2018) via games and exercises (Stanish *et al.* 2001; Shields *et al.* 2008; Rosety-Rodriguez *et al.* 2013; Bossink *et al.* 2017; Silva *et al.* 2017; Przysucha *et al.* 2020; Zurita-Ortega *et al.* 2020), minimal supervision (Pitetti & Tan 1991), impacts of exercise on mental health (Carmeli *et al.* 2009; Carraro & Gobbi 2012) empowerment (Shields & Taylor 2015), life satisfaction and community integration (Pommering *et al.* 1994; Messent *et al.* 1998; Heller *et al.* 2004). Authors aimed to address gaps by comparing intervention effect with an unmatched population (Giagkoudaki *et al.* 2010; Mendonca *et al.* 2011) or similar interventions (Calders *et al.* 2011). No studies mentioned participant involvement in intervention design, although some interventions were informed by people familiar with the participants' preferences (Jones *et al.* 2007) or pilot sessions evaluating participant's skills and interests (Stanish *et al.* 2001).

Theory-informed interventions drew upon social cognitive theory (Heller *et al.* 2004; Yan *et al.* 2015; van Schijndel-Speet *et al.* 2017), transtheoretical model of behaviour change (Heller *et al.* 2004; Melville *et al.* 2015) and the theory of planned behaviour (van Schijndel-Speet *et al.* 2017). Behaviour change taxonomy coding for all interventions featured shaping knowledge, comparison of behaviour, repetition and substitution, goal and planning, feedback and monitoring, social support, natural consequences, reward and threat, self-belief, covert learning and antecedents.

Interventions were delivered by investigators, various trained personnel, or social supporters (see Figure 4). Although some studies reported social support (Heller *et al.* 2004; Shields *et al.* 2008; Carmeli *et al.* 2009; Shields & Taylor 2015; Bossink *et al.* 2017; Pérez-Cruzado & Cuesta-Vargas 2017; van Schijndel-Speet *et al.* 2017), none directly targeted social supporters. The level of social support varied among the studies (Messent *et al.* 1998; Stanish *et al.* 2001; Jones *et al.* 2007; Moss 2009; Wu *et al.* 2010; Yen *et al.* 2012; Yan *et al.* 2015; Pérez-Cruzado & Cuesta-Vargas 2016; Przysucha *et al.* 2020; Zurita-Ortega *et al.* 2020). Sessions were conducted individually (Pitetti & Tan 1991; Pommering *et al.* 1994; Stanish *et al.* 2001; Carmeli *et al.* 2004; Jones *et al.* 2007; Shields *et al.* 2008; Carmeli *et al.* 2009; Moss 2009; Wu *et al.* 2010; Ordonez *et al.* 2014; Shields & Taylor 2015; Yan *et al.* 2015; Melville *et al.* 2015; Bossink *et al.* 2017; Zurita-Ortega *et al.* 2020) or in groups (Heller *et al.* 2004; Podgorski *et al.* 2004; Shields *et al.* 2008; Giagkoudaki *et al.* 2010; Calders *et al.* 2011; Mendonca *et al.* 2011; Carraro & Gobbi 2012; Rosety-Rodriguez *et al.* 2013; Boer *et al.* 2016; Pérez-Cruzado & Cuesta-Vargas 2017; Silva *et al.* 2017; van Schijndel-Speet *et al.* 2017; Boer 2018), with small groups allowing closer supervision (Shields *et al.* 2008; Carraro & Gobbi 2012; Rosety-Rodriguez *et al.* 2013; Silva *et al.* 2017). The personalisation levels varied, considering each participant's mental/physical disabilities (Jones *et al.* 2007; Yan *et al.* 2015) and physical activity habits (Moss 2009). It also incorporated individualised training consultations (Melville *et al.* 2015) or regimens (Carmeli *et al.* 2009) such as independent/family accompanied-walks (Shields & Taylor 2015) or tailoring of exercise sessions' content and duration (Yan *et al.* 2015; Przysucha *et al.* 2020; Zurita-Ortega *et al.* 2020). Figure 5 highlights strategies employed by the studies to enhance intervention accessibility.

Multiple behaviours (low physical activity, sedentary behaviour and poor diet). The majority of interventions were based on energy deficit diet + aerobic exercise + behaviour change technique as core components (Rotatori *et al.* 1980; Rotatori *et al.* 1986; Mann *et al.* 2006; Melville *et al.* 2011; Saunders *et al.* 2011; McDermott *et al.* 2012; Bergström *et al.* 2013; Spanos *et al.* 2014; San Mauro-Martín *et al.* 2016; Harris *et al.* 2017; Ptomey *et al.* 2018a,b; Ptomey *et al.* 2020; Niemeier *et al.* 2021; Lally *et al.* 2022). Other core components combinations included diet advice (Jackson & Thorbecke 1982; Fisher 1986; Norvell & Ahern 1987; Chapman *et al.* 2005; Chapman *et al.* 2008; Bazzano *et al.* 2009; Curtin *et al.* 2013; Marks *et al.* 2013;

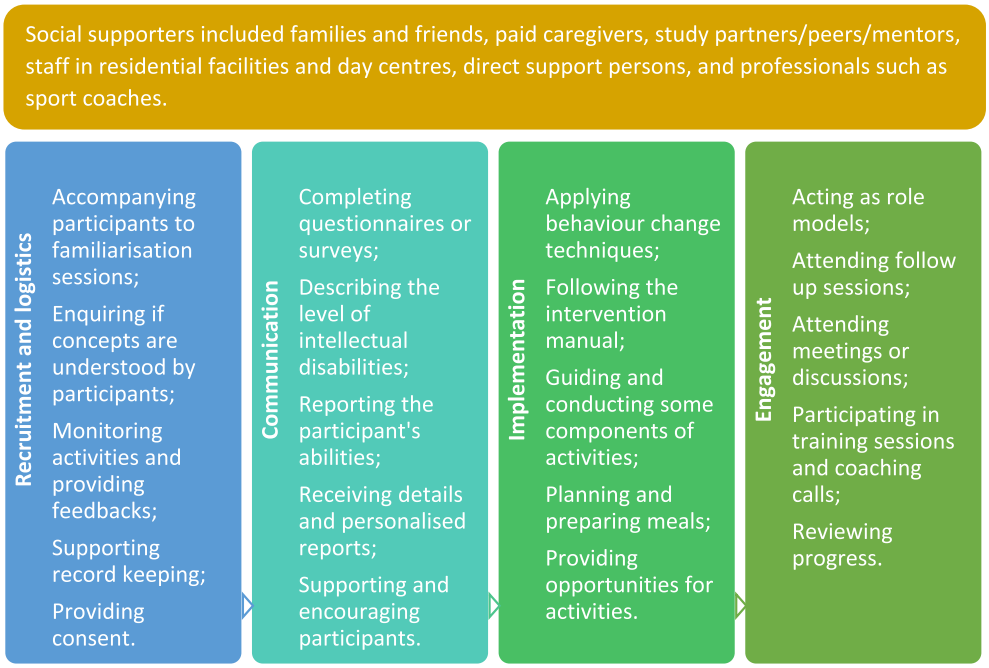

Figure 4. Examples of support provided by social supporters to the participants in interventions targeting low physical activities only or multiple behaviours.

Neumeier *et al.* 2021; Lally *et al.* 2022) and resistance exercise (Marks *et al.* 2013; Pett *et al.* 2013; Martínez-Zaragoza *et al.* 2016; Kovačič *et al.* 2020). Interventions were also based on single core-components (Yilmaz *et al.* 2014; Croot *et al.* 2018; House A *et al.* 2018a; Marks *et al.* 2019).

Comparator groups included active comparators (Harris *et al.* 2017; Kovačič *et al.* 2020), waitlist control (Rotatori *et al.* 1986; Norvell & Ahern 1987; McCarran & Andrasik 1990; Marks *et al.* 2013; Pett *et al.* 2013; Neumeier *et al.* 2021), treatment/activities control (Rotatori *et al.* 1980; Jackson & Thorbecke 1982) or usual care (Fisher 1986; McDermott *et al.* 2012; Bergström *et al.* 2013; Curtin *et al.* 2013; House A *et al.* 2018a; Ptomey *et al.* 2018a, b; Niemeier *et al.* 2021; Lally *et al.* 2022). For example, active comparators included Special Olympics training (Kovačič *et al.* 2020) or an adapted mainstream weight management programme (Harris *et al.* 2017). Waitlist controls underwent regular assessments (Rotatori *et al.* 1986; Norvell & Ahern 1987; Neumeier *et al.* 2021), received social recognition for weight loss (Rotatori *et al.* 1986) and engaged in consultations with medical professionals or health coaches (Norvell & Ahern 1987; Neumeier *et al.* 2021). The patched-up waitlist included those participants with scheduling conflicts (McCarran & Andrasik 1990). Treatment/activity control groups were advised to attempt weight loss independently or were given verbal reinforcement (Rotatori *et al.* 1980; Jackson & Thorbecke 1982). Usual care included potential future participation in the study, receiving intervention with no extra support (Fisher 1986; Niemeier *et al.* 2021), conventional diets with 500–700 kcal/day energy deficit (Ptomey *et al.* 2018a, b) and classes on nutrition, activity, safety and hygiene (McDermott *et al.* 2012; Curtin *et al.* 2013). Information materials were posted to participants (House A *et al.* 2018a) or a short discussion session on exercise and nutrition was conducted (Lally *et al.* 2022).

Interventions were developed and adapted for people with IDs. Studies consulted existing literature and manual published by the authors (Rotatori *et al.* 1980; Jackson & Thorbecke 1982; Harris & Bloom 1984; Fisher 1986; Rotatori *et al.* 1986; Norvell

Figure 5. Various ways accessibility was improved in interventions targeting low physical activity only or multiple behaviours.

& Ahern 1987; Melville *et al.* 2011; Saunders *et al.* 2011; Marks *et al.* 2013; San Mauro-Martín *et al.* 2016; Spanos *et al.* 2016; Harris *et al.* 2017; Ptomey *et al.* 2018a,b; Ptomey *et al.* 2020; Niemeier *et al.* 2021), such as the Glasgow and Clyde Weight Management Service (GCWMS) (Melville *et al.* 2011), the original SHAPE UP weight management programme (Lally *et al.* 2022) and Stoplight diet guides (Saunders *et al.* 2011; Ptomey *et al.* 2018a,b). Health curriculum was specially tailored using information such as Health Education Learning Program (HELP) (Ewing *et al.* 2004; Mann *et al.* 2006; McDermott *et al.* 2012), HealthMatters collaborative community empowerment (Marks *et al.* 2013; Marks *et al.* 2019), and the materials by the Health Promotion Agency in Northern Ireland (Croot *et al.* 2018). The authors addressed gaps in the literature by focusing on staff training, knowledge and motivation in community organisations, improving BCTs (House A *et al.* 2018a; Niemeier *et al.* 2021) and targeting specifically adults who are overweight or vulnerable to metabolic conditions (Bazzano *et al.* 2009).

Studies rarely included participant involvement in intervention design. However, some studies incorporated suggestions to alter interventions

according to the participants' abilities obtained via regular consultation meetings (Melville *et al.* 2011; McDermott *et al.* 2012; Pett *et al.* 2013; Harris *et al.* 2017; Croot *et al.* 2018; House A *et al.* 2018a). For example, health education content was streamlined, and additional lessons were organised per the participants' request (Pett *et al.* 2013). Few interventions were based on theories such as social cognitive theory (Bazzano *et al.* 2009; McDermott *et al.* 2012; Bergström *et al.* 2013; Marks *et al.* 2013; Pett *et al.* 2013; Ptomey *et al.* 2018a,b; Marks *et al.* 2019; Ptomey *et al.* 2020; Lally *et al.* 2022), control theory (Lally *et al.* 2022), empowerment theory (Geller & Crowley 2009), person-centred theory (Neumeier *et al.* 2021), and models such as transtheoretical model/stages of change theory (Marks *et al.* 2013; Marks *et al.* 2019; Neumeier *et al.* 2021), and socio-ecological model (Neumeier *et al.* 2021). Behaviour change taxonomy coding included goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour and outcome, associations, repetition and substitution, reward and threat, regulation, antecedents, self-belief and identity.

Interventions were administered by investigators, trained personnel or social supporters (Figure 4). While not all studies reported or were explicit about the involvement of social supporters, certain studies directly targeted them (Jackson & Thorbecke 1982; Fox *et al.* 1984; Fox *et al.* 1985; McCarran & Andrasik 1990; Chapman *et al.* 2005; Chapman *et al.* 2008; Melville *et al.* 2011; Bodde *et al.* 2012; Bergström *et al.* 2013; Curtin *et al.* 2013; Pett *et al.* 2013; Spanos *et al.* 2014; Yilmaz *et al.* 2014; Martínez-Zaragoza *et al.* 2016; Harris *et al.* 2017; Croot *et al.* 2018; Ptomey *et al.* 2018a,b; Marks *et al.* 2019; Kovačič *et al.* 2020; Ptomey *et al.* 2020; Lally *et al.* 2022). The level of social support provided varied. Sessions were conducted individually (Rotatori *et al.* 1980; Jackson & Thorbecke 1982; Fox *et al.* 1985; Rotatori *et al.* 1986; McCarran & Andrasik 1990; Chapman *et al.* 2005; Mann *et al.* 2006; Chapman *et al.* 2008; Geller & Crowley 2009; Melville *et al.* 2011; Saunders *et al.* 2011; McDermott *et al.* 2012; Curtin *et al.* 2013; Marks *et al.* 2013; Spanos *et al.* 2014; Martínez-Zaragoza *et al.* 2016; Harris *et al.* 2017; Croot *et al.* 2018; House A *et al.* 2018a; Ptomey *et al.* 2018a,b; Marks *et al.* 2019; Kovačič *et al.* 2020; Ptomey *et al.* 2020; Neumeier *et al.* 2021) or in groups (Fox *et al.* 1984; Harris & Bloom 1984; Fisher 1986; Ewing *et al.* 2004; Bazzano *et al.* 2009; Bodde *et al.* 2012; Bergström *et al.* 2013; Yilmaz *et al.* 2014; Croot *et al.* 2018; Niemeier *et al.* 2021; Lally *et al.* 2022). The level of personalisation varied as well, with some interventions being tailored following assessments (Jackson & Thorbecke 1982; Chapman *et al.* 2005; Chapman *et al.* 2008) and adapted to include modified goals and caregiver involvement based on participant's level of ID, abilities and preferences (Jackson & Thorbecke 1982; Pett *et al.* 2013; Harris *et al.* 2017). For example, personalised plans were regularly reviewed to offer feedback (Chapman *et al.* 2005; Mann *et al.* 2006; Chapman *et al.* 2008; Geller & Crowley 2009; Melville *et al.* 2011; Saunders *et al.* 2011; Martínez-Zaragoza *et al.* 2016; Spanos *et al.* 2016; Harris *et al.* 2017; Marks *et al.* 2019), or intervention delivered remotely using communication technology (Neumeier *et al.* 2021). Figure 5 highlights strategies employed by the studies to enhance intervention accessibility.

Outcome characteristics

Alcohol consumption and smoking. Participants received interventions of varying intensity spanning 2 weeks to 6 months, with follow-up extending up to a year. Reasons for drop-out included adverse impacts of the therapy (increased alcohol cravings and psychological distress), apprehension about meeting new individuals and work conflicts (Mendel & Hipkins 2002; Kouimtsidis *et al.* 2017). No other adverse effects were reported. Among the assessed studies, only one RCT (Kouimtsidis *et al.* 2017) explored the costs of delivering the intervention (£430 per unit) and the feasibility of conducting a cost-effectiveness analysis alongside the full trial.

The overall direction of effect and the interventions' effect on individual outcomes are available in Table 1. The intervention effects were assessed using behavioural, cognitive, knowledge, quality of life and psychosocial outcomes (Lindsay *et al.* 1998; Forbat 1999; Mendel & Hipkins 2002; Kouimtsidis *et al.* 2017). The RCT-based intervention targeting alcohol consumption (Kouimtsidis *et al.* 2017) yielded mixed results. It improved behavioural outcomes but worsened quality of life outcomes. The RCT-based intervention for

smoking led to strong improvements in behavioural outcomes (Singh *et al.* 2014). Non-RCTs showing improved outcomes varied in strengths, with a strong positive intervention effect in knowledge-related outcomes (Tracy & Hosken 1997; Lindsay *et al.* 1998; Forbat 1999; Mendel & Hipkins 2002).

Low physical activity only. Participants received interventions of varying intensity spanning 8 weeks to 9 months with a maximum follow-up of 3 months. The maintenance period consisted of 'detraining time' (Boer 2018). Drop-out reasons included medical conditions related to soreness or injury from interventions, disease diagnosis, death, behavioural and mental health conditions, and logistical problems such as lack of consent by primary care providers. Few studies explicitly reported that no adverse events were observed (Shields *et al.* 2008; Mendonca *et al.* 2011; Melville *et al.* 2015; Bossink *et al.* 2017) or that such occurrences were rare and consisted mild (Calders *et al.* 2011; Shields & Taylor 2015) musculoskeletal complaints (Calders *et al.* 2011; Shields & Taylor 2015). Cost-effectiveness was not reported by any studies.

The overall direction of effect and the interventions' effect on individual outcomes are available in Table 1. The intervention effect was evaluated using anthropometric, cardiorespiratory, functional and general health outcomes. In RCTs, the effectiveness of interventions varied. Interventions led to improvement of varying strengths and instances of no change or worse outcomes. In non-RCTs, interventions also exhibited similar and diverse effects on outcomes across studies.

Multiple behaviours (low physical activity, sedentary behaviours and poor diet). Participants received interventions of varying intensity for 6 weeks to 16 months, with some studies reporting only six sessions (Wilson & Parkinson 1993; Melville *et al.* 2011; Bodde *et al.* 2012). Maintenance periods ranging from 5 weeks to 18 months featured regular meetings with participants and their parents (Fox *et al.* 1984; Fox *et al.* 1985), sessions on knowledge retention and support (Harris *et al.* 2017), continuations of physical activity (Ptomey *et al.* 2018a,b), and homework assignments (Rotatori *et al.* 1980). Periods where participants maintained weight or were followed up to assess weight were also called maintenance periods. Drop-out reasons included illness, behavioural and mental health conditions (anxiety and unwanted negative responses from people without ID), scheduling conflicts (vacation and job-related conflicts), or other issues (consent refusal, withdrawal by caretakers, preference to go on outings with family or disability agency staff, inability to arrange transport, simply lack of interest etc). Few studies explicitly reported no adverse events (Heller *et al.* 2004; Melville *et al.* 2011; Bergström *et al.* 2013; Curtin *et al.* 2013; House A *et al.* 2018a), while one study considered weight gain as an adverse event (Saunders *et al.* 2011). Only one study assessed the feasibility of collecting cost-effectiveness outcomes or analysed the cost of delivering the intervention to service users (£598.40 per service user) (House A *et al.* 2018a; House A *et al.* 2018b; Lally *et al.* 2022). A study highlighted the usefulness of cost–benefit analysis (Spanos *et al.* 2014).

The overall direction of effect and the interventions' effect on individual outcomes are available in Table 1. The effect of interventions was assessed using anthropometric, behavioural, cardiorespiratory, functional, cognitive, food and nutrition, psychosocial, physical activity and sedentary behaviour, quality of life and general health outcomes. RCT-based interventions led to improvements in a range of outcomes, but the strength of the effect varied or, in a few cases, led to no change/worse outcomes. Interventions in non-RCTs yielded similar effects.

Risk of bias

The overall assessment of the risk of bias for RCTs and non-RCTs and risk of bias items as percentages is available as Supporting information, section F. Twenty-one RCTs (2 alcohol comsumption and smoking; 12 low physical activity only; 8 multiple behaviours) (Rotatori *et al.* 1980; Jackson & Thorbecke 1982; Fox *et al.* 1984; Fisher *et al.* 1986; Rotatori *et al.* 1986; Heller *et al.* 2004; Rimmer *et al.* 2004; Carmeli *et al.* 2009; Calders *et al.* 2011; Carraro & Gobbi 2012; McDermott *et al.* 2012; Bergstrom *et al.* 2013; Pett *et al.* 2013; Rosety-Rodriguez *et al.* 2013; Ordonez *et al.* 2014; Melville *et al.* 2015; Boer *et al.* 2016; Bossink *et al.* 2017; Pérez-Cruzado & Cuesta-Vargas 2017; van

Table 1 Details of participants, interventions and outcomes with individual intervention effect and overall effect direction. The overall effect direction is summarised using a stop-light system: green signifies interventions that led to positive change in outcomes; yellow signifies interventions that led to positive, negative, and no change in outcomes; orange signifies interventions that led to positive and negative change in outcomes. * shows outcomes which were reported to be statistically significant. *^ symbol means that we're unable to comment on the level of statistical significance of the results as it was not reported by the studies, and ** symbol means that varying level of statistical significance was reported for different outcomes in the study. Shades of green have been used to show strengths of the intervention effect; with darkest signifying interventions that led to positive and statistically significant change in outcome.

	PARTICIPANTS CHARACTERISTICS	INTERVENTION CHARACTERISTICS		OUTCOME CHARACTERISTICS		
Author, year	**No. of participants; Age**	**Core components**	**Duration of active intervention; follow up; intensity**	**Outcome**	**Intervention effect**	**Effect direction**
TARGET BEHAVIOUR: ALCOHOL CONSUMPTION AND SMOKING						
RCT						
Alcohol						
Kouimtsidis *et al.*, 2017	30 Extended Brief Intervention (EBI) + usual care (15); Median age =45 (8–5) Usual care (15); Median age= 44 (22.5)	BCT	8 weeks; 3 months No maintenance periods. 5 times a week, for 30-mins and 1-h follow-up session 3 weeks later.	Reduction in alcohol intake (Modified Alcohol Use Disorders Identification Test - AUDIT) Readiness to Change Questionnaire (RCQ) Euro-QoL EQ-5D Youth (EQ-5D-Y) Quality-adjusted life years (QALYs) Wellbeing via Clinical Outcomes in Routine Evaluation (CORELD)	Decrease in AUDIT score, CORE-LD, RCQ score Decrease in EQ-5D-Y.	Mix of positive and negative*^
Smoking						
Singh *et al.*, 2014	51 Mindfulness-based intervention (25); Mean age (sd)= 32.56 (10.29) TAU (26); Mean age (sd) =34.40 (10.46)	BCT + Mindfulness	40 weeks; 1 year No maintenance period. 4-week baseline phase and up to 36 weeks intervention phase.	Number of cigarettes smoked per week Number of cigarettes smoked at the conclusion of the treatment phase Relapse	Decrease in number of cigarettes smoked per week*, at the conclusion of the treatment phase* and follow up time measuring relapse* than the comparator group.	Positive

Table 1. *(Continued)*

	PARTICIPANTS CHARACTERISTICS	INTERVENTION CHARACTERISTICS		OUTCOME CHARACTERISTICS		
Author, year	**No. of participants; Age**	**Core components**	**Duration of active intervention; follow up; intensity**	**Outcome**	**Intervention effect**	**Effect direction**
TARGET BEHAVIOUR: ALCOHOL CONSUMPTION AND SMOKING						
Controlled pre-post						
Smoking and alcohol						
Lindsay *et al.*, 1998	Smoking programme (16), no treatment control (16), leaflet control (16) Alcohol programme (23), no treatment (23) HIV/AIDS programme (10), no treatment (10), leaflet control (10); Age not reported.	BCT	8 weeks; 3 months No maintenance periods. One session per week.	Assessment of knowledge about Smoking/Alcohol/ HIVAIDS	Improved knowledge*	Positive
Uncontrolled pre post						
Alcohol						
Mendel & Hipkins, 2002	Motivational interviewing (7); Age = 18-54 years	BCT + Mindfulness	2 weeks; No follow up and maintenance period. 3 sessions over a 2-week period.	Readiness to change Questionnaire (RCQ) Self-efficacy	Increase in motivation to change and in confidence in ability to achieve.	Positive*^
Forbat, 1999	Alcohol awareness course (5); Age not reported.	BCT + Mindfulness	6 months; No follow up and maintenance period. 7-week pilot course, 2-hours sessions	Retention of information six months after course completion	Improved retention of information	Positive*^
Smoking						
Tracy & Hosken, 1997	Fresh Start smoking education (11); Age = Under 25 years	BCT	7 weeks; 12 months No maintenance period. 8 weekly, 2 hours sessions. Additional supplementary sessions as required.	Smoking habits Interest in quitting Experience in quitting Knowledge of health effects	Increase no. of participants who stopped smoking, expressed interest in quitting, gave up smoking for at least one day and had increased concerns about health effects.	Positive*^

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
RCT						
Boer *et al.*, 2016	42 Interval training (13); Mean age (sd) = 30.0 (7.4) Continuous aerobic training (13); Mean age (sd) = 34.2 (9.2) No training control (16); Mean age (sd) = 36.6 (8.4)	Interval training: Aerobic exercise Continuous aerobic training: Aerobic exercise	12 weeks; No maintenance period. 3 sessions per week, 30 minutes	Weight (kg) BMI (kg/m2) Waist circumference (cm) Hip (cm) Fat mass (kg) Blood pressure (SBP- mmHg, DBP- mmHg) Blood profile (T-Chol - mg/dL, Glucose - mg/dL) Physical fitness (Peak VO2 - L/min, Relative peak VO2 - mL/kg/min, VE - L/min, Time to exhaustion - seconds, Peak hear rate - bpm) Functional ability (6 Minute walking distance - m, Hand grip strength - kg, 8-ft up and go - seconds, Sit-to-stand-amount/30 s)	Decrease in weight in both groups*, decrease in BMI in IT group* and no change in CAT group, decrease in weight circumference, hip, and fat mass in both groups. Increase in peak VO2, relative VO2, time to exhaustion in both groups*. Increase in VE (L/min) in IT* and CAT group. Increase in 6MWD and decrease in 8-ft up and go and increase in Sit-to-stand in IT and CAT* group. Increase in peak HR in IT group and no change in CAT group. Increase in HGS in both groups.	Mix of positive, negative and no change**
Boer, 2018	Same as above	Same as above	3 months Maintenance period: Entire study could be MP as 3 months was 'detraining' time. 3 sessions per week, 30 minutes	Weight (kg) BMI (kg/m2) Physical fitness (Peak VO2 - L/min, Rel. peak VO2 - mL/kg/min, VE - L/min, Time to exhaustion - seconds, Peak hear rate - bpm) Functional ability (6 Minute walking distance - m, Hand grip strength - kg, 8-ft up and go - seconds, Sit-to-stand - amount/30 s)	Decrease in weight in both groups*, decrease in BMI in IT group* and no change in CAT group. Decrease in Rel. peak VO2, time to exhaustion, 6 minute walking distancefor both groups* Increase in 8-ft up and go for both groups* Decrease in peak VO2, VE, peak HR in IT* and CAT group. Decrease in RER in IT and increase in RER CAT group. Decrease in sit-to-stand in both groups.	Mix of positive, negative and no change**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Bossink *et al.*, 2017	37 Power-assisted exercise (19) Care as usual (18) Mean age (sd) = 32.1 (14.6)	Resistance exercise	20 weeks; No follow up and maintenance period. 3 sessions per week, 30 minutes	BMI Behavioural Appraisal Scales (BAS) Alertness Observation List Modified Ashworth Scale QOL-PMD (QoL of people with profound multiple disabilities)	Decrease in BMI in underweight sub-group, increase in BMI in normal sub-group and no change in BMI in overweight sub-group Increase in BAS domains, except visual behaviour. Increase in alertness observation list, muscle tone, QOL-PMD in intervention group.	Mix of positive, negative and no change**
Calders *et al.*, 2011	45 Combined training (15); Mean age (sd) = 42 (7.5) Aerobic training (15); Mean age (sd) = 42 (9.3) No exercise control (15); Mean age (sd) = 43 (11.4)	Combined training: Aerobic exercise + Resistance exercise Aerobic training: Aerobic exercise	20 weeks; No follow up and maintenance period. 2 sessions per week, 70 minutes	Physical fitness (Peak VO2 -L/min), Relative peak VO2- ml kg-1 min-1, Peak power- Watt, Peak heart rate - #/min, 6 minute walk distance - m, 1 rep maximum upper limb and lower limb - kg, Abdominal muscle - kg, Low back muscle - kg, Hand grip - kg, Muscle fatigue resistance - seconds, Sit-to-stand-amount/30 s) Weight (kg) BMI (kg/m2) Waist (cm) Fat mass (kg) Fat free mass (kg) Blood pressure (SBP, DBP) Lipid profile (Total cholesterol, high and low density lipoprotein)	Increase in peak VO2, relative peak VO2,maximal strength lower and upperlimb, abdominal muscle, hand grip and sit-to-stand in COT* and AET group Increase in peak power, 6 minute walk distance and muscle fatigue in both groups* Increase in low back musclein both groups Decrease in peak heart rate in both groups Increase in weight in COT and no change in AET group No change in BMI, waist in both groups Decrease in fat mass in both group Increase in fat free mass in both groups Decrease in SBP in both COT and AET groups*, Decrease in DBP in both groups	Mix of positive, negative and no change**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
					Decrease in total cholesterol in COT* but AET group Increase in HDL in both groups Decrease in LDL in both groups	
Carmeli *et al.*, 2009	24 Aerobic training (8); Mean age (sd)=47.8 Leisure activities (8); Mean age (sd)= 50.4 No physical only vocational activities control (8); Mean age (sd)= 51.8	Aerobic training: Aerobic exercise Leisure activities: Aerobic exercise	26 weeks; No maintenance period. 3 sessions per week, 20-30 minutes Leisure session: 20-40 mins	Hamilton Anxiety Scale (HAM-A)	Decrease in HAM-A in both groups*	Positive
Carraro & Gobbi, 2012	27 Exercise programme (14) Minimal activity control (13) Mean age (sd)= 40.1 (6.2)	Aerobic exercise + Resistance exercise + Mindfulness	12 weeks; No follow up and maintenance period. 2 sessions per week, an hour each	Zung Self-Rating Anxiety Scale (SAS) ID Trait anxiety (TRAIT-A) State anxiety (STATE-A)	Decrease in SAS-ID, TRAIT-A and STATE-A*	Positive*^
Heller *et al.*, 2004	53 Fitness and health education program (32); Mean age (sd)= 39.41 (6.92) No training control (21); Mean age (sd)= 40.22 (6.38)	Aerobic exercises + Resistance exercises + BCT	12 weeks; No follow up and maintenance period. 3 sessions per week, 2 hours (1 hour for the exercise class and 1 hour for health education)	Attitudes towards exercise (Cognitive emotional barriers, outcome expectations, performance self-efficacy) Psychosocial outcomes (Community integration, depressions, life satisfaction)	Decrease in cognitive emotional barriers* and increase in outcome expectation* and performance self-efficacy* Increase in community integration and life satisfaction* Decrease in depression	Positive
Melville *et al.*, 2015	102 Walk well programme (54); Mean age (sd)= 44.9 (13.5) Wait-list control (48); Mean age (sd)= 47.7 (12.3)	Aerobic exercises + BCT	12 weeks; 24 weeks No maintenance period. 3 meetings	Step count per day Total physical activity - International Physical Activity Questionnaire (IPAQ-S) (percentage time per day) BMI (kg/m2) Waist circumference (cm)	Increase in step count per day Decrease in percentage time per day PA, MVPA, total MET minutes per week Increase in percentage time per day sedentary Decrease in BMI and waist circumference	Mix of positive and negative*^

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
				Subjective Vitality Scale Self-Efficacy for Activity for Persons with Intellectual Disability EQ-5D	Increase in subjective vitality and self-efficacy No change in EQ 5D	
Ordonez *et al*., 2014	20 Aerobic training programme (11); Mean age (sd)=24.7(3.6) No activity control (9); Mean age (sd)=25.1(3.9)	Aerobic exercise	10 weeks; No follow up and maintenance period. 3 sessions per week	Fat mass (%) BMI (kg/m2) Waist-to-hip ratio Waist circumference (cm) VO2 max Heart rate (min) Fitness (ml/kg/min) Plasmatic levels (tumour necrosis factor, interleukin, high sensitive C-reactive protein, waist-to-hip ratio, waist circumference)	Decrease in fat mass*, BMI, waist-to-hip ratio*, BMI, waist circumference* Decrease in plasmatic levels*	Positive**
Pérez-Cruzado & Cuesta-Vargas, 2017	8 Smartphone reminders (4) No smartphone (4) Age not reported.	BCT	12 weeks; No follow up and maintenance period. 2 days	International Physical Activity Questionnaire [IPAQ] WHOQoL Self- Efficacy/Social Support Scales for Activity for persons with Intellectual Disability [SE/SS-AID]	Increase in METS vigorous*, moderate, walking* and total*. Increase in quality of life*, self-efficacy Decrease in family support, professional support* Increase in peer support	Positive **
Rimmer *et al*., 2004	52 Cardiovascular and strength exercise training (30); Mean age (sd)= 38.6 (6.2) No exercise control (22); Mean age (sd)= 40.6 (6.5)	Aerobic exercise + Resistance exercise	12 weeks; No follow up and maintenance period. 4 sessions per week, 30 to 45 minutes of cardiovascular exercise and 15 to 20 minutes of muscular strength and endurance training	Peak VO2 (ml/min/1) Peak heart rate (beat/min) Time to exhaustion (sec) Max workload (W) Respiratory exchange ratio Bench press (lbs) Leg press (lbs) Hand grip (left and right) Body weight (kg) BMI (kg•m2) Total skinfold measure (mm)	Increase in peak VO2*, peak heart rate*, time to exhaustion*, max workload* and respiratory exchange ratio Increase in bench press*, leg press* and hand grip Decrease in body weight*, BMI, and total skinfold	Positive**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Rosety-Rodriguez *et al.*, 2013	40 Resistance circuit training (24) No exercise control (16) Mean age (sd) = 23.7 (3.1)	Aerobic exercise + Resistance exercise	12 weeks; No follow up and maintenance period. 3 days per week	Plasmatic levels (leptin, adiponectin, TNF-a, IL-6) Fat free mass Waist circumference Timed get-up-and-go (TGUG) test	Decrease in plasmatic levels* Decrease in fat free mass* and waiist circumference* Increase in timed get up and go	Positive**
Shields *et al.*, 2008	20 Progressive resistance training programme (9); Mean age (sd) = 25.8 (5.4) Usual activities (11); Mean age (sd)= 27.6 (9.5)	Resistance exercise	10 weeks; No follow up and maintenance period. 2 sessions per week	Muscle strength ('Chest press 1-RM (kg), leg press 1-RM (kg), no. of repetitions of chest press and leg press) Timed up and down stairs test (s) Grocery shelving task (s)	Increase in muscle strength (chest press, leg press) Decrease in timed up and go test and grocery selving task	Positive (not significant)
Shields & Taylor, 2015	16 Walkabout program (8); Mean age (sd)=21.6 (3.4) Usual activities (8); Mean age (sd)=21.2 (3.2)	Aerobic exercise + BCT	8 weeks; 4 weeks No maintenance period. Walkabout program: 2 sessions per week, 150 minutes Social program: Once a week; 90 minutes	Waist circumference (cm) Weight Self-selected walking speed (cm/s) Fast walking speed (cm/s) 6-minute walk distance (m) Physical activity counts (7-day accelerometer) Exercise Outcomes Scale Life Satisfaction Scale Safety of the intervention (number of adverse events)	Decrease in waist circumference and weight Increase in physical activity counts, self-selected walking speed and 6-minute walk distance Decrease in fast walking speed, exercise outcomes and Life Satisfaction Scale	Mix of positive and negative*^
Silva *et al.*, 2017	25 Wii based exercise program (14) Usual daily activities (13) Age = 18-60 years	Aerobic exercise + Resistance exercise	2 months; No follow up and maintenance period. 3 sessions per week, an hour each	Body weight (kg) BMI (kg/m2) Body fat (%) Visceral fat Muscle mass Waist circumference	Decrease in weight*, body fat %, visceral fat, muscle mass, waist circumference Increase in BMI Decrease in limb movement*, running speed and agility,	Mix of positive and negative **

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
				Limb movement (Plate Tapping Test) Static arm strength (Handgrip Test) Running speed and agility (Shuttle Run) Balance (Flamingo Balance Test) Flexibility (Sit and Reach Test) Explosive leg power (Standing Broad Jump) Trunk strength (30-sec Sit-Ups) Muscular endurance (Bent Arm Hang) Aerobic endurance (Six-Minute Walk) Right hand coordination Left hand coordination Bruininks–Oseretsky Response Speed Subtest Functional- Timed Up & GoTest	Increase in static arm strength, balance, flexibility, explosive leg power, trunk strength*, muscular endurance, aerobic endurance Increase in right hand coordination and response speed Decrease in left hand coordination and functional time up and go test*	
Van Schijndel-Speet *et al.*, 2017	131 Structured physical activity and fitness programme (66); Mean age (range) = 58.2 (44-83) CAU (65); Mean age (range) = 57.9 (42-78)	Aerobic exercise + Resistance exercise + BCT	8 months; No follow up and maintenance period. 2 sessions per week, 45 minutes	NL-1000 steps/day StepWatch steps/day Strength kg/m Balance BBS (0–58) Walk Speed comfortable/s Walk. Speed fast/s Blood pressure (DBP, SBP) Aerobic performance min: sec ISWT	Increase in NL-1000 steps/day* Decrease in StepWatch steps/day* Increase in strength* and balance Decrease in walk speed fast m/s No change in walk speed m/s	Mix of positive, negative and no change**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
				Weight (kg) Waist circumference (cm) Glucose (mmol/l) Cholesterol (mmol/l) Mobility (0–72) Activities of daily living (ADL) Barthel index (0–20) Instrumental ADL Lawton scale (0–33) Depressive symptoms Signalizing Depression List for people with Intellectual Disabilities (SDL-ID) Dementia Questionnaire for Persons with Mental Retardation (DMR) Cognitive subscale (0–50)	Increase in SBP* and aerobic performance Decrease in DBP* Increase in weight Decrease in waist circumference Increase in glucose Decrease in cholesterol* Increase in mobility and Depressive symptoms. SDL-ID Decrease in ADL Barthel index, IADL Lawton scale Increase in cognitive functioning*	
Controlled pre-post						
Carmeli *et al.*, 2004	14 Structural walking A1 (without intermittent claudification) (8) Structural walking A2 (with intermittent claudification) (6) Mean age (sd) = 65.5(3.6) No exercise control (12); Mean age (sd)= 62 (2.8)	Aerobic exercise	15 weeks; No follow up and maintenance period. 3 sessions per week, initially for 5-15 minutes and then gradually for as long as 40 minutes	Walking performance - Distance, speed, duration Pain level - PPI 0 to 5 scale Photoplethysmography (PPG) Ankle-Brachial Index ratio (ABI) Heart pulse - 1 min Blood pressure (mm Hg) Respiration rate	Increase in walking performance, PPG, ABI in A1* and A2 groups Decrease in pain in both groups*	Positive
	72			Weight		

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Oviedo *et al.*, 2014	Combined PA Program (CPAP) programme (3); Mean age (sd)=41 (11) No training control (29); Mean age (sd)=46 (12)	Aerobic exercise + Resistance exercise	14 weeks; No follow up and maintenance period. 3 sessions per week, for an hour each	BMI Waist circumference Body density Body fat percentage VO2 peak (L min 1), Relative VO2 peak (ml kg 1 min 1), Minute ventilation (VE, VE, L min 1) Respiratory exchange ratio (RER) 6-min walk test (6MWT) Timed up and go test (TUGT) Handgrip strength	Decrease in weight*, BMI*, waist circumference, fat mass and fat-free mass Increase in bone mass, residual mass Increase in VO2 peak*, peak heart rate, VE, peak workload*, RER, blood pressure*, 6-min walk test* Increase in handgrip and leg strength* Increase in SRT*, FSRT*, SLST* Decrease in TUGT*, Increase in SLST*, Increase in COP TTD Decrease in COP APD, RA, MLD*	Mix of positive and negative**
Uncontrolled pre-post						
Jones *et al.*, 2007	Rebound Therapy-Based Exercise Program (8); Mean age (sd)= 41.3 (6.5)	Aerobic exercises	16 weeks; 3 months No maintenance period. 3–5 times per week, 20-40 minutes	Physiological measurement (Physical function, Oxygen saturation, Pulse rate baseline Blood pressure, BMI (kg), Frequency of seizures per month follow-up, Complex partial baseline) Behavioural and psychosocial measurement (British Institute of Intellectual disabilities (BILD) Life Experiences Check List, Aberrant Behaviour Checklist (ABC), Alertness Scale- daily % unengaged)	No change in physiological outcomes. Increase in BILD freedom* and decrease in Aberrant Behaviour Checklist (ABC) total score* and alertness scale.	Mix of positive and no change**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Messent *et al.*, 1998	Community-based exercise (24); Mean age (range), male = 35.4 (26-47), female= 32.9 (24-38)	Aerobic exercise	10 weeks; No follow up and maintenance period. Once a week for one hour	Weight (kg) BMI (kg/m2) V02max	Decrease in body mass* and BMI Increase in VO2 max*	Positive**
Moss, 2009	Walking programme (100); Mean age (sd), male= 39.2 (8.9), female = 37.5 (10.1)	Aerobic exercise +BCT exercise	12 weeks; No follow up and maintenance period. 3 days per week	BMI (kg/m2) Waist-hip ratio Body fat (%) Blood pressure - SBP, DBP (mmHg) Physical work capacity (watt/kg) Cholesterol (mmol/L) Glucose (mmol/L)	Decrease in body mass and BMI in males and females Increase in wait-hip ratio in males and decrease in females Decrease in body fat in both sexes* Increase in physical work capacity in both sexes*	Mix of positive and negative**
Pérez-Cruzado & Cuesta-Vargas, 2016	Physical activity and educational programme (40); Mean age (sd)= 35.86 (9.93)	Aerobic exercise + Resistance exercise + BCT	8 weeks; No follow up and maintenance period. 2 hours weekly	METs vigorous, moderate and walking Self-efficacy/Social support-AID scale WHOQOL-DIS (World Health Organization Quality of Life Scale-Disabilities Module) Physical fitness (Passive knee extension, Calf muscle flexibility, Anterior hip flexibility, Functional shoulder rotation, Time-stands test, Partial sit-up test, Seated push-up, Handgrip test, Single-leg stance with opened eyes, Single-leg stance with closed eyes, Functional reach test, Two-minute step test before exercise, Two-minute step test after exercise, Two-minute step test_2 minute after)	Increase in METs *, professional support*, peer support*, quality of life* Decrease in self-efficacy*, family support* Decrease in time-stands test and two-minute step test before exercise Increase in rest	Mix of positive and negative**

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Pitetti & Tan, 1991	Minimally supervised exercise programme (12); Mean age (sd) = 25 (3)	Aerobic exercise	16 weeks; No follow up and maintenance period. 3 days per week	VO2 (ml kg min) Heart rate (bpm) Body weight (kg) Body fat (%) RQ (VCO2/VO2)	Decrease in weight and body fat* Increase in VO28, heart rate, VE, RQ	Positive**
Podgorski *et al*., 2004	Physical activity programme (15); Age = 40-80 years	Aerobic exercise + Resistance exercise	12 weeks; 1 year No maintenance period. 4 sessions per week, 30-45 minutes	Upper and lower body strength (no of curls n 30 secs and chair rises) Range of motions (left and right shoulders; left and right hip) Mobility gait (secs)	Increase in upper and lower body strength and range of motions Decrease in mobility gait	Mix of positive and negative*^
Pommering *et al*., 1994	Aerobic exercise programme (14); Mean age (sd) = 29.1 (7.4)	Aerobic exercise	10 weeks; 1 week No maintenance period. 4 times per week	VO2 max (ml/kg) Max oxygen pulse (ml/beat) Max vent (l/min) Max time (min) Heart rate (watts) Sit and reach test Flexibility (cm) Weight (kg) Body fat (%) Lean mass (%) Body water or hydration (%)	Increase in VO2 max*, max oxygen pulse*, max vent* and max time* Increase in flexibility* No change in weight, BMI, lean mass, body water	Mix of positive and no change**
Przysucha *et al*., 2020	Progressive and combined training programme (7); Mean age (sd) = 23.1 (2.29)	Aerobic exercise + Resistance exercise	6 weeks; No follow up and maintenance period. 3 sessions per week, a one hour each	Upper body strength (10RM chest press) Lower body strength (10RM seated leg press) Cardio-respiratory fitness (Leger 20 - meter shuttle run) VO2 max	Increase in upper and lower body strength*, cardio-respiratory fitness, VO2 max*	Positive
Stanish *et al*., 2001	Video-directed aerobic dance (17) Leader-directed aerobic dance (17)	Aerobic exercise + BCT	10 weeks; 14 weeks Maintenance period: 4 weeks.	Engagement in MVPA Attendance to physical activity sessions	Increase in MVPA engagement and attendance	Positive (not significant)

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
	Mean age (range) = 42.6 (30-65)		3 sessions per week, 15-17 minutes The number of sessions in the final reversal was extended to 12, duration based on time constraints.			
Wu *et al.*, 2010	Healthy Physical Fitness Programmes in a Disability Institution (HPFPDI) programme (146); Age = 19-67 years	Aerobic exercise	6 months; No follow up and maintenance period. 4 times per week, 40 minutes	Weight (kg) BMI (kg/m2) V-shape sit and reach test (cm) Sit-up (30s and 60s) Shuttle run (s)	Decrease in weight* and BMI* Increase in V-shape sit and reach test*, sit-ups* and shuttle runs*	Positive
Yen *et al.*, 2012	Same as above; Mean age (sd), male = 33.66 (10.02), female = 33.69 (9.22)	Same as above	9 months; No follow up and maintenance period. 4 times per week, 40 minutes	Weight BMI V-shape sit and reach test Sit ups 30s and 60s Shuttle run (seconds)	Decrease in weight* and BMI* Increase in V-shape sit and reach test, sit-ups* and shuttle run*	Positive**
Yan *et al.*, 2015	Education curriculum (22); Mean age = 26.7	Aerobic exercise + Resistance exercise + BCT	6 weeks; No follow up and maintenance period. 2 days a week	BMI (kg/m2) Waist circumference (cm) Physical activity (steps/hr) Handgrip (kg) Sit Stand test (sec) 6 mins walking (m) Balance (errors)	Increase in BMI, physical activity*, handgrip, 6 min walking, Decrease in waist circumference*, sit stand test*, balance*	Mix of positive and negative**
Zurita-Ortega *et al.*, 2020	Kinball sports programme (47), Mean age (sd)= 29.85 (10.41)	Aerobic exercise + Resistance exercise	12 weeks; No follow up and maintenance period. 1 hour session per week	BMI Six-minute test 50 m speed test Hand-grip dynamometer Endurance (six-minute test, 50 m speed test, Hand-grip dynamometer) Speed Balance and coordination	Decrease in BMI* and speed* Increase in strength*, balance*, endurance* and coordination*	Positive

Table 1. *(Continued)*

TARGET BEHAVIOUR: LOW PHYSICAL ACTIVITY ONLY						
Case control						
Giagkoudaki *et al.*, 2010	20 Exercise training (10); Mean age (sd)= 24.2 (5.1) No down syndrome control (10); Mean age (sd)= 23.3 (4.6)	Aerobic exercises	6 months; No follow up and maintenance period. 3 sessions per week, 60 minutes	Body weight (kg) BMI (kg/m2) Resting heart rate	Decrease in body weight* and no change in BMI	Mix of positive and no change**
Mendonca *et al.*, 2011	25 Combined exercise programme (13); Mean age (sd)= 36.5 (5.5) No down syndrome control (12); Mean age (sd)= 38.7 (8.3)	Aerobic exercise + Resistance exercise	12 weeks; No follow up and maintenance period. 3 days per week	Body mass (kg) Body surface area (m2) BMI (kg/m2) Fat mass (kg) Fat-free mass (kg) Relative fat mass (%) VO2 (mL/kg/min) Body surface area (L/min1/m2) Respiratory exchange ratio Heart rate (beats/min)	Decrease in body mass*, body surface area* and fat free mass* Decrease in BMI, fat mass and relative fat mass	Positive**
TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
RCT						
Bergström *et al.*, 2013	130 Multicomponent universal intervention (64); Mean age (sd)= 36.2 (57.8) Work-as-usual wait-list control (66); Mean age (sd) = 39.4 (11.4)	Energy deficit diet + Aerobic exercise + BCT	12-16 months No follow up and maintenance period. 10 sessions, 90 minutes	Physical activity (steps/day) BMI (kg/m2) Waist circumference (cm) Dietary quality: (Food diversity (groups/day), vegetable consumption (occasions/day), lunches complying with the plate model and	Increase in physical activity* Decrease in BMI, waist circumference Increase in work routines * No change in satisfaction in life	Mix of positive and no change**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				dinners complying with the plate model) Satisfaction with life (housing environment, life, meals, recreational activities) Work routines (general health promoting, food and meals, physical activity (% of full score)		
Curtin *et al.*, 2013	21 Nutrition Activity Education + Behavioural Intervention (NAE + BI) (11); Mean age (sd)= 20.5 (4.1) Nutrition Activity Education (NAE) (10); Mean age (sd)= 20.5(2.4)	NAE+BI: Diet advice + Aerobic exercise + BCT NAE: Diet advice + Aerobic exercise	6 months; 1 year No maintenance periods. 16 sessions, 90 minutes 10 sessions per week in the first 3 months, followed by 3 months of 4 bi-weekly sessions, followed by 2 sessions every third week.	Body weight (kg) Percentage body fat (%fat) Intake of fruits (servings/day) Intake of vegetables (servings/day) Treat in-take Energy-dense low-nutrient snack food (treats) intake (kcal/day) Moderate/vigorous physical activity	Decrease in weight in NAE + BI group*, body fat, fruit intake, vegetable intake, treats intake Increase in MVPA in NAE + BI group*,	Mix of positive and negative**
Fisher, 1986	17 Behavioural self-control + PA (9) Behavioural self-control without PA (8) > 20 years old	Behavioural self-control and PA: Energy deficit diet + Aerobic exercise + BCT Behavioural self-control without PA: Energy deficit diet + BCT	8 weeks; 4 weeks No maintenance period. Behavioural self-control + PA: 2 sessions per week + every two weeks an increase of 5 minutes of walking time Behavioural self-control: 2 sessions per week	Weight	Decrease in weight in both groups	Positive (not significant)

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Fox *et al*., 1984	16 Behaviour therapy (8); Mean age (sd) = 29.5 (7.2) Behaviour therapy + reinforcement (8); Mean age (sd) =27.5 years (5.4)	Energy deficit diet + BCT	10 weeks; 1 year after maintenance period 5 weeks maintenance period A session per week	Body weight (pounds/ percent overweight)	Decrease in weight in both groups	Positive (not significant)
House et al, 2018	82 Supported self-management + TAU (41); Mean age (sd) = 54.8 (10.83) TAU (41); Mean age (sd) = 57.3 (12.26)	BCT	6-8 weeks; 6 months No maintenance period. 3-4 sessions, 30-60 minutes	HbA1c (mmol/mol) BMI Waist measurement (cm) Waist to hip ratio Blood pressure (SBP, DBP) Lipids (total cholesterol, triglycerides) Renal function Patient Health Questionnaire-2	Decrease in HBA1C Increase in BMI, weight, waist measurement, waist to hip ratio Decrease in SBP, DBP, total cholesterol, triglycerides, creatinine Increase in eGFR, urea Increase in PHQ-2 score	Mix of positive and negative*^
Jackson & Thorbecke, 1982	12 Behavioural weight reduction programme (6); Mean age (range)= 21.8 (16-34) No treatment control (6); Mean age (range)= 23.5 (16-34)	Behavioural weight reduction programme: BCT + Diet advice No treatment control: BCT	14 weeks; 6 months, 12 months. No maintenance periods. Parents group: Fortnightly, an hour each Treatment group: 6 sessions held weekly between weeks 3 to 8 of treatment.	Weight loss (kg) Percentage of body-weight loss Reduction quotient	Decrease in weight, percentage body weight and reduction quotient*	Positive**
Kovačič *et al*., 2020	150 Fun fitness + Multicomponent balance-specific exercise	Fun fitness + MBSEP: Aerobic exercise + Resistance exercise + Diet advice	16 weeks No follow up and maintenance period.	Dynamic balance tests - functional reach tests Static balance tests- Single leg stance test with	Increase in functional reach for intervention groups MBSEP* and	Positive

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
	programme (MBSEP) (50) Wellness programme (50) Special Olympics training (50) Age = 18-49 and above 50	Wellness: Aerobic exercise + Resistance exercise + Diet advice + Mindfulness	Fun fitness + MBSEP: Once a week, 60 minutes for 60 mins Wellness: Once a week, 60minutes (all together 12 sessions).15-35 minutes fitness session All groups: Once a week, 60 minutes regular Special Olympics athletic training Twice a week, 60minutes same as above but individually.	eyes opened and eyes closed. Falls assessment - frequency of falls in the 4 months	Wellness*; no change in SO group*. Increase in dynamic balance for intervention groups*; no change in SO group*. Decrease in frequency of falls in the 4 months previous in intervention groups*; no change in SO group.	
Lally *et al.*, 2022	50 Shape Up LD (25); Mean age (sd)= 41 (13) Usual care (25); Mean age (sd =40 (15)	Shape Up LD: Diet advice + Aerobic exercise + BCT. Usual care: Diet advice + Aerobic exercise	3 months, 6 months No maintenance period. Shape UP LD: A session per week, 120 minutes. Usual care: Short 30 minutes discussion	Weight (kg) Body fat (%) Waist circumference (cm) Acceptability of following outcome measures: Mental health (Clinical Outcomes in Routine Evaluation for Intellectual disabilities) EQ 5D and EQ 5D Y Rosenberg Self-Esteem Scale for people with an intellectual disability Diet and activity behaviours (simple frequency items) Attitudes towards healthy behaviours	No change in weight Increase in waist circumference Decrease in body fat	Mix of positive and no change*^

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				(adapted measure from Change4Life Survey) Service use (adapted Client Service Receipt Inventory) Changes in food purchasing (Shopping receipts)		
McDermott *et al.*, 2012	443 (14 groups, consisting of 10–15 participants each divided into Steps to your health (STYH) and Hygiene and safety control Mean age (range)=38.8 (19–70)	STYH: Aerobic exercise +Energy deficit diet + BCT Hygiene and safety control: BCT	9 weeks; 6 months, 12 months No maintenance period. Steps to your health (STYH): A session every alternate week, 90 minutes Hygiene and safety classes control: A session per week, 90 minutes	Knowledge questionnaire (diet, exercise, healthy weight) includes: Life stress survey Food availability (availability of fruits, vegetables, grains, high fat foods, sweetened beverages and snacks, and low fat/reduced calorie foods) MVPA Weight BMI (kg/m2)	Increase in MVPA in both groups, Decrease in BMI in both groups, Positive response in knowledge questionnaire	Positive (not significant)
Marks *et al.*, 2013	67 Health matters program (32); Mean age (sd)= 42.6 (7.4) Wait-list control (35); Mean age (sd)= 47.6 (7.0)	Aerobic exercise + Resistance exercises + Diet advice + BCT	12 weeks No follow up and maintenance period. 3 days a week, two hours	Psychosocial and physiological health status: Perceived general health	Increase in perceived general health, social/ environmental supports for exercise (SESE)*, Social/Environmental supports for nutrition	Positive**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				Social/Environmental supports for exercise (SESE) Social/Environmental supports for nutrition (SESN) Perceived Health Behaviours Weight (lbs) Total cholesterol (TC) Glucose Knowledge and skills: Self-Efficacy to Exercise Nutrition and Activity Knowledge Scale Fitness level: Shoulder Flexibility Test (cm) YMCA Sit-and- Reach 6-Minute Walk Test Timed Get-Up-and-Go (TGUG) Test One-Minute Timed Sit-to-Stand Test	(SESN)*, perceived health behaviours* Decrease in weight Decrease in cholesterol and glucose Increase in self-efficacy to exercise* and NAKS total* (NAKS nutrition subscale, NAKS weight subscale*) Decrease in shoulder flexibility*, sit and reach, Timed Get-Up-and-Go (TGUG) Test Increase in 6-minute walk and one-minute timed sit-to-stand	
Harris *et al.*, 2017	50 Take 5 (26); Mean age (sd)= 40.6 (15.0) Waist Winners Too (24); Mean age (sd)=43.6 (14.0)	TAKE 5: Energy deficit diet + Aerobic exercise + BCT. Waist Winners Too: Diet advice + Aerobic exercise + BCT	12 months No follow up. 6 months maintenance period; considered within active intervention. 9 to 12 sessions, 40–60 minutes	Weight (kg) Weight loss of 5% or more of initial body weight BMI (kg/m2) Waist circumference (cm) Body fat (%) Sedentary behaviour (% time spent/d) Light PA (% time spent/d)	Decrease in weight, % weight, BMI, waist circumference, body fat in Take 5* and WWToo Decrease in sedentary behaviour in Take 5 and increase in WWToo Increase in light physical activity, MVPA, total PA in Take 5 and decrease in WWToo	Mix of positive and negative**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				MVPA (% time spent/d) Total (% time spent/d) European Quality of Life-5 dimensions (EQ-5D) youth version	No change in EQ 5D in in Take 5 and decrease in WWToo	
Neumeier *et al.*, 2021	35 POWERSforID (17) Minimal information control (18) Mean age (sd)= 34.6 (5.7)	POWERSforID: BCT + Diet advice + Aerobic exercise Control: BCT	24 weeks No follow up and maintenance period. Weekly (weeks 1-12) Biweekly (weeks 13-24)	Weight (kg) BMI (kg/m2) Waist circumference (cm) Body fat (%) Blood pressure - SBP, DBP (mmHg) A1C (%) Heart rate Lipid profile (mg/dL) - high density lipoprotein, low density lipoprotein, triglycerides, cholesterol	Decrease in body weight*, BMI*, waist circumference* Decrease in body fat, Increase in SBP, high density lipoprotein and decrease in A1C, DBP, low density lipoprotein, triglycerides, and cholesterol.	Positive**
Pett *et al.*, 2013	30 Cohort 1 Yes, We Can (YWC) (11); Mean age (sd)= 23.6 (3.1) Wait list control (Cohort 2) (11). Cohort 2 YWC + We Can Too! (WCT) (11); Mean age (sd)= 25.6 (4.8) Cohort 3 WCT (8); Mean age (sd)= 22.9 (4.5) Cohort 2 served as a pre-/postintervention wait list control (WLC) group for Cohort 1.	YWC: Diet advice + Aerobic exercise + Resistance exercise + BCT WCT: Diet advice + Aerobic exercise + Resistance exercise + BCT	12 weeks; 3 months No maintenance periods. YWC: 2 times per week, 1.5 hours. Total 36 hours. Yes, We Can (YWC) + We Can Too! (WCT) Once a week, an hour. Total 5 18 hours. We Can Too! (WCT): Once a week, 1K hours per session. Total 5 18 hours.	Weight (lb) BMI Waist and hip circumference (inches) Blood pressure Resting heart rate Cholesterol Blood glucose Sit-to-stand muscular endurance test Handgrip Bench press (reps x weight) Maximum leg press (1-repetition maximum, lb) 6-minute walk (ft) Sit and reach test Timed Get-Up-and-Go	Decrease in weight, BMI in YWC* and YWC+WCT* Increase in hip circumference in YWC* and decrease in YWC +WCT* Decrease in blood pressure, blood sugar in YWC* and increase in YWC+WCT* Increase in 6-minute walk*, sit to reach, timed get up and go* in YWC and decrease in YWC +WCT Increase in Tinetti balance* in both	Mix of positive and negative**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				Tinetti balance test Self-reported general health Depression- a 10-item child depression inventory Self-Efficacy to Exercise Scale Exercise Perception Scale Cognitive-Emotional Barriers to Exercise Scale Choice-Making Inventory–2 [CMI-2] CAI	Decrease in bench press, leg press in YWC* and increase in YWC+WCT* Decrease in barriers to exercise in both*	
Ptomey et al, 2018	150 Enhanced stop light diet (eSLD) (78); Mean age (sd)= 36.1(12.0) Conventional diet (72); Mean age (sd)= 37 (12.5)	eSLD: Energy deficit diet + Aerobic exercise + BCT Conventional diet: Energy deficit diet + Aerobic exercise + BCT	18 months No follow up 12 months maintenance period after 6 months weight loss; considered within active intervention. Once a month, 45-60 minutes	Body weight (kg) BMI (kg/m2) Waist circumference (cm) Energy intake (kcal/day) Fat (% energy intake) Dietary Intake - fruits (Servings/day), vegetables (Servings/day), portion- controlled entrees (number/day), portion- controlled shakes (number/day), Stop Light green foods (number/day), Stop Light red foods (number/day) Moderate-to-vigorous physical activity.	Decrease in weight*, BMI, waist circumference* Decrease in energy intake, fruit and vegetable serving Increase in portion-controlled entrees, shakes and Stop Light green foods Decrease in Stop Light red foods	Mix of positive and negative**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Ptomey et al, 2018	146 Enhanced stop light diet (eSLD) (77); Mean age (sd)= 36.1(12.0) Conventional diet (69); Mean age (sd)= 36.5 (12.1)	Same as above	Same as above	Mean energy intake per day Macronutrients intake per day (fat, carb, protein) Healthy Eating Index-2010 (HEI-2010)	Decrease in energy (kcal)*, fat*, carb*, protein, % energy from fat* Increase in % energy from carb and protein* Increase in total healthy eating index	Positive**
Rotatori *et al.*, 1980	18 Multicomponent behaviour therapy (10) No exercise control (8) Age not reported.	Aerobic exercise + Energy deficit diet + BCT	7 weeks; 10 weeks after the maintenance 6 weeks maintenance period. A session per week, 50 minutes	Weight loss	Decrease in weight*	Positive
Rotatori *et al.*, 1986	13 Experimental maintenance booster session group (7); Mean age (sd) = 26.6 (4.5) Post-treatment maintenance control (6); Mean age (sd) = 35.7 (8.8)	Behaviour therapy weight reduction program: Energy deficit diet + Aerobic exercise + BCT Post-treatment maintenance control: BCT	12 weeks (Phase I), 10 months (Phase 2), 52 weeks (Phase 3), 12 months after Phase 3 (Phase 4) No information?	Weight	Decrease in weight.	Positive (not significant)
Controlled pre-post						
Bodde *et al.*, 2012	42 Promoting Health Through Physical Activity Knowledge and Skills (PHPAKS) Immediate group (21) Wait-list delayed control (21) Age = 19-62 years	BCT + Aerobic exercise	8 sessions No follow up and maintenance period. 8 sessions, 30 minutes	Knowledge-McGillivary's Nutrition and Knowledge Scale (NAKS) Physical activity recommendations Assessment (PARA) Moderate to vigorous physical activity (MVPA) (min)	Increase in NAKS, PARA in immediate group, delayed group and both group combined* Increase in MVPA in immediate group, decrease in delayed group*, both groups combined.	Mix of positive and negative**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Chapman *et al*., 2005	88 Fighting fit input group (50); Mean age (sd) = 37.13 (8.75) Non input group (38); Mean age (sd) = 43.32 (10.97)	Diet advice + BCT	1 year No follow up and maintenance period. Once every six months	Weight (kg) BMI (kg/m2)	Decrease in weight* and BMI* in input group.	Positive
Chapman *et al*., 2008	73 Fighting fit input group (33); Mean age (sd) = 37.13 (8.75) Non-input group (40); Mean age (sd) = 43.32 (10.97)	Same as above	1 year*; 6 years No maintenance period Once every six months	Weight (kg) BMI (kg/m2)	Decrease in weight and BMI in input group.	Positive (not significant)
Fox *et al*., 1985	15 Parent involvement (8); Mean age (sd) = 27 (2.7) Subject involvement (7); Mean age (sd) = 29 (2.2)	Energy deficit diet + BCT	10 weeks; 22 weeks, 3 months 22 weeks maintenance period. 10 weeks with one hour treatment meeting held for each group twice weekly.	Body weight (pounds)	Decrease in weight in PI* and SI groups	Positive
Mauro-Martín et al, 2016	47 Nutrition and physical exercise workshop (11) Control (36) Mean age (sd)= 37 (9.4)	BCT + Energy deficit diet + Aerobic exercises	3 months No follow up and maintenance period. 5 sessions each (2 workshops) se- unemployed for weeks (one a week), an hour	Weight (kg) BMI Body fat (%) Visceral fat (%) Food consumption: KidMed questionnaire on adherence to diet Mediterranean	Decrease in weight, BMI, body fat, visceral fat* Increase in KidMed score	Positive**
Niemeier *et al*., 2021	66 Fit5 programme (34); Mean age (sd) = 37.6 (11.2) Control (32); Mean age (sd) = 31.7 years (12.3)	Energy deficit diet + BCT + Aerobic exercise	8 weeks No follow up and maintenance period. A session per week, 90 minutes Additional 3-4 sessions.	BMI Blood pressures (systolic and diastolic) Heart rate	Increase in BMI* Decrease in SBP*, DBP*, resting heart rate*	Positive

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Norvell & Ahern, 1987	13 Weight loss intervention (7); Mean age (sd)=30.2 (3.9) Attention-placebo, waitlist control (6); Mean (sd)=30.1 (8.1)	Diet advice + BCT	10 weeks; 6 months for 1st treatment group and 3 months for 2nd treatment group. Maintenance period; considered as follow up. Weekly, an hour	Weight loss Weight reduction quotient (kg)	Decrease in weight.	Positive (not significant)
Steele McCarran et al, 1990	8 Home help (4); Mean age=27 No help patched-up control (4) (4); Mean age=31	Home-help group: BCT + Energy deficit diet No home-help group: BCT + Energy deficit diet	14 weeks; 1-, 3-, 6- and 12-months follow up. 5 weeks maintenance period. 3 sessions, 60-minutes	Weight (lbs) Percent overweight Weight reduction quotient BMI Caliper measurement change Time taken to consume a meal (number of times dieters placed utensils on the table between bites) Speed of eating (bites per minute) Eating Habit Record	Decrease in weight, percent overweight*, weight reduction quotient*, BMI* and Caliper measurement* Increase in time taken to consume a meal and decrease in speed of eating*	Positive
Uncontrolled pre-post						
Bazzano et al., 2009	Health lifestyle change program (44) Age = 18-65 years	Diet advice + Aerobic exercise + BCT	7 months No follow up and maintenance period. 2 sessions, two hours	Weight (lbs) BMI Abdominal girth (inches) Exercise (mean frequency (times per week), mean minutes per week) Eating habits (Vegetable servings per day, fruit servings per day, meat, bread, whole wheat	Decrease in weight*, BMI* and abdominal girth* Increase in exercise*, nutrient dense food, fruit* and water* Increase in self-efficacy related to exercise and eating habits Increase in knowledge related to cooking*,	Positive**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)			
	bread, dairy, diet soda, regular soda, glasses of water per day) Self-efficacy related to: Exercise (%) - Totally sure that can stretch , totally sure that can exercise hard enough to sweat, breathe hard, totally sure that can exercise three times per week Eating habits (%)- Totally sure that can choose healthy food at home, totally sure that can choose healthy food when eat out Healthy eating knowledge (%) - Know how to cook healthy food, know how to buy healthy food, know how to order healthy food, believe that fast food is easier to buy than healthy food, totally sure that can make doctor's appointment Healthcare access: Totally sure can make doctor's appointment (%)	buying, ordering healthy food Decrease in belief that healthy food is easier to buy* Increase in healthcare access*	

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Croot *et al*., 2018	Slimming world (9) Age not reported.	BCT	8 weeks No follow up and maintenance period. Once a week	Weight loss BMI	Decrease in weight and BMI	Positive*^
Geller & Crowley, 2009	Empowerment-based model (45) Mean age (sd)= 42.6	Aerobic exercises + BCT	Mean (sd)= 13.5 (6.4) No follow up and maintenance period. Twice weekly, an hour (only 16 participants) Once a week (remaining 27 participants)	Weight (lbs)	Decrease in weight*	Positive
Harris & Bloom, 1984	Behavioural weight control programme (21); Mean age (sd)= 25.3 (6.37)	BCT + Energy deficit diet	7 weeks; 1 year No maintenance period. A session per week 5 to 10 minutes training sessions 1 hour booster session 26 weeks after the first meeting	Weight (kg) Girth (hips, waist, thigh, arms) Aerobic fitness (individually timed while walking, jogging, or running a half-mile course) Knowledge of nutrition Self-management of behaviour	Decrease in weight* in girth* of hips, waist, thigs, arms Increase in knowledge of nutrition* and self-management of behaviour*	Positive
Mann *et al*., 2006	Steps to your health (STYH) programme (192); Mean age (sd)= 38.6 (11.5)	Aerobic exercise +Energy deficit diet + BCT	8 weeks; 1 week No maintenance period. 8 sessions, 90 minutes	BMI Knowledge score (% correct) Exercise frequency Dietary intake	Decrease in BMI*, Increase in exercise frequency*, knowledge score*, intake of healthy meals*	Positive
Marks et al, 2019	HealthMessages Peer-to-Peer Program (311); Mean age (sd)= 41.2 (16.1)	BCT	12 weeks No follow up and maintenance period. Weekly, 75 minutes session in Phase 1and 30-	Peer participants: Physical activity knowledge (Activity Knowledge Scale)	Peer participants: Increase in physical activity knowledge*, hydration knowledge*, social support*, total health behaviour*	Positive

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
			minutes sessions in Phase 2 Additional one-hour surveys every week	Hydration knowledge (Hydration Knowledge Scale) Social support and total health behaviour (Health behaviours questionnaire)		
Marshall *et al.*, 2003	25 Health promotion in local leisure centre (10) Day centre programme (9) Facility residents (6) Age = less than 20, 30-60, over 60	BCT	6 weeks (two groups) or 8 weeks (one group) No follow up or maintenance period. 2 hours per week	Weight loss (kg) BMI (kg/m2)	Decrease in weight* and BMI*	Positive
Melville *et al.*, 2011	TAKE 5 (54) Mean age (sd) = 48.3 (12.01)	Energy deficit diet + Aerobic exercise + BCT	9 sessions; Approximately 24 weeks. No maintenance periods. Every 2 to 3 weeks.	Weight (kg) BMI Waist circumference Light-intensity physical activity/d at 24 weeks (min) Moderate-to-vigorous-intensity physical activity/d at 24 weeks (min) Sedentary behaviour/d at 24 weeks (min) Percentage of time spent in light-intensity physical activity (min) Percentage of time spent in moderate-to-vigorous-intensity physical activity (min) Percentage of time spent in sedentary behaviour (min)	Decrease in weight*, BMI*, waist circumference* Increase in light-intensity physical activity, moderate-to-vigorous-intensity, percentage of time spent in light-intensity physical activity*, percentage of time spent in moderate-to-vigorous-intensity physical activity, moderate-to-vigorous-intensity physical activity in previous 7 d at 24 weeks*, time walking in previous 7 d at 24 weeks Decrease in sedentary behaviour* and percentage of time spent in sedentary behaviour*, time sitting/d at 24 weeks	Positive**

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
				Moderate-to-vigorous-intensity physical activity in previous 7 d at 24 weeks (min) Time walking in previous 7 d at 24 weeks (min) Time sitting/d at 24 weeks (min)		
Spanos *et al.*, 2016	TAKE 5 (28) Age not reported.	Same as above	12 months No follow up. Maintenance period: based on weight changes between end of Phase I and end of Phase II studies. A session per week, 40-50 minutes	Weight (kg) Weight maintenance Waist circumference (cm) BMI Time (minutes) per day spent in light and moderate-to-vigorous physical activity at 12 months. Time (minutes) spent in sedentary behaviour per day at 12 months	Decrease in weight, BMI, and waist circumference Weight maintained by 50% participants Decrease in sedentary time Increase in physical activity	Positive (not significant)
Saunders *et al.*, 2011	Stop light diet (SLD) guide (73) 18-62 years	Energy deficit diet + Aerobic exercise + BCT	6 months; 6 months No maintenance period. Once every month, 30 minutes	Weight loss Participation in physical activities Total calorie intake	Decrease in weight and total calorie intake Increase in physical activity	Positive*^
Wilson & Parkinson, 1993	Healthy eating programme (10) Age not reported.	BCT + Diet advice + Aerobic exercise	6 sessions No follow up and maintenance period. 6 sessions, 2 hours	Weight (lbs) Exercise tolerance test Mealtime behaviour (speed of eating and amount of food consumed) Healthy eating questionnaire	Decrease in weight, speed of eating and amount of food consumed Increase in exercise tolerance and HEQ scores	Positive (not significant)

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Yilmaz et al, 2014	Nutrition and activity programmes (37) Mean age (sd) = 26.61 (7.87)	BCT	15 weeks No follow up and maintenance period. Families' education programme: 2 hrs/day for 2 days Educational programmes: Session, 25 to 30 minutes. Activity: 3 days a week, 30 minutes	Nutrition and Activity Knowledge Scale	Increase in nutrition and knowledge*	Positive
Case control						
Ewing *et al*., 2004	189 Health Education Learning Program (HELP) (92); Mean age (sd) = 39.7 (11.5) Normal learners (97); Mean age (sd) = 49.9 (11.48)	Aerobic exercise + BCT	8 weeks No follow up and maintenance period. 8 sessions, 90 minutes	BMI (kg/m2) Self-reported fruit and vegetable intake (% increased) Self-reported exercise (% increased) Knowledge scores relating to healthy eating and physical activity (% increased)	Decrease in BMI*, Increase in self-reported exercise*, fruit and vegetable intake and knowledge score	Positive**
Mart ınez-Zaragoza *et al*., 2016	64 Multicomponent programme (33); Mean age (sd)=34 (5.71) Non-equivalent control (31); Mean age (sd)= 34.71 (5.84)	Energy deficit diet + Aerobic exercises + Resistance exercises + BCT	17 weeks; 6 months No maintenance period. 5 sessions per week, 1 hour	Weight (kg) Heart rate (HR) (beats per Minute at rest) Systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg)	Decrease in weight* and DBP* Increase in heart rate and SBP	Positive**
Spanos et al, 2014	156 TAKE 5 ID (52); Median age (range)= 51 (26-73) No ID (104); Median age (range)= 51 (28-73)	Energy deficit diet + Aerobic exercise + BCT	16 weeks No follow up and maintenance period. 10 optional structured supervised activity classes	Weight (kg) BMI (kg/m2).	Decrease in weight and BMI	Positive (not significant)

Table 1. *(Continued)*

TARGET BEHAVIOUR: MULTIPLE (LOW PHYSICALY ACTIVITY, SEDENTARY BEHAVIOUR, POOR DIET)						
Ptomey *et al.*, 2020	124 Enhanced stop light diet (eSLD) (24) No down syndrome (103) 18-62 years	Energy deficit diet + Aerobic exercise + BCT	18 months No follow up 12 months maintenance period after 6 months weight loss; considered within active intervention. Once a month, 45-60 minutes	Weight BMI Mean energy intake per day Macronutrients intake per day (fat, carb, protein) Sedentary (% of wear time) LPA (% of wear time) MVPA (% of wear time)	Decrease in weight and BMI Decrease in energy intake Increase in carbohydrate and protein intake Decrease in fat intake Decrease in sedentary time Increase in LPA and MVPA	Positive (not significant)

*Significant change in outcome.
**^Unable to comment on the significance of the results.
***Varying level of significance

Schijndel-Speet *et al.* 2017; Ptomey *et al.* 2018a) were at overall high risk of bias, nine RCTs (1 smoking behaviour; 2 low physical activity only; 6 multiple behaviours) (Curtin *et al.* 2013; Marks *et al.* 2013; Singh *et al.* 2014; Shields & Taylor 2015; Harris *et al.* 2017; Silva *et al.* 2017; House A *et al.* 2018a; Kovačič *et al.* 2020; Lally *et al.* 2022) had some concerns overall, and only three RCTs (1 alcohol consumption, 1 low physical activity only; 1 multiple behaviours) (Shields *et al.* 2008; Kouimtsidis *et al.* 2017; Neumeier *et al.* 2021) were at overall low risk of bias. Thirty-six non-RCTs (4 alcohol consumption and smoking; 13 low physical activity only; 19 multiple behaviours) (Harris & Bloom 1984; Fox *et al.* 1985; Fisher 1986; Norvell & Ahern 1987; McCarran & Andrasik 1990; Pitetti & Tan 1991; Wilson & Parkinson 1993; Tracy & Hosken 1997; Lindsay *et al.* 1998; Messent *et al.* 1998; Forbat 1999; Stanish *et al.* 2001; Mendel & J. 2002; Ewing *et al.* 2004; Podgorski *et al.* 2004; Chapman *et al.* 2005; Jones *et al.* 2007; Carmeli *et al.* 2009; Geller & Crowley 2009; Moss 2009; Bazzano *et al.* 2009; Giagkoudaki *et al.* 2010; Wu *et al.* 2010; Mendonca *et al.* 2011; Saunders *et al.* 2011; Bodde *et al.* 2012; Spanos *et al.* 2014; Yilmaz *et al.* 2014; Yan *et al.* 2015; Mart ınez-Zaragoza *et al.* 2016; Spanos *et al.* 2016; Pérez-Cruzado & Cuesta-Vargas 2017; Croot *et al.* 2018; Marks *et al.* 2019; Przysucha *et al.* 2020; Niemeier *et al.* 2021) were at overall serious risk of bias, a non-RCT (1 multiple behaviours) (San Mauro-Martín *et al.* 2016) had overall critical risk of bias and seven non-RCTs (3 low physical activity only; 3 multiple behaviours) (Pommering *et al.* 1994; Marshall *et al.* 2003; Mann *et al.* 2006; Melville *et al.* 2011; Yen *et al.* 2012; Oviedo *et al.* 2014; Zurita-Ortega *et al.* 2020) had overall moderate risk of bias.

Meta-analysis

Meta-analysis was conducted only for RCTs with interventions reporting weight management (anthropometric) outcomes at the intervention and component levels. Due to high heterogeneity in outcome measurement and reporting, we did not pool other outcomes for analysis. Given the variability in study design, non-RCTs were also not pooled for analysis. The meta-analysis includes 15 RCTs targeting low physical activity only or multiple behaviours in 920 participants.

Intervention-level meta-analysis

Pairwise meta-analysis. The pairwise meta-analysis allowed us to compare lifestyle modification interventions to TAU. For the change in weight (kg) outcome, a comparison of all interventions lumped together against TAU (9 RCTs with 542 adults) showed no significant difference for change in weight (MD −0.46; 95% CI −1.25 to 0.33, I^2 = 0%,

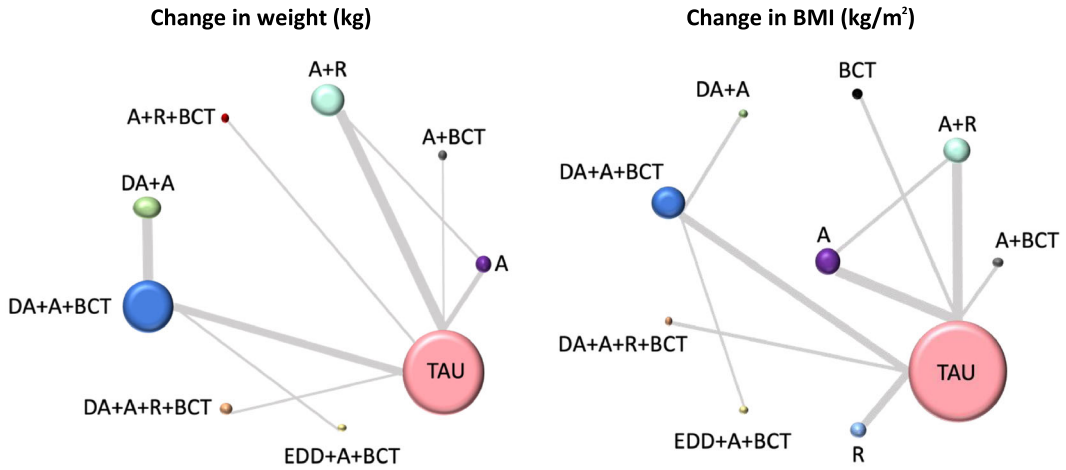

Figure 6. Networks of interventions for weight management in adults with intellectual disability. From left: Change in weight (kg) and change in BMI (kg/m^2); the size of each node is proportional to the number of people who received the intervention, and the width of the line is proportional to the number of trials comparing the interventions directly.

Table 2 Summary of NMA results for mean change in weight (kg) and mean change in BMI (kg/m^2) compared to TAU.

Intervention coded as core components	Mean change in Weight (Vs TAU) (95% CrI LL, UL)	Mean change in BMI (Vs TAU) (95% CrI LL, UL)
Aerobic exercise	−1.56 (−7.45, 4.33)	−0.62 (−1.59,0.33)
BCT	—	0.59 (−3.02, 4.19)
Resistance exercise	—	0.37 (−1.38, 2.14)
Aerobic exercise + BCT	−1.35 (−12.67, 9.82)	−0.49 (−3.51, 2.53)
Aerobic exercise + resistance exercise	−0.76 (−6.89, 5.25)	−0.29 (−2.29, 1.73)
Dietary Advice + aerobic exercise	0.94(−3.93, 4.91)	0.68(−3.86, 5.24)
Dietary Advice + aerobic exercise + BCT	−1.02 (−4.60, 1.99)	0.15(−0.62,0.83)
Aerobic exercise + resistance exercise + BCT	0.21 (−6.53, 6.85)	—
Energy deficit diet + aerobic exercise + BCT	−3.61 (−9.68, 1.95)	−0.75(−2.31,0.78)
Dietary advice + aerobic exercise + resistance exercise + BCT	−2.02 (−7.25, 3.35)	−0.72(−6.28,4.76)

BCT, behaviour change technique; CrI, credible interval; LL, lower limit; TAU, treatment as usual (usual care); UL, upper limit.

τ^2 = 0.00). For the change in BMI (kg/m^2) outcome, a comparison of all interventions lumped together against TAU (11 RCTs with 721 adults) showed no significant change in BMI between the two groups (MD 0.06, 95% CI −0.20 to 0.31, I^2 = 0%, τ^2 = 0.00). Results for both weight and BMI outcomes were further categorised into sub-groups to differentiate the effect of interventions with single or multiple core components (combinations of core components) (see Supporting information, section G).

Network meta-analysis. The core-components based NMA allowed us to compare all lifestyle modification interventions directly and indirectly with each other and TAU. Additionally, the coding of intervention core components ensured that each intervention was treated distinctly rather than being lumped together. For the change in weight (kg) outcome, interventions with combinations of six core components (13 RCTs; 690 participants) were compared head-to-head with TAU (Figure 6). For the change in BMI (kg/m^2) outcome, interventions with combinations of eight core components (13 RCTs; 798 participants) were compared head-to-head with TAU (Figure 6). The result shows that the changes in both outcomes were not significant when compared with TAU (Table 2). Comparisons between all interventions for both outcomes are available in Table 3. Results of NMA on additional weight management outcomes, that is, change in waist circumference (cm) and body fat (%), are available in Supporting information, section H.

Assumption of transitivity. Within our network, the proportion of participants with mild to moderate ID was balanced across the comparisons. Any potential imbalance could be a chance error, given the limited inclusion of participants with severe or profound levels of ID by the studies. As a result, the assumption of transitivity remains valid.

Assessment of consistency. Both the fixed and random effects models exhibited satisfactory convergence after 50 000 iterations. We also compared the models using the results based on samples from an additional 150 000 iterations. The DICs for both the random and fixed effects models were similar. Comparison between DICs showed no meaningful differences between the fit of the random effects consistency and inconsistency models (Supporting information, section I).

Sensitivity analysis. In the context of core-components based NMA for change in BMI (kg/m^2) outcome, a sensitivity analysis was performed by excluding a study (Bergström *et al.* 2013) in which exercise intervention incorporated the use of power-assisted equipment operated by the participants. This exercise approach differed from interventions in other studies, as it entailed the equipment performing the exercise activity rather

Table 3 League table with NMA estimates for mean change in weight (kg) and mean change in BMI (kg/m^2)

A	−0.18 (−12.85, 12.46)	−0.76 (−8.18, 6.59)		−1.76 (−10.68, 7.22)	−2.42 (−9.49, 5.11)	−0.47 (−7.03, 6.39)	0.44 (−7.55, 8.38)	2.08 (−5.96, 10.44)		−1.56 (−7.45, 4.33)
−0.14 (−3.29, 3.03)	A + BCT	−0.57 (−13.39, 12.26)		−1.58 (−14.63, 11.44)	−2.18 (−14.18, 9.97)	−0.26 (−11.98, 11.52)	0.67 (−11.80, 12.94)	2.29 (−10.29, 15.04)		−1.35 (−12.67, 9.82)
−0.33 (−2.47, 1.74)	−0.19 (−3.80, 3.44)	A + R		−0.98 (−10.00, 8.06)	−1.62 (−8.97, 6.07)	0.33 (−6.52, 7.29)	1.17 (−6.86, 9.25)	2.91 (−5.39, 11.37)		−0.76 (−6.89, 5.25)
−1.21 (−4.93, 2.56)	−1.05 (−5.79, 3.65)	−0.88 (−4.96, 3.25)	BCT							
				A + R + BCT	−0.66 (−8.49, 7.62)	1.28 (−6.03, 8.90)	2.19 (−6.30, 10.70)	3.85 (−4.79, 12.76)		0.21 (−6.53, 6.85)
−1.31 (−5.97, 3.35)	−1.16 (−6.64, 4.34)	−0.98 (−5.97, 4.06)	−0.11 (−5.98, 5.75)		DA + A	1.98 (−1.10, 4.77)	2.91 (−4.29, 9.43)	4.53 (−1.18, 10.02)		0.94 (−3.93, 4.91)
−0.76 (−1.93, 0.44)	−0.62 (−3.71, 2.48)	−0.43 (−2.53, 1.72)	0.46 (−3.22, 4.11)		0.55 (−3.96, 5.055)	DA + A + BCT	0.94 (−5.52, 6.91)	2.56 (−2.22, 7.34)		−1.02 (−4.60, 1.99)
0.09 (−5.46, 5.75)	0.27 (−6.06, 6.63)	0.44 (−5.42, 6.37)	1.35 (−5.32, 7.93)		1.44 (−5.65, 8.58)	0.86 (−4.64, 6.46)	DA + A + R + BCT	1.62 (−5.95, 9.67)		−2.02 (−7.25, 3.35)
0.12 (−1.68, 1.96)	0.28 (−3.13, 3.65)	0.45 (−2.06, 3.00)	1.34 (−2.56, 5.22)		1.43 (−3.25, 6.15)	0.88 (−0.49, 2.25)	0.03 (−5.77, 5.69)	EDD + A + BCT		−3.61 (−9.68, 1.95)
−0.99 (−2.99, 0.99)	−0.86 (−4.33, 2.66)	−0.67 (−3.29, 2.02)	0.21 (−3.81, 4.23)		0.31 (−4.57, 5.19)	−0.23 (−2.13, 1.63)	−1.09 (−6.98, 4.59)	−1.13 (−3.45, 1.18)	R	
−0.62 (−1.59, 0.33)	−0.49 (−3.51, 2.53)	−0.29 (−2.29, 1.73)	0.59 (−3.02, 4.19)		0.68 (−3.86, 5.24)	0.15 (−0.62, 0.83)	−0.72 (−6.28, 4.76)	−0.75 (−2.31, 0.78)	0.37 (−1.38, 2.14)	TAU

Comparisons should be read from left to right. The effectiveness estimate is located at the intersection of the column and row. Mean change in weight (upper part of the table) effect estimate is presented in mean difference in kilogrammes with the 95% credible interval (CrI), mean difference (MD) below 0 favours the column-defining treatment (weight loss). Change in body mass index (bottom part of the table) effects estimate is presented in mean difference in BMI with the 95% CrI, an MD below 0 favours the column-defining treatment (decrease in BMI).

Table 4 Core and additional intervention components for change in BMI (kg/m^2) outcome

	Study ID	Treatment Arm	Number of participants	Exercise	Dietary Advice	Energy deficit diet	Behaviour change technique	Individual delivery	Support Mechanisms
1	Bergstorm *et al.* 2013	TAU	57	✗	✗	✗	✗	✗	✗
	Bergstorm *et al.* 2013	A + DA + BCT	53	✓	✓	✗	✓	✗	✓
2	Boer *et al.* 2016	TAU	16	✗	✗	✗	✗	✗	✗
	Boer *et al.* 2016	A	26	✓	✗	✗	✗	✗	✓
3	Bossink *et al.* 2017	TAU	11	✗	✗	✗	✗	✗	✗
	Bossink *et al.* 2017	R	17	✓	✗	✗	✗	✗	✓
4	Calders *et al.* 2011	TAU	15	✗	✗	✗	✗	✗	✗
	Calders *et al.* 2011	A + R	15	✓	✗	✗	✗	✗	✓
	Calders *et al.* 2011	A	15	✓	✗	✗	✗	✗	✓
5	Harris *et al.* 2017	A + DA + BCT	24	✓	✓	✗	✗	✗	✓
	Harris *et al.* 2017	A + EDD + BCT	24	✓	✗	✓	✓	✓	✓
6	House A *et al.* 2018	TAU	41	✗	✗	✗	✗	✗	✗
	House A *et al.* 2018	BCT	41	✗	✗	✗	✓	✗	✓
7	Melville *et al.* 2015	TAU	48	✗	✗	✗	✗	✗	✗
	Melville *et al.* 2015	A + BCT	52	✓	✗	✗	✓	✗	✓
8	McDermott *et al.* 2012	TAU	94	✗	✗	✗	✗	✗	✗
	McDermott *et al.* 2012	A + DA + BCT	101	✓	✓	✗	✓	✗	✓
9	Ordonez *et al.* 2014	TAU	9	✗	✗	✗	✗	✗	✗
	Ordonez *et al.* 2014	A	11	✓	✗	✗	✗	✗	✗
10	Pett *et al.* 2013	TAU	11	✗	✗	✗	✗	✗	✗
	Pett *et al.* 2013	AR + DA + BCT	11	✓	✓	✗	✓	✗	✓
11	Rimmer *et al.* 2004	TAU	22	✗	✗	✗	✗	✗	✗
	Rimmer *et al.* 2004	A + R	30	✓	✗	✗	✗	✓	✓
12	Silva *et al.* 2017	TAU	13	✗	✗	✗	✗	✗	✗
	Silva *et al.* 2017	A + R	12	✓	✗	✗	✗	✗	✗
13	Neumeier *et al.* 2021	DA + A	15	✓	✓	✗	✗	✗	✗
	Neumeier *et al.* 2021	AR + DA + BCT	14	✓	✓	✗	✓	✓	✓

Exercise ✓ = aerobic exercises or resistance exercises or both; ✗ = none. Behaviour change technique (BCT), dietary advice (DA), energy deficit diet (EDD) ✓ = intervention components are present, ✗ = components are absent. Individual delivery ✓ = intervention delivered to each participant individually; ✗ = delivered in groups. Support mechanisms ✓ = living in a supported setting/presence of care givers, ✗ = living independently/no caregivers.

than participants actively engaging in it. Excluding the study from the analysis did not change the relative effects of the interventions (Supporting information, section J).

Component-level network meta-analysis

CNMA was based on core components and additional components identified as important by our PPI members, including mode of intervention delivery (individually or in groups), the availability of support mechanisms, such as caregiver involvement and residence status (living in a supported setting or independently). Table 4 contains a detailed breakdown of core components for each intervention in the included studies.

CNMA was performed only for change in BMI (kg/m^2) outcome (13 RCTs; 798 participants), given it yielded the most extensive available data. The additive model emerged as the most parsimonious model. As expected, results were consistent with the NMA results, that is, none of the interventions led to meaningful treatment effects when compared with TAU (see Supporting information, section K).

Discussion

Our systematic review is the first to comprehensively explore lifestyle modification interventions targeting a range of single and multiple health risk behaviours in adults with ID, which was co-produced with PPI

members with lived experience. It goes beyond current reviews by focusing on a range of health risk behaviours and outcomes. We systematically dismantled the inter-connected component structure that influences health risk behaviours and identified six distinct core components that exist individually (single core-component) or in various combinations (multiple core component) within intervention and comparator structures. We also assessed the extent of theories and BCTs used in developing and adapting lifestyle modification interventions. As a result, our approach acknowledges the complex nature of lifestyle modification interventions, treating each intervention as distinct.

Our findings show that lifestyle modification interventions targeting alcohol consumption and smoking behaviour with mindfulness and BCT as core components yielded positive effects on outcomes, though the evidence is limited. Interventions aimed at only improving low physical activity with a combination of aerobic exercise, resistance exercise, mindfulness and BCTs as core components, and interventions targeting multiple health behaviours (low physical activity, sedentary behaviour and poor diet) with combinations of aerobic exercise, resistance exercise, diet advice, energy deficit diet, mindfulness and BCT as core components yielded results of mixed effectiveness. While most interventions in both cases generated positive effects on various outcomes, some had no impact or even worsened outcomes. Notably, interventions targeting multiple health behaviours were less likely to result in no change or worsened outcomes compared with those targeting low physical activity only. Overall, no change or worsened outcomes could be attributed to the presence of a single core component (e.g., aerobic exercises) or a combination of similar core components (e.g., aerobic exercises and resistance exercise) in interventions.

Our quantitative synthesis employed meta-analysis methods not used in this field before. We replicated existing pairwise meta-analyses on weight management outcomes and included newer studies. Unlike existing pairwise meta-analysis, which lumps lifestyle modification interventions as homogenous for direct comparison to TAU (Harris *et al.* 2018), our identification of core components also allowed us to perform intervention-level, core-components-based NMA. This enabled the comparison of all interventions directly and indirectly with TAU and each other. Similar to the previous reviews (Harris *et al.* 2018), we focused on RCTs with weight management (anthropometric) outcomes, including change in weight (kg), BMI (kg/m^2), waist circumference (cm) and body fat (%). The majority of interventions with weight management outcomes had aerobic exercise, resistance exercise and BCT as core components and lacked energy deficit diet core component. Our pairwise meta-analysis and NMA results indicated no significant difference in the effect of interventions compared with TAU and each other. In the CNMA, we further dismantled the inter-connected structure of the interventions using the additive model to assess the contribution of the individual core and additional components to the overall intervention effect. Most interventions with weight management outcomes had exercise as a core component and support mechanism as an additional component. Few interventions had energy deficit diet as a core component. Our CNMA confirmed the findings of our NMA, revealing no significant differences between individual components and TAU.

Our findings have practical implications for future research. It highlights the need to address methodological and reporting shortcomings in the existing literature and emphasises the necessity of developing population-specific strategies, measures and evaluation frameworks for lifestyle modification interventions.

Future studies must target a broad range of single or multiple health risk behaviours. In line with the existing reviews (Rotatori *et al.* 1981; Hamilton *et al.* 2007; Bartlo & Klein 2011; Heller *et al.* 2011; Jinks *et al.* 2011; Kerr *et al.* 2013; Spanos *et al.* 2013; Spanos *et al.* 2014; Temple *et al.* 2017; Doherty *et al.* 2018; Harris *et al.* 2018; Willems *et al.* 2018; van Duijvenbode & VanDerNagel 2019; Hassan *et al.* 2019; Bondár *et al.* 2020), our research identified an emerging but unbalanced evidence base, particularly for health behaviours such as alcohol consumption and smoking. Sedentary behaviour should also be considered a separate health risk behaviour rather than simply a lack of physical activity (Melville *et al.* 2011; Spanos *et al.* 2016; Harris *et al.* 2017).

There is a need for more high-quality, appropriately powered studies (Heller *et al.* 2011; Kerr *et al.* 2013; Spanos *et al.* 2013; Bondár *et al.* 2020), which includes diverse population who are not captured by the existing studies. Many of the studies we examined had small, inadequately justified sample sizes set exclusively in high-income countries and under-represented specific population segments, such as adults from ethnic groups other than Caucasian, who are older than 65 years, have long-term medical conditions, and adults with severe to profound levels of ID (Spanos *et al.* 2016; Kouimtsidis *et al.* 2017; Doherty *et al.* 2018; Bondár *et al.* 2020).

Future researchers must observe caution regarding the validity and reliability of existing studies. Included RCTs had a high risk of bias due to deviations from intended interventions, outcome measurement and missing outcome data. There were some concerns related to the randomisation process and the selection of reported results. For non-RCTs, we observed a critical risk of bias from confounding and the classification of interventions, as well as a serious risk of bias from factors such as outcome measurement, missing data, selection of reported results, deviations from intended interventions and participant selection.

The issue of under-reporting observed in most of the studies (Hamilton *et al.* 2007; Heller *et al.* 2011; Spanos *et al.* 2016; Temple *et al.* 2017; Harris *et al.* 2018), could be remedied by developing a comprehensive reporting checklist. The existing studies provide limited information on comorbidities, the relationship between ID and other conditions, socioeconomic status and living arrangements. Related to the intervention design, we observed insufficient intervention description (Willems *et al.* 2018), including lack of a setting-specific definition for the usual care comparator, whether the interventions followed established clinical guidelines, and if theories and BCTs were used (Harris *et al.* 2018). Future researchers may also consider the development of a population-specific instrument, such as theory-coding and behaviour change taxonomy instruments, as the current instruments which were primarily designed for the general population may not be suitable (Michie *et al.* 2011; Willems *et al.* 2019). The inclusion of more objective behaviour change taxonomy items, instead of abstract ones, is also necessary. The appropriateness of behaviour change taxonomy items, such as self-monitoring, for individuals with severe or profound IDs, must also be evaluated by future researchers. Moreover, explicit details on the level of social support, particularly caregiver involvement before and during the intervention, are warranted. Caregiver involvement can increase participant engagement, especially when interventions target participants and caregivers based on their support capacity. Future researchers should consider a holistic approach to improving the intervention adaptation/development, design and acceptability, which involves incorporating a wider stakeholder group encompassing people with lived experience. Also, methods to enhance intervention accessibility and personalisation should be shared widely.

Additionally, although newer studies have included mental health and quality of life outcomes, cost-effectiveness outcomes were absent. The choice of primary and secondary outcomes and their measures, the reliability and suitability of self-reported or proxy measures, and the overall clinical significance of the effects require careful consideration. A distinction must be made between outcomes with immediate or long-term effects in real life. For example, while behaviours take a long time to develop, the psychological impact of interventions is often immediate. Also, future researchers must consider the correlation arising from the inclusion of similar multiple outcomes measured at various time points. To ensure long-term behaviour change and improved health outcomes, it is imperative for future researchers to ascertain whether the effectiveness of lifestyle modification interventions can be sustained over an extended period. Several studies did not report the adverse effects and reasons for participants' attrition. The short follow-up and lack of information on the maintenance period hinder the assessment of long-term changes in behaviour (Heller *et al.* 2011; Temple *et al.* 2017; Harris *et al.* 2018). Future researchers should also investigate participants' experiences and the influence of external social or environmental factors on the intervention's effectiveness.

Our review does have several limitations that need to be acknowledged. Our PPI group did not include family and paid caregivers, which could have enriched the findings. We used filtering criteria in clinical trial registries to focus on adult participants, which may have influenced the inclusiveness of our study pool.

Caution is warranted when interpreting coding related to the extent of theory use and behaviour change taxonomy. It is important to note that Michie *et al.*'s theory coding scheme and behaviour change taxonomy was developed for the general population and emphasises motivational influences (Michie & Prestwich 2010; Michie *et al.* 2013). Thus, it rendered the coding process difficult and subjective. Similarly, care should be exercised when interpreting and generalising findings from non-RCTs, especially case–control studies that included the general population without intellectual disabilities. Moreover, our meta-analysis was confined to RCT-based weight management outcomes and constrained due to its limited availability. Other outcomes and studies with non-RCT design could not be included due to high heterogeneity. Our pairwise meta-analysis may have introduced heterogeneity by 'lumping' interventions; however, this is an inherent shortcoming of the method, which lets us optimise our analysis when there is limited data. The inconsistencies in reporting in studies also affected our ability to include individual BCTs as a component in CNMA. Although the component NMA could not pinpoint the optimal combination of components for enhancing intervention effectiveness, it provides a foundation for exploring its application in this field. Overall, the results of the meta-analysis should also be interpreted carefully as included studies had a high and moderate risk of bias. The inconsistency and insufficient reporting by studies also led to complications in the assessment of the risk of bias in non-RCTs. Therefore, our study's findings should be interpreted with due consideration of these limitations, as they could have influenced the scope and depth of our conclusions.

In conclusion, our systematic review summarises the importance of mixed-methods research in understanding lifestyle modification interventions and the need for population-specific improvements in the field. These improvements include the need for tailored lifestyle modification interventions, the development of evaluation instruments or tools, the use of rigorous research methodologies, and comprehensive reporting frameworks. Related knowledge should be widely disseminated. Finally, the involvement of PPI groups, including people with lived experience, will help future researchers design interventions that consider the unique needs, desires and abilities of people with ID.

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Conflict of interest

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Ethics approval statement

This research did not require any ethical approval.

Data availability statement

Further data from either part of the project are available on request from the corresponding author.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.

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