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Extended Research Article

Understanding the effectiveness and underlying mechanisms of lifestyle modification interventions in adults with learning disabilities: a mixed-methods systematic review

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Abstract

Background: Adults with learning disabilities face increased risks of unhealthy lifestyle behaviours, including alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet. Lifestyle modification interventions that target health-risk behaviours can prevent or reduce their negative effects. The goal of this project was to investigate the effectiveness and underlying mechanisms of lifestyle modification interventions in adults with learning disabilities.

Methods: A systematic review and meta-analysis were conducted to determine the effectiveness of lifestyle modification interventions and their components in targeting health risk behaviours in adults with learning disabilities. Major electronic databases, clinical trial registries, grey literature, and citations of systematic reviews and included studies were searched in January 2021 (updated in February 2022). We included randomised and non-randomised controlled trials targeting alcohol consumption, smoking, low physical activity only, sedentary behaviour and poor diet in adults (aged ≥ 18 years) with learning disabilities. Studies were also coded based on the extent of use of theories and behaviour change techniques in interventions. Risk of bias in studies was assessed using appropriate tools. A realist synthesis of qualitative, quantitative and mixed-methods literature was conducted to complement the systematic review findings by identifying key intervention mechanisms that are likely to improve the health of adults with learning disabilities. Data were synthesised in the form of a programme theory regarding complex causal mechanisms and how these interact with social context to produce outcomes. All findings were integrated into a logic model. A patient and public involvement group provided input and insights throughout the project.

Results: A total of 80 studies with 4805 participants were included in the systematic review. The complexity of lifestyle modification interventions was dismantled by identifying six core components that influenced outcomes. These components could be present in interventions targeting single or multiple health risk behaviors, either as individual elements or in various combinations. Interventions on alcohol and smoking behaviours were found to be effective, but this was based on limited evidence. The effectiveness of interventions targeting low physical activity only or multiple behaviours (low physical activity only, sedentary behaviours and poor diet) was mixed. All interventions had a varying level of statistical significance. The intervention-level network meta-analysis for weight management outcomes showed none of the interventions was associated with a statistically significant change in outcomes when compared to treatment as usual and each other. Similar findings were observed in the component network meta-analysis. A variety of theories and behaviour change techniques were employed in the development and adaptation of interventions. Most studies had a high and moderate risk of bias.

A total of 79 studies, reporting the experiences of more than 3604 adults with intellectual disabilities and over 490 caregivers, were included in the realist synthesis. The resulting programme theory highlighted the contexts and mechanisms relating to support involvement, negotiating the balance between autonomy and behaviour change, fostering social connectedness and fun, the accessibility and suitability of intervention strategies and delivery, along with the broader behavioural pathways to lifestyle change. It also brought out the importance of working with people with lived experiences when developing and evaluating interventions. Our logic model, bringing together the findings of both syntheses, provides guidance on the design of future interventions.

Discussion: This study was the first comprehensive mixed-methods evidence synthesis to explore lifestyle modification interventions targeting multiple unhealthy lifestyle behaviours in adults with learning disabilities. We conclude that future research could benefit from codeveloping interventions and population-specific assessment frameworks with people with lived experiences. There is a need for more high-quality research with appropriate outcomes and a focus on qualitative and mixed-methods research to better understand what works for whom and why.

Trial registration: This trial is registered as PROSPERO CRD 42020223290.

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List of abbreviations

ASSIA	Applied Social Sciences Index and Abstracts
BCT	behaviour change technique
BMI	body mass index
CENTRAL	Cochrane Central Register of Controlled Trials
CI	confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CMOC	context–mechanism–outcome configurations
CNMA	component network meta-analysis
CrI	credible interval
DIC	deviance information criteria
EDD	energy-deficit diet
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre
GRADE	Grading of Recommendations Assessment, Development and Evaluation
ISRCTN	International Standard Randomised Controlled Trials Number
MCMC	Markov Chain Monte Carlo
MD	mean difference
NMA	network meta-analysis
PPI	patient and public involvement
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analysis
RCT	randomised controlled trial
ROBINS-I	Risk Of Bias In Non-randomised Studies – of Interventions
SD	standard deviation
SE	standard error
TAU	treatment as usual
TCS	theory coding scheme

Plain language summary

Our question

Adults with learning disabilities are more likely to have an unhealthy lifestyle. This includes alcohol misuse, smoking, not much physical activity and an unhealthy diet. An unhealthy lifestyle can cause serious health problems. We wanted to understand what and why lifestyle change programmes for adults with learning disabilities work, how they work and why they work sometimes but not others.

What we did

We searched for studies about lifestyle change programmes on alcohol consumption, smoking, low physical activity only, sedentary behaviour, and poor diet in adults with learning disabilities. We split our review into two. The first review focused on studies on lifestyle change programmes. The second review focused on some studies from the first review and also studies that interviewed people with learning disabilities and their caregivers.

We also asked what people with learning disabilities and other researchers thought were important.

What we found

Our first review found 80 studies with 4805 adults. Studies showed mixed results related to what existing lifestyle change programmes work in adults with learning disabilities. Our second review found 79 studies. It explained the results of the first review and identified key characteristics of lifestyle programmes that are likely to improve the lives of adults with learning disabilities. Both reviews found that changing the lifestyles of adults with learning disabilities is very complex. We identified various personal, health, social and environmental aspects that are important to adults with learning disabilities.

Conclusions

Current lifestyle change programmes need to consider the needs, wants and lives of people with learning disabilities. The best way to do this is by involving people with lived experiences when making the programmes.

Scientific summary

Background

Adults with learning disabilities are at an increased risk of unhealthy lifestyles consisting of multiple behaviours, including alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet. These health-risk behaviours often occur together and significantly impact their life expectancy. Lifestyle modification interventions that target health-risk behaviours can prevent or reduce such negative effects.

Aims and objectives

The goal of our project was to investigate the effectiveness and underlying mechanisms of lifestyle modification interventions in adults with learning disabilities.

Following are our objectives:

1. to determine the effectiveness of lifestyle modification interventions and their components in targeting health risk behaviours in adults with learning disabilities;
2. to establish how lifestyle modification interventions for adults with learning disabilities work, for whom they work, as well as why they may work in particular circumstances and not in others;
3. to integrate the findings of the quantitative and qualitative syntheses using a logic model;
4. to identify future research priorities to develop lifestyle modification interventions for the NHS and social care services to improve the health of adults with learning disabilities.

Methods

We conducted a mixed-methods evidence synthesis, which includes a systematic review, meta-analysis and realist evidence synthesis. Our patient and public representatives were consulted throughout the process.

Systematic review and meta-analysis

Our systematic review included randomised controlled trials (RCTs) and non-randomised controlled trials (controlled and uncontrolled pre–post studies and case-control studies) of lifestyle modification interventions for adults with learning disabilities.

Participants aged ≥ 18 years were considered as adults. Learning disability was defined as a limitation in intellectual functioning (intelligence quotient < 70) and adaptive behaviour with onset before age 18 years.

We included lifestyle behaviour change interventions targeting one or more of the following health-risk behaviours: alcohol consumption, smoking (cigarettes or tobacco), low physical activity only, sedentary behaviour and poor diet. We included studies that measured and reported any primary or secondary outcomes of lifestyle modification interventions.

We searched key databases, clinical trial registries, grey literature and additional sources such as citations of systematic reviews and included studies. Two review authors independently assessed studies for inclusion data. Three authors extracted the data and coded the extent of theory use and behaviour change techniques in interventions using Michie's 19-item theory coding scheme and 94-item behaviour change taxonomy. They also assessed the risk of bias in studies using the Cochrane Risk of Bias (ROB) Version 2 and Risk of Bias in Non-randomised Studies of Interventions (ROBINS-I).

We also conducted an intervention-level and component-level meta-analysis of weight management outcomes reported by randomised clinical trials whose interventions targeted low physical activity, sedentary behaviour and poor diet. The pairwise meta-analysis determined the effectiveness of all lifestyle modification interventions compared with treatment as usual (TAU). The network meta-analysis determined the effectiveness of all lifestyle modification interventions compared directly and indirectly with each other and TAU. A random-effects model was used. This analysis was extended to a component network meta-analysis to identify the most effective components of lifestyle modification interventions targeting weight management outcomes. An additive model, which assumes the effect of a multicomponent intervention is the sum of individual effects of each component, was used.

Realist synthesis

The realist synthesis was conducted to develop a programme theory to identify the contexts and mechanisms (e.g. how the intervention works: behavioural and emotional responses) that together contribute to intervention outcomes. First, a draft programme theory was based on non-systematic search of the literature and input from expert researchers and the patient and public involvement (PPI) group. Following this, formal searches were conducted and the systematic screening procedures were used to select a short list of eligible studies. This was conducted simultaneously with the systematic review. The formal searches conducted were used to shortlist a selection of studies. Following realist synthesis guidelines, these were then appraised for relevance to the programme theory and methodological rigour using pre-selected quality appraisal tools. Additional searches were conducted to address any gaps in the literature.

To synthesise the data, the richest sources were identified through rereading the studies. These were uploaded to NVivo, and a coding framework was developed. After this was finalised through iterative discussions between two researchers, the remaining studies were uploaded, and the coding framework was applied. Following this, the specific interacting contexts and underlying mechanisms were appraised, and the synthesis focused on developing context–mechanism–outcome configurations (CMOCs), which formed the basis of the emerging programme theory. This was finalised through discussions and feedback with the wider research team and the PPI group.

Results

Systematic review and meta-analysis

We found 80 studies (35 RCTs, 11 controlled pre–post studies, 28 uncontrolled pre–post studies and 6 case-control studies), with 4805 participants reporting the effects of interventions targeting alcohol consumption, smoking, low physical activity only, sedentary behaviour and poor diet. We identified and defined a range of core components present in lifestlyle modification interventions based on the descriptions of included studies and any follow-up studies. Core components are single or multiple interacting contents of an intervention which influence its outcomes. We identified six core components of the interventions and comparators: (1) aerobic exercise; (2) resistance exercise; (3) energy-deficit diet; (4) diet advice; (5) mindfulness; and (6) behaviour change techniques. Interventions and comparators could comprise of any combinations of these core components. These components could be present in interventions targeting single or multiple health risk behaviors, either individually or in various combinations. It must be noted that the behaviour change technique component was only identified if explicitly stated by the study. Whereas, Michie's 94-item behaviour change taxonomy is a tool used separately to identify the extent which these techniques were used.

We have reported our findings according to the target health behaviour of the studies.

- Six studies with 228 participants targeted alcohol consumption and smoking behaviour. This included two RCTs, one controlled pre–post and three uncontrolled pre–post studies. Core components of interventions and comparators consisted of behaviour change techniques, mindfulness and a combination of both. These interventions targeted behavioural, cognitive, knowledge-related, psychosocial and quality-of-life outcomes of participants. The RCT-based intervention for alcohol consumption had mixed effectiveness results, improving behavioural outcomes but worsening quality of life outcomes. The RCT-based smoking intervention also improved behavioural outcomes. Among the non-RCTs, the strengths of improvement in outcomes varied, a strong improvement was observed on knowledge-related outcomes. However, these results were based on limited evidence and had a varying level of statistical significance.

- Thirty-three studies with 1413 participants targeted low physical activity only behaviour. This included 16 RCTs, 2 controlled pre–post, 13 uncontrolled pre–post and 2 case-control studies. Core components of interventions and comparators primarily consisted of aerobic exercise only or a combination of aerobic exercise, resistance exercise, behaviour change technique and mindfulness. These interventions targeted anthropometric, cardiorespiratory, functional and general health outcomes. In RCTs, intervention effectiveness was mixed, leading to improvements in outcomes as well as instances of no change or worsened outcomes. Non-RCTs also exhibited a similar range of effects on outcomes across different studies. No change or worsened outcomes could be attributed to the presence of a single core-component or a combination of similar core-components. However, the interventions had a varying level of statistical significance.
- Forty-one studies with 3164 participants targeted multiple behaviours, that is, low physical activity, sedentary behaviour, and poor diet together. This included 17 RCTs, 8 controlled pre–post, 12 uncontrolled pre–post and 4 case-control studies. Core components of interventions and comparators primarily consisted of a combination of energy-deficit diet (EDD), aerobic exercise and behaviour change technique. Other component combinations included diet advice and resistance excercise. These interventions targeted anthropometric, behavioural, cardiorespiratory, functional, cognitive, food and nutrition, physical activity and sedentary behaviour-related, psychosocial, quality of life and general health outcomes. Similar to the low physical activity-only interventions, multiple behaviour interventions reported results of mixed effectiveness. RCT-based interventions resulted in improvements across a range of outcomes, although the strength of these effects varied or, in some instances, led to no change or adverse outcomes which could be attributed to the presence of a single core-component or a combination of similar core-components. Similar results were observed in non-RCTs. Compared to interventions targeting low physical activity only, fewer studies with interventions targeting multiple behaviours reported no change or worsened outcomes. However, the interventions had a varying level of statistical significance.

Our meta-analysis was conducted on weight management outcomes: change in weight, change in body mass index (BMI), change in waist circumference and change in body fat. The pair-wise meta-analysis was conducted on two weight management outcomes: change in weight and change in BMI. The network meta-analysis was conducted on all weight management outcomes listed above.

- Change in weight (kg): Pair-wise meta-analysis (9 RCTs, 542 participants) found that the change in weight by the lifestyle-modifying interventions was not significant when compared to the TAU (mean difference = −0.46; 95% CI −1.25 to 0.33). Network meta-analysis (13 RCTs, 690 participants, 8 interventions) showed that the change in weight ranged from a decrease of 3.7 kg to an increase of 700 g when compared to TAU. None of the interventions could show a statistically significant change in weight.
- Change in BMI (kg/m^2): Pair-wise meta-analysis (11 RCTs, 721 participants) found that the change in BMI by the lifestyle-modifying interventions was not significant when compared to TAU (mean difference = −0.45, 95% CI −1.05, 0.15). Network meta-analysis (13 RCTs, 798 participants, 9 interventions) showed that the change in BMI ranged from a decrease of 1 kg/m^2 to an increase of 0.6 kg/m^2 when compared to TAU. None of the interventions could show a statistically significant change in BMI.
- Change in waist circumference (cm): we found a disconnected network (8 RCTs, 378 participants, 6 interventions). Our network meta-analysis showed that none of the interventions could show a significant change in waist circumference when compared with TAU (a decrease of 2.8 cm to an increase of 1.8 cm). None of the interventions could show a statistically significant change in waist circumference (cm).
- Change in body fat: we found a disconnected network (4 RCTs with 139 adults evaluating 4 interventions). In a connected network, the TAU was not the comparator. Instead, the comparator was dietary advice and aerobic exercise. None of the interventions could show a statistically significant change in body fat.

For the component network meta-analysis (CNMA), we included core components, as mentioned above, and identified further components that were deemed as important by our PPI group members. This included mode of delivery of interventions, availability of support mechanisms, and residence status. We also combined aerobic exercise and resistance exercise core components as exercise. Exercise was the most common intervention component. CNMA was conducted only for BMI outcomes due to the availability of extensive data. Our analysis showed that none of the individual components could produce a statistically significant change in BMI when compared to TAU.

Overall, our review found that adults with learning disabilities who are of ethnicities other than Caucasian, who are older than 65 years, who have long-term medical conditions and who have severe to profound levels of learning disabilities are underrepresented in the studies. The evidence base in this field is imbalanced in terms of the health behaviours targeted by the interventions.. It also lacks methodological and reporting rigour. There is a lack of high-quality, appropriately powered studies in this field. Sample size is often unjustified. The intervention, its intensity and follow-up period varied across studies. Most studies had short follow-ups (maximum of 12–18 months). Primary and secondary outcomes were not always clearly defined in studies. Variety of outcomes also contributed to studies neglecting the correlation between multiple outcomes, and the same outcome measures at multiple time points. There was a lack of standardised measures used to assess similar outcomes. Other important information about participant and intervention characteristics, including extent of theories and behaviour change techniques used in intervention development, was limited.

Realist evidence synthesis

A total of 79 studies were included in the realist evidence synthesis. These included intervention studies along with relevant qualitative and mixed-methods studies. The programme theory developed consisted of 33 CMOCs and involved 6 partial programme theories. These partial programme theories are related to negotiating the balance between autonomy and behaviour change, importance of support involvement, accessibility and suitability of intervention strategies, delivery of the intervention, social connectedness and fun and the broader pathways to behaviour change. The programme theory emphasised the complexity of lifestyle modification for adults with learning disabilities and the importance of including people with lived experiences when developing interventions.

Synthesis of findings

We integrated the findings from the systematic review, meta-analysis and realist evidence synthesis by developing a logic model. We started by examining the studies that were included in both the systematic review and realist evidence synthesis to explore why some interventions were (in)effective. Our logic model shows the intervention mechanisms and provides guidance on designing an appropriate lifestyle modification intervention for a maximum and long-lasting impact on lives of adults with learning disabilities.

Conclusion

This study was the first comprehensive mixed-methods evidence synthesis to explore lifestyle modification interventions targeting multiple unhealthy lifestyle behaviours in adults with learning disabilities. The study was coproduced with people with learning disabilities and ensured the findings reflected their needs and experiences. Our quantitative and qualitative findings complement each other.

Key research recommendations:

1. Codevelop new research studies with people living with learning disabilities. There needs to be greater reflection on how to make methods more accessible to improve the inclusion of adults with severe and profound learning disabilities in research.
2. Undertake research to codevelop population-specific materials, including new frameworks for assessing extent of theory and behaviour change taxonomies used in development of interventions.
3. Undertake research to address variability in methodologies used in assessing effectiveness of interventions in research studies. This includes designing high-quality studies with appropriate outcomes.
4. Undertake more qualitative and mixed-method research to improve understanding of what works, for whom and why.

Key recommendations for policy and practice:

1. New lifestyle interventions need to be co-designed with people living with intellectual disability and their caregivers.
2. There is unlikely to be a one-size-fits-all approach, instead a more holistic person-centred approach is required that addresses root causes, is tailored to individual context and codeveloped with the individual and their carers.

3. Communications should be clear, simple, precise and codeveloped with the target audience.
4. Future interventions should include peer support, fun, group-based activities and opportunities for social interaction. All of which can offer important far-reaching benefits such as improved well-being and quality of life which should be considered as part of a person-centred compassionate approach to long-term care and measured accordingly.

Trial registration

This trial is registered as PROSPERO CRD 42020223290.

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Chapter 1 Background

Adults with learning disabilities are individuals diagnosed as experiencing impairments in intellectual and adaptive functioning during their developmental period (< 18–22 years).[2] Impairments in intellectual functioning include challenges with learning, problem-solving and reasoning skills and are indicated by an intelligence quotient (IQ) score < 70, which is two standard deviations below the average.[2] Given the criticisms related to this arbitrary cut-off, recent diagnostic manuals have adopted a more flexible upper limit of an IQ < 75.[3] Adaptive functioning is necessary for independent living and supports conceptual skills such as language and the concept of time and practical skills such as the use of money.[2] Commonly, the levels of learning disabilities are defined based on IQ scores, which range from mild (IQ < 70–50) to profound (IQ < 20) or by assessing the level of required support.[4] Individuals with mild learning disabilities are able to live independently with some additional support, whereas individuals with moderate learning disabilities are also able to live relatively independently but require more 'moderate' support. Individuals with severe or profound learning disabilities are unable to live independently and require daily assistance or 24-hour care.[2,4]

Adults with learning disabilities have considerably poorer health compared to individuals without learning disabilities.[5] Consequently, this also means that they have a significantly higher likelihood of experiencing a reduced life expectancy by 20 years, which is primarily caused by metabolic respiratory, circulatory and heart diseases.[6–8] Thus, improving their health and well-being is a priority in order to address the wide range of preventable health risks, reduced life expectancy and inequalities.[7,9]

In the UK, adults with learning disabilities have transitioned from living in institutional settings to residing in the community.[10] While living in the community is less restrictive and offers more opportunities, it exposes them to social and environmental pressures.[11] This is concerning as their health and well-being are being further impacted by unhealthy lifestyles, consisting of multiple behaviours such as alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet. Gateway theories postulate that participating in one unhealthy lifestyle behaviour can increase the risk of another, which may have multiple detrimental effects on an individual's overall health.[12,13]

High alcohol consumption is known to worsen health inequalities and is associated with an increased risk of all-cause mortality in the general population.[14,15] It also increases the risk of coronary disease and heart failure,[15] which are leading causes of mortality among adults with learning disabilities.[7,8] Although adults with learning disabilities may have lower overall alcohol consumption, the rate of alcohol misuse may be higher among this population.[16] Relatedly, respiratory conditions are a leading cause of mortality among adults with learning disabilities.[7,8] Adults with mild learning disabilities may have higher smoking rates compared to those with more severe learning disabilities.[17] However, research has yielded mixed results on how smoking rates among these populations compare to the general population.[16]

Adults with learning disabilities are consistently reported to have low levels of physical activity, with approximately 9% meeting the recommended levels needed to maintain a healthy lifestyle.[18] They also have high levels of the sedentary behaviour.[19] Sedentary behaviour refers to all waking behaviours in sitting or lying positions that do not increase energy expenditure and do not describe low levels of physical activity.[20] However, there has been less focus on sedentary behaviour in the literature on learning disabilities, with researchers sometimes incorrectly defining low physical activity as sedentariness.[21,22] Related research has also found an association between physical activity, sedentary behaviour and mental health.[23] Low levels of physical activity and high levels of sedentary behaviour have been independently linked to an increased risk of all-cause mortality, cardiovascular disease and type 2 diabetes, as well as poorer perceived health.[24,25] High levels of physical activity can also reduce sedentary behaviour and risk of lower life expectancy.[26] Although mixed findings have been reported for sedentary behaviour, there is evidence of an association between obesity and low physical activity for adults with learning disabilities.[6,19,27] Obesity is a modifiable risk factor for numerous

non-communicable diseases and reduced life expectancy resulting from an imbalance between energy expenditure and energy intake often through diet.[18]

Research has indicated that adults with learning disabilities may have unhealthy diets,[28] which also reflects the health inequalities in this population. Poor-quality diets contribute to obesity and non-communicable diseases.[29] Intake of fruit and vegetables, an essential part of healthy diet, has been reported to be low in adults with learning disabilities.[28] Additionally, the overall quality of diet was poor compared to adults without learning disabilities.[30] It has been suggested that diet quality may be poorest among individuals with mild learning disabilities compared to individuals with severe or profound learning disabilities. A possible reason could be reduced support adults with mild learning disabilities may have with their diets compared to adults requiring 24-hour care and supervision.[30]

Programmes or interventions that have been developed to target health risk behaviours can prevent or reduce their negative health consequences.[31]

There is an emerging number of literature on lifestyle modification interventions for adults with learning disabilities.[32–46] However, these literature tend to be imbalanced as they focus only on particular health risk behaviours. They concentrate on interventions targeting low physical activity only[36–38,41] or a combination of low physical activity and poor diet.[32–35,42–46] Only a few reviews target alcohol consumption and smoking behaviour.[39,40] Reviews also mostly concentrate on multiple broad outcomes related to physical activity or weight management outcomes.[32,34–38,44,45] Moreover, existing literature also overlooks the assessment of intervention design, including the application of theories and behaviour change techniques. Lifestyle modification interventions, whether targeting single or multiple health risk behaviours, are complex interventions with inter-connected component structures.[47] The process of behaviour modification itself is multifaceted. Although the literature recognises the complexity of such interventions, they do not attempt to deconstruct their structure to understand how they influence unhealthy lifestyle behaviours. So far, only one review on weight management interventions has tried to identify intervention components.[34,35] It can be difficult to determine the individual contributions of each component to the overall effect of the complex intervention as effectiveness is influenced by its characteristics, the setting or context of its implementation, intervention implementation processes and intervention participants.[47] For example, physical activity participation is impacted by numerous factors, including social support, caregiver knowledge and organisational policies for activity promotion, in addition to influences such as motivation and own knowledge of the behaviours.[7] Thus, a methodological approach is necessary, particularly for quantitative synthesis. Relatedly, quantitative synthesis of evidence regarding the effectiveness of these interventions remains limited, with only one review[32] quantitatively assessing weight management interventions. Using a lumped approach treats interventions as homogenous entities to enable comparison with usual care in pairwise meta-analysis.

Therefore, there is an urgent need for a comprehensive synthesis of lifestyle modification interventions for all the behaviours contributing to unhealthy lifestyles in adults with learning disabilities. Such synthesis may enrich our understanding of complex interventions and their underlying mechanisms while contributing to the development of effective strategies for addressing health-risk behaviours in adults with learning disabilities.

Aims and objectives

The goal of this project was to investigate the effectiveness and underlying mechanisms of lifestyle modification interventions in adults with learning disabilities. In particular, we sought:

1. to determine the effectiveness of lifestyle modification interventions and their components in targeting health risk behaviours in adults with learning disabilities;
2. to establish how lifestyle modification interventions for adults with learning disabilities work, for whom they work, as well as why they may work in particular circumstances and not in others;
3. to integrate the findings of the quantitative and qualitative syntheses using a logic model;
4. to identify future research priorities to develop lifestyle modification interventions for the NHS and social care services to improve the health of adults with learning disabilities.

Chapter 2 Methods

A mixed-methods evidence synthesis approach was used. A systematic review and meta-analysis were undertaken to determine effectiveness of interventions targeting all core health risk behaviours (alcohol consumption, smoking, low physical activity, sedentary behaviour and poor diet). Intervention-level and component-level meta-analysis were conducted to quantify the overall effects of the intervention and its components. A realist evidence synthesis was undertaken to determine what works, for whom, in what context and why for adults with learning disabilities. The systematic review and realist evidence synthesis were conducted simultaneously. One single search was conducted to identify relevant evidence; however, the realist synthesis incorporated additional qualitative and mixed-methods literature. A logic model was developed to integrate the findings of all three methods.

This evidence synthesis was coproduced by academic researchers and patient and public involvement (PPI) group with learning disabilities, who challenged our assumptions and provided guidance and feedback on all stages. Such collaboration is imperative to ensure interventions reflect lived experiences of adults with learning disabilities.[48]

Systematic review and meta-analysis

The systematic review and meta-analysis adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA), its extension on incorporating network meta-analysis and reporting literature searches and the principles set out by the International Society for Pharmacoeconomics Outcomes Research (ISPOR) Taskforce.[49–53]

Eligibility criteria

Participants

We included studies on adults (mean age ≥ 18 years) with learning disabilities. We followed the international definition of learning disability, which is a limitation in intellectual functioning (intelligence quotient <70) and adaptive behaviour with onset before age 18 years. These definition criteria were updated to intelligent quotient <75 and adaptive onset before age 22 years in 2021.[54] We also captured studies including adults with Down syndrome, given their diversity in severity level of learning disabilities and evidence suggesting that generic behaviour change programmes work for them.

Intervention and comparators

Studies with lifestyle modification interventions on one or more of health-risk behaviours: alcohol consumption, smoking (cigarettes or tobacco), low physical activity, sedentary behaviour and poor diet were included. There were no restrictions on intervention settings. Comparators could include active comparators, controls or ‘treatment as usual’. We accept that the study authors may have different definitions of usual care depending on the study setting and timing.

Outcomes

We included studies that measured and reported any primary or secondary outcomes of lifestyle modification interventions.

Type of studies

We included individual or cluster RCTs and non-randomised study designs such as pre–post controlled, uncontrolled studies and case-control studies.

Information sources

We conducted electronic searches of the following five databases from inception up to 14 January 2021:

- Applied Social Sciences Index and Abstracts (ASSIA) via ProQuest;
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO Host;
- Ovid EMBASE 1947 to present, updated daily;
- Ovid MEDLINE (R) 1946 to January 2021;
- APA PsycINFO via EBSCO Host.

We also searched the following registered and ongoing clinical trial registries:

- Cochrane Central Register of Controlled Trials (CENTRAL) – https://www.cochranelibrary.com/central
- U.S National Library of Medicine ClinicalTrials.gov – https://clinicaltrials.gov/
- International Standard Randomised Controlled Trials Number (ISRCTN) – https://www.isrctn.com/
- Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) – https://eppi.ioe.ac.uk/cms/.

We identified Grey literature via Google Scholar and conducted citation searches of existing systematic reviews and included studies. An updated main database search was conducted in February 2022. We monitored for new publications and tracked protocols of unpublished studies to ensure all relevant studies were included. Where necessary, we sought translation of studies written in languages other than English and pre-print versions of newer studies.

It is important to note that our search strategies (see *Appendix 1*) were designed to capture studies relevant for both the systematic review and the realist evidence synthesis. We consulted our university library, PPI group members and the project team during the strategy development process. Moreover, search filters were used in clinical trial registries to filter past or ongoing trials according to adult participants.

Selection process

Reference management software Covidence and EndNote X9 were used to collate the results of searches. Duplicates were removed and double-checked by reviewers using Covidence software's in-built feature. Two of four review authors (DR, SW) independently screened the titles and abstracts to identify relevant studies. Results were compared at regular intervals, and consensus was reached through discussion with a third reviewer (AMG). Following full-text retrieval, relevant studies were tagged for inclusion in the systematic review and the realist evidence synthesis.

Data collection process and items

Our data extraction form was adapted from the Cochrane Handbook[55] and existing systematic reviews. PPI group was consulted to ensure that all important data were captured. The form captured the following information and was recorded in Microsoft Excel®:

- Study information: year of publication, country where the study was conducted, funder, study design, aim, study inclusion and exclusion criteria.
- Population information: recruitment process, age, gender, ethnicity, socioeconomic status, level of learning disabilities, comorbidities and residential setting.
- Intervention and comparator information: number of participants in each group, comparator description, intervention target, intervention provider, social support information, accessibility of intervention, intervention development and adaptability, extent of use of theories and behaviour change taxonomy, intensity of interventions and extent of intervention individualisation.
- Outcomes: all relevant outcomes as measured and reported, including time points of measurement.

During the data extraction process, we also coded the extent to which theory has been used in the intervention design using a 19-item Theory Coding Scheme (TCS) by Michie *et al.*[56] Similarly, a 93-item behaviour change taxonomy by Michie *et al.*[57] was used to code the extent of behaviour change techniques utilised by the intervention. In both cases, items were coded only if the studies provided sufficient descriptions matching the item definition.

We combined studies on the same population or follow-up publications under a single identification number. Data from the included studies was extracted by three authors (DR, SW, NJ) independently using pre-piloted data extraction designed for the review.

Study risk of bias assessment

We conducted risk of bias assessments for RCTs using Cochrane Risk of Bias (ROB) Version 2.[58] The following five domains were assessed:

- Domain 1: risk of bias arising from the randomisation process.
- Domain 2: risk of bias due to deviations from the intended interventions.
- Domain 3: risk of bias due to missing outcome data.
- Domain 4: risk of bias in measurement of the outcome.
- Domain 5: risk of bias in selection of the reported result.

Similarly, we assessed non-RCTs using Risk of Bias in Non-randomised Studies of Interventions (ROBINS-I)[59] on the following seven domains:

- bias due to confounding;
- bias due to selection of participants for the study;
- bias in classification of interventions;
- bias due to deviation from intended interventions;
- bias due to missing data;
- bias in measurement of outcomes;
- bias in selection of the reported results.

Three authors (DR, SW, NJ) independently assessed the studies twice using the tools. Overall assessment was made following the tool's guidance. The RoB Version 2's risk of bias judgement was stated as low, high and some concerns. The ROBINS-I's risk of bias judgement was stated as low, moderate, serious, critical and no information. Any discrepancies were resolved through discussion. All eligible studies were included in the systematic review, regardless of their risk of bias assessments.

Narrative synthesis

We conducted a narrative synthesis of the lifestyle interventions evaluated in all the studies included in the systematic review. The evidence was summarised separately for interventions that targeted alcohol consumption and smoking behaviour; low physical activity only; and multiple behaviours (low physical activity, sedentary behaviour and poor diet).

Meta-analysis

We conducted meta-analysis at an intervention-level and component-level. We were only able to include weight management (anthropometric) outcomes reported by RCTs of weight management interventions. These outcomes were derived from studies that targeted low physical activity only behaviour and multiple behaviours (low physical activity, sedentary behaviour and poor diet).

We extracted continuous and dichotomous data depending on the measurement methods, tools and scales used by the study authors. Where possible, we reported continuous data as mean differences (MDs) or standardised mean differences (SMDs) and dichotomous data as risk ratios (RRs), along with their 95% confidence intervals (CIs).

The following actions and calculations were undertaken:

- if mean change and standard error/deviation (SE/SD) from baseline for each intervention arm were reported, we recorded the same outcome as the study;
- if only mean and confidence intervals were reported, we used CIs to impute SEs or SDs;

- if the key statistics like SDs or SEs were not available in the published report and no data were available to calculate them, we excluded the studies from both meta-analyses;
- if the two-arm RCTs had interventions and comparators with same core components, we excluded the study from both meta-analyses;
- if multiarm RCTs had intervention arms with same core components, we combined the arms using the formulae described in chapter 7 of the *Cochrane Handbook for Systematic Reviews of Interventions*;[55]
- if data were not combined in studies selected for inclusion in the network meta-analysis, we calculated the variance and covariances between the treatment arms.

We attempted to contact the study authors via e-mail if further information was needed on the reported outcome. Other outcomes could not be pooled together due to the high level of heterogeneity pertaining to the measuring and reporting of outcomes. We did not pool studies from non-RCTs.

Intervention-level meta-analysis

Meta-analysis at this level was based on the intervention and performed in statistical software R:

1. A pairwise meta-analysis compared the effectiveness of all lifestyle modification interventions targeting weight management outcomes with treatment as usual (TAU). Here, all interventions were 'lumped' together to compare our results with existing systematic reviews and meta-analyses. A random effects model was used. Subgroup analysis was based on the intervention core components, such as exercise only, behaviour change technique (BCT) only and multicomponent interventions.
2. A network meta-analysis (NMA) compared the effectiveness of all lifestyle modification interventions targeting weight management outcomes directly and indirectly with TAU and with each other. A random-effects model was used. The analysis was carried out using Bayesian Markov chain Monte Carlo method fitted using Just Another Gibbs Samplers (JAGS) software within BUGSnet and Gemtc packages for R statistical software.

The models were assessed for their adequacy and parsimony. Model fit was assessed using the DIC (Deviance Information Criteria), complexity of the model (pD) and residual deviances (Dres) in leverage plots. We compared the posterior mean deviance of the individual data points in the inconsistency model against the consistency model. We performed the sensitivity analysis by excluding studies where the exercise interventions used power-assisted equipment and participants did not actually perform the exercises.

Component-level meta-analysis

We further extended our NMA to conduct component-level network meta-analysis (CNMA) and identify the most effective components of lifestyle-modifying interventions targeting weight management outcomes. Intervention core components were expanded by including additional components identified by our PPI group, such as mode of delivery (individual or group), availability of support mechanisms (role of supporters such as caregivers) and living status (living alone or with family/paid care giver).

The CNMA was performed using additive model in WinBugs Version 1.4.3 (see *Appendix 2*). We explored the additive model,[60,61] which assumes the effect of a multicomponent intervention is the sum of individual effects of each component and that there is no interaction between the components. For instance, the total effect of a multicomponent intervention with components of exercise, BCT, dietary advice, EDD, individual delivery and support mechanism could be written as

$$d_{\mathbf{k}} = d_{\mathbf{E}} + d_{\mathbf{B}} + d_{\mathbf{DA}} + d_{\mathbf{EDD}} + d_{\mathbf{ID}} + d_{\mathbf{S}} \quad (1)$$

where d_k is the total intervention effect and d_E, d_B, d_{DA}, d_{EDD}, d_{ID} and d_S represent the effect of each component.

Realist evidence synthesis

A realist evidence synthesis was used to understand what works, for whom, in what context and why, for lifestyle modification programmes developed for adults with learning disabilities. This form of synthesis provides an understanding of the important contexts and mechanisms that lead to specific outcomes, that is, context–mechanism–outcome configurations (CMOCs).[62] The contexts relate to 'for whom does it work' in addition to 'in what context', and mechanisms are often hidden behavioural or emotional processes that relate to how the contexts generate specific outcomes.[62]

A realist approach has been previously applied to interventions targeting weight and obesity of adults with learning disabilities.[63,64] However, this was not an in-depth realist synthesis and only included 14 studies that were identified from hand-searching of six systematic reviews. Additionally, the synthesis was purely based on quantitative reports of intervention effectiveness, with no consideration of broader qualitative and mixed-methods literature. The review by Taggart *et al.*[63] also did not include people with learning disabilities with the necessary lived experiences to guide the development and interpretation of the synthesis outcomes. Taggart *et al.*[63] also focused purely on diet and physical activity, while the realist synthesis described in this report also included alcohol, smoking and sedentary behaviour.

In contrast, the realist evidence synthesis reported here included a broad range of literature, involving qualitative and mixed-methods studies. The synthesis was produced through rigorous methods that followed the recommended procedures of a realist synthesis, with all quality criteria fulfilled (see *Table 1*).[62] It was also produced in collaboration with adults with learning disabilities and gained input from a steering committee with a high level of relevant expertise, including in realist evidence syntheses. Therefore, this realist evidence synthesis is the first to provide a comprehensive understanding of the important CMOCs that contribute to lifestyle modification programmes for adults with learning disabilities.

Developing a draft programme theory

The first stage in the realist evidence synthesis was between September and November 2020. The goal was to develop a draft programme theory providing an initial overview of the potential contexts and mechanisms relating to lifestyle modification for adults with learning disabilities. This was based on the extant literature that was identified rapidly through non-systematic searching. This involved forward citation and related article searches for studies already known to the research team. Following this, title-abstract-key term searches were performed on Scopus and PsycINFO, along with supplementary Google Scholar searches. Specific journals, such as Sociology of Health and Illness and Social Science and Medicine, were also searched for articles including terms related to learning disabilities in their titles. Additionally, the reference lists of relevant systematic reviews and articles identified were hand-searched. A more detailed summary of this process is provided in *Appendix 3*.

Papers were initially prioritised for reading based on whether they were likely to inform the development of a draft programme theory. Data were extracted using an Excel spreadsheet to record basic study characteristics and note down observations relating to potential contexts and mechanisms. Broad themes were identified across the studies, and draft CMOCs were developed. This was refined and reviewed through iterative discussions with a second researcher.

The draft programme theory was presented to the PPI group in an accessible format using visual aids and concise descriptions. Expert researchers within the research team were interviewed on what they believed were the priorities for lifestyle modification research for people with learning disabilities and were presented the draft programme theory. The input from both the PPI group and expert researchers was integrated into the draft programme theory (see *Appendix 4*). This was then used as a rough guide for the development of the final programme theory and helped to consider potential CMOCs.

Searching for evidence

Formal searching for evidence

The formal structured searches were conducted in conjunction with the systematic review and meta-analysis. This involved systematic searches of five databases along with additional searches, such as hand-searching reference lists

TABLE 1 Quality standards for realist synthesis

Quality standards for realist synthesis	Criteria fulfilment
The research topic is appropriate for a realist approach.	The research topic was lifestyle modification interventions for adults with learning disabilities. There are many multidimensional contexts and mechanisms that influence behaviour change, and research would benefit from a realist approach.
The research question is constructed in a way to be suitable for a realist synthesis.	The overarching research question was to understand what works, for whom, in what context and why, which is appropriate for a realist evidence synthesis.
The review team demonstrated understanding and application of realist philosophy and realist logic, which underpin a realist analysis.	The data from the included studies were synthesised to build CMOCs to develop a realist programme theory. A realist logic of inquiry was followed when synthesising the data.
The review question was sufficiently focused.	The overarching review question was focused on covering the core lifestyle behaviours that could contribute to negative health outcomes that exacerbate health inequalities for adults with learning disabilities. The critical decision was made to further focus the review based on the many challenges to taking part in interventions and the mixed/limited effectiveness of interventions. The review was focused on considering the CMOCs that contributed to active engagement with the programme as designed.
The review team identified, developed and refined their initial realist programme theory.	An initial programme theory was developed in the first stage of the review. This was used as a starting point to consider potential CMOCs. Throughout the review, a more comprehensive programme theory was developed. This was discussed with the wider research team, PPI group and steering committee to further refine the programme theory.
The search process identified data to enable the review team to develop, refine and test programme theory.	A comprehensive search process was developed, which involved a thorough formal search of databases and clinical trial registries. This was followed by additional hand-searching through reference lists of intervention studies and systematic reviews. Additional non-systematic searches were done to address any gaps and build upon any areas of the developing programme theory that were 'weak' and based on limited literature.
The selection and appraisal process ensured that documents of relevance to the review containing material of sufficient rigour were included.	Following the initial shortlisting of papers using formal eligibility criteria, studies were selected based on their relevance to programme theory and methodological rigour using quality appraisal tools.
The data extraction process captured the necessary data to enable a realistic review.	The data extracted reflected potential context, mechanisms and outcomes. This was an iterative process with an initial thematic approach. Following this, the excerpts of texts were read through, and potential contexts and mechanisms were identified. This was then discussed between researchers. It was then considered how these related to outcomes, and CMOCs were developed.
The review team used the items listed in the Realist and Meta-narrative Evidence Synthesis: Evolving Standards Reporting standard for realist synthesis when reporting the realist synthesis.	The Realist and Meta-narrative Evidence Synthesis: Evolving Standards guidelines and training materials were closely followed when reporting the findings.

of included studies. This process is outlined in the previous section (see *Chapter 2*, section *Systematic review and meta-analysis*) when describing the process of identification of information sources and selection process.

Additional searches

Searches based on steering committee feedback

Following advice from the steering committee, it was decided that the developing programme theory would benefit from additional searches. This was to build upon potential gaps in the literature identified by the formal searches. A 'berry picking' approach was used to identify literature relating to autonomy and freedom of choice, social inclusion, mental health, participatory research and research including people with severe and profound learning disabilities. To identify this literature, searches were run on Google Scholar with the search terms relating to the area of interest and terms relating to learning disabilities.

Updated search

Based on guidance by the NIHR, an updated search was conducted, as the initial formal search was done in 2021. For the realist evidence synthesis, this involved forward citation searching for all the systematic reviews identified by initial formal search (n = 19). Systematic reviews were most likely to be cited by future studies, and this allowed for any important literature published post January 2021 to be identified. Additionally, searches were performed on Google Scholar for articles that had the specified lifestyle behaviour (i.e. alcohol, smoking, physical activity, sedentary behaviour or diet) in their title and terms for learning disabilities that were published from 2021 onwards.

Selecting articles

Creating a short list of papers

The first stage of study selection involved identifying a short list of papers using formal eligibility criteria. This was performed alongside the study selection for the systematic review. Detail related to this process is reported in the previous section (see *Chapter 2*, section *Systematic review and meta-analysis*).

Appraising articles on relevance and rigour

Reflecting the recommendations by Wong *et al.*,[62] inclusion into the realist evidence synthesis was based on appraisals of relevance and rigour. To appraise methodological rigour, critical appraisal tools were identified. For qualitative literature, the Qualitative Critical Appraisal Skills Programme (CASP) checklist was used.[65] This tool consists of 10 items that relate to the validity of the results, the findings of the study and whether the results have value. A higher number of 'yes' scores was used to indicate better methodological rigour. For quantitative studies, such as cross-sectional correlational studies, The Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields: Quantitative checklist was used. This tool was used as it can be applied to multiple study designs, which reflected the broad range of methodologies included.[66] To assess the quality of intervention studies, the Cochrane ROB-2 and ROBINS-I tools were used for randomised and non-randomised trials, respectively. As the intervention studies were part of the systematic review and NMA, a proportion of these were independently appraised by two researchers. Any discrepancies were discussed and resolved by a third reviewer to further reduce the risk of bias.

Relevance was based on the potential contribution to the emergent programme theory. Upon reading the full text, a paper was appraised as highly relevant if it provided conceptually rich and relevant data. For example, this could include qualitative process evaluations of lifestyle modification programmes for adults with learning disabilities or qualitative follow-up interviews with adults with learning disabilities taking part in lifestyle change interventions. Papers were considered most relevant if they were based in a UK context, as the NIHR-funded project will be used by UK researchers and policy-makers. 'Relevant' papers were less relevant than 'highly relevant' papers but still appraised as meaningful to programme theory development. This included lifestyle modification interventions reporting quantitative data on effectiveness that could still provide insight on outcomes. Additionally, this could include studies not explicitly related to interventions but still reporting on influences of healthy lifestyles and processes leading to behaviour change.

Articles were of low relevance if they were unlikely to make a meaningful contribution to the programme theory. For example, some older studies had contexts that did not reflect the current lived experiences of people living with learning disabilities. Additionally, a small sample of intervention studies that met eligibility criteria for the NMA and systematic review were considered to have low relevance. These studies included more structured exercise programmes that had limited focus on behaviour change or lifestyle modification, and instead were concerned with the direct physiological impact of structured exercise.

Papers were included in the realist review if they were appraised as being relevant and having sufficient methodological rigour. Decisions of relevance were an iterative process, as 'relevance to the programme theory' was a subjective appraisal. Any papers where the relevance was not clear were flagged for 're-appraisal'. These papers were read again at the end of the selection process, and a decision was made established from the improved understanding based on what was already included.

Extracting and organising data

Relevant contextual information, such as study and participant characteristics, was recorded for each study using a data extraction spreadsheet on Microsoft Excel®. To extract and organise data relevant to the development of the programme theory, an initial familiarisation stage was performed, reflecting the procedure of Papoutsi *et al.*[67] Included articles were reread, with this conducted according to lifestyle behaviour. Observations were noted relating to potential contexts, mechanisms and outcomes. This was compared to the CMOCs in the draft programme theory developed in the first stage of the realist evidence synthesis. From this, a selection of *n* = 14 'key' papers was identified. These were the papers with the richest data and were considered most likely to inform the programme theory.

The richest sources were uploaded to NVivo 12 (QSR International, Warrington, UK). Data relating to the study findings and, where relevant, the intervention design and methods were extracted. For qualitative data, extracting findings related to illustrative quotes provided for participants, the description of themes and subthemes, observations and any theories or models developed based on the data. For both qualitative and quantitative methods, author interpretations were also counted as relevant data. Initial line-by-line coding of relevant data was not focused on contexts or mechanisms, instead it was related to what was explicitly reported. The text tied to the codes was then reviewed, and similar codes were grouped together. This was continued until descriptive themes were developed. This initial coding framework was refined through discussions between two researchers. The coding framework developed was then applied to the remaining studies included in the realist evidence synthesis (see *Appendix 5*).

During the familiarisation stage, it also became apparent that interventions had mixed to low effectiveness, and there were differences in the intervention strategies, specific outcomes targeted and measurement methods used for the lifestyle behaviours. The initial descriptive themes primarily related to challenges in actively engaging with the intervention as designed. For example, issues relating to the abstract nature of BCTs, difficulties using measurement methods and the importance of additional support, which is not always available. To achieve behaviour change, it is necessary for participants to actively engage with, interact with and process the intervention strategies as delivered. It is essential to consider the contexts and mechanisms that contribute to active engagement with interventions for adults with learning disabilities. Subsequently, the critical decision was made to focus the programme theory on active engagement.

Synthesising the evidence and drawing conclusions

To determine links between contexts and mechanisms, the associated individual studies were read and compared to determine the possible interaction. This allowed for the synthesis of potential CMOCs across studies. Due to the aforementioned reasons, the focus of the overarching outcomes is primarily related to active engagement with the intervention as delivered. As a result, when applying a realist logic of enquiry, instead of first identifying the outcomes and working backwards, the contexts were identified, followed by the associated mechanisms.

This was an iterative process with frequent discussions between two researchers about interpretations of the potential contexts and mechanisms. Once potential contexts and the underlying mechanisms were identified, the reviewer went back through the associated text and studies to determine the resulting outcome within the developed CMOCs.

The developing CMOCs were read through, and thematically similar CMOCs were identified. This resulted in clusters of CMOCs being produced. Diagrams were developed about how these CMOCs were linked and the processes leading to specific outcomes. This resulted in the development of partial programme theories.

To ensure the emerging programme theory accurately reflected the lived experiences of adults with learning disabilities, input was sought during a PPI meeting. Easy-read/accessible versions of the programme theory were developed and presented to the PPI group. The PPI group agreed with what was covered in the emerging programme theory and provided further insight into the challenges people face. The valuable input was used to further refine the programme theory and identify important CMOCs that reflect the experiences of people with learning disabilities.

The programme theory was also presented to the steering committee. The feedback was used to help refine the wording of the programme theory and solidify decisions around what were the contexts or mechanisms. The steering committee provided the recommendations around the additional searches to strengthen specific areas of

the programme theory. Additionally, members of the steering committee with expertise in realist evidence synthesis provided input on the synthesis process, and through discussions around the programme theory, the overarching programme theory was refined.

The synthesis of the evidence was an iterative process. It was necessary to frequently go back to the literature and appraise the CMOCs and determine whether they best captured what was being presented and what was discussed as important by the PPI group. The overarching programme theory was developed by capturing the core aspects of the partial programme theories and through discussions and feedback from others with considerable expertise.

Changes to the protocol

Our mixed-methods synthesis diverted from the published protocol[1] in the following few instances:

1. We only searched for grey literature in Google Scholar and not in the Open Systems for Information on Grey Literature in Europe (OpenSIGLE) database. This will have minimal impact on our search results given that we have conducted a comprehensive search of five main databases, four clinical trial registries and additional searches via hand-searches of existing systematic reviews and included studies.
2. We were unable to explore other models of CNMA, such as the interactive model, due to the large amount of data demanded by these models.
3. We did not assess the confidence in cumulative evidence through the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology.[68] Our initial attempt proved it to be highly subjective, given the limitations of included studies. This includes limited numbers of studies on certain health behaviours and heterogeneity in study designs, intervention characteristics and outcomes. Standardised outcomes were not used to demonstrate behaviour change of similar behaviours, and insufficient information was available in studies. Therefore, GRADE assessment did not align with our purpose to bring together the existing evidence from two syntheses into a logic model.

Chapter 3 Results of the systematic review and meta-analysis

Studies included in the review

As summarised in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) flow diagram (see *Figure 1*), 12,180 studies were obtained from searching five databases. Following removal of 3742 duplicates, we screened 8437 titles and abstracts. Two hundred and seventy-one full texts were retrieved, of which a study[69] written in Hebrew was not retrieved as the team was unable to translate it. We looked at the full text of 270 studies and excluded 203 studies. The most common reasons for exclusion were:

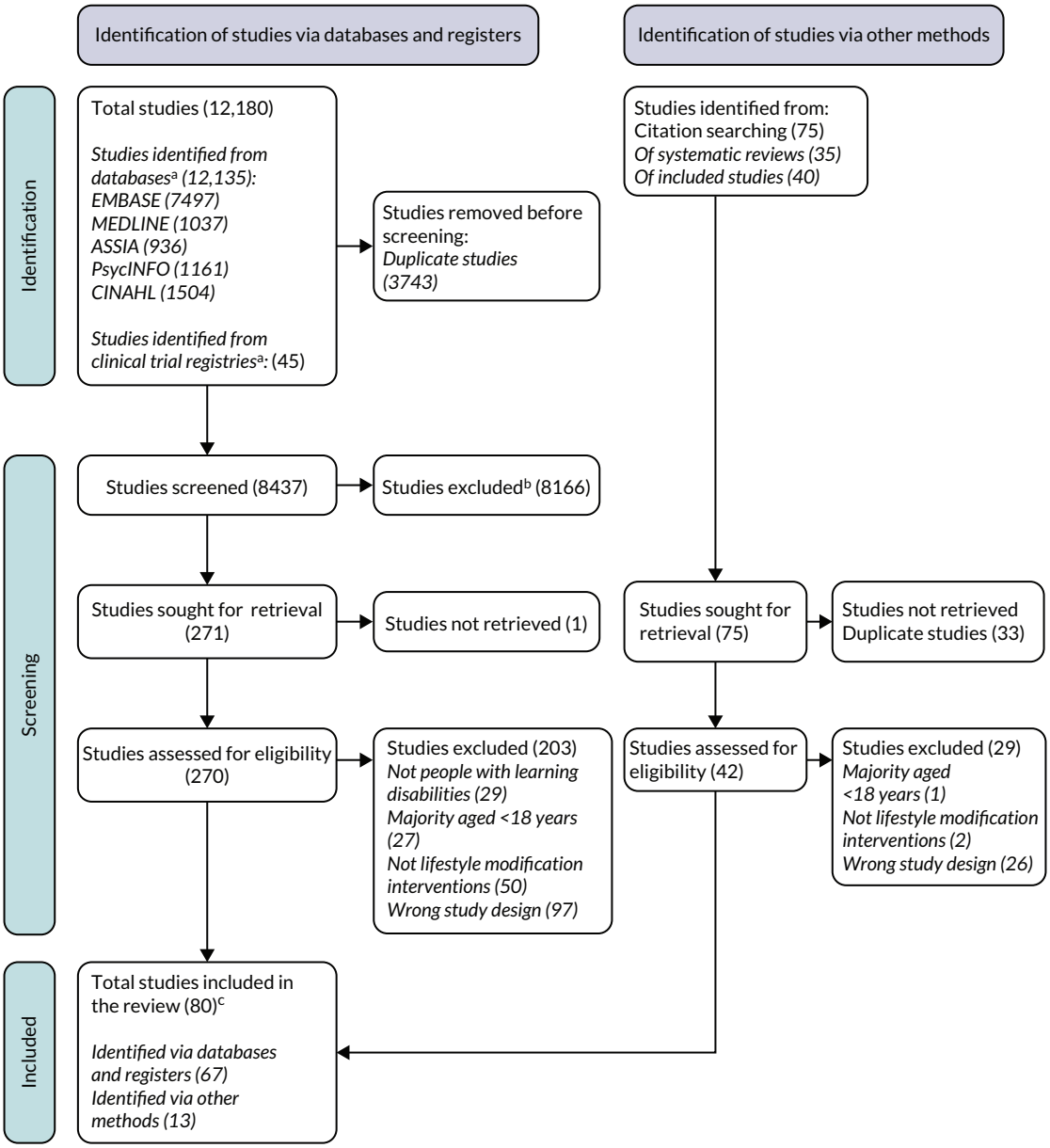

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-analysis flow diagram. a, Searches were conducted before the publication of the PRISMA 2020 statement. Clinical trial registries have been merged with the main database search to reflect the guidance; b, All studies removed via the Covidence software's in-built feature were double-checked; c, Duplicate of studies identified via database and registers were removed at the end.

- Wrong study designs – 97 studies in form of surveys, research news, case studies, conference abstracts, protocols and systematic reviews were excluded only after retrieval of the full texts. This was because we simultaneously conducted the search and screening for the systematic review and realist evidence synthesis.
- Studies not related to lifestyle modification interventions – 50 studies on various topics pertaining to adults with learning disabilities, such as patient and caregiver experiences, quality of support and guideline development.
- Articles focusing on Prader–Willi syndrome, Bardet–Biedl syndrome and non-specific developmental delay populations. Only some people in this population could have learning disabilities, so these 29 studies were considered to not meet our criteria.
- Participants being less than 18 years old – 27 studies were on participants as young as 6-year-olds, with majority focusing on adolescents.

Simultaneously, we also retrieved 75 studies from an additional search of citations, which included hand-searching of systematic reviews and included studies. We assessed 42 full texts against our inclusion criteria. Studies were excluded as having wrong study designs due to the same reasons as above. Other exclusion reasons include studies not related to lifestyle modification interventions and participants aged less than 18 years old.

In total, 80 studies were identified as eligible for inclusion in the systematic review (see *Appendix 6*). Sixty-seven studies were identified via databases and clinical registries and 13 via additional search. This includes three new additional studies identified from the updated search in February 2022.

We classified 80 studies, published between the years 1980 and 2022, according to the health behaviours their interventions targeted. Six studies were on alcohol consumption and smoking, 33 studies were on low physical activity only behaviours and 41 studies were on multiple behaviours, that is, low physical activity, sedentary behaviour and poor diet. These studies included 35 RCTs, 11 controlled pre–post studies, 28 uncontrolled pre–post studies and 6 case-control studies.

Identification of core components in interventions and comparators

Six core components identified in the interventions and comparators are presented in *Table 2*. As there is no systematic way of describing these interventions and comparators for adults with learning disabilities, we have included the definitions we developed to identify them. These core components can be combined in different ways to form interventions that aim to influence different health-risk behaviour outcomes. Behaviour change techniques were only coded as present if studies explicitly mentioned them. Health education is considered a part of the BCT core component rather than a separate core component. This was done to be consistent with Michie's behaviour change taxonomy item 5.1: 'Information about health consequences'.[57] Diet advice is treated as distinct from EDDs and is

TABLE 2 Core components of interventions and comparators

Core components	Definition and example
Aerobic exercise	Any exercise that raises participants' heart rate – for example, a progressive walking programme.
Resistance exercise	Any exercise that involves strengthening muscles – for example, strength training using an exercise equipment.
Energy-deficit diet	Any recommended diet where participants are advised to eat less – for example, portion-controlled entrées and shakes.
Diet advice	Any recommendations on healthy eating, but participants are not advised to eat less – for example, health education to enhance positive attitudes towards healthy food and exercise.
Mindfulness	Any technique which focuses on acceptance of feelings/sensations/thoughts – for example, verbal self-affirmations to not smoke and to give directionality to conscious decision to stop smoking.
BCT	Any BCTs which focuses on changing diet, exercise and smoking behaviours beyond simply explaining to a participant how to do something – for example, modelling how to use treadmill.

considered a separate core component. The core components for comparison groups were only defined if they were active comparators or provided adequate information about TAU, that is, routine care participants are expected to receive as part of normal practice, which varied across studies.

Summary of studies targeting alcohol consumption and smoking behaviour

Six studies targeting alcohol consumption, smoking and both behaviours in 228 participants were included in the review.

Studies on alcohol consumption included one RCT[70] and two uncontrolled pre–post studies.[71,72] These studies were undertaken in the UK.[70,72] Studies on smoking behaviour included an RCT[73] and an uncontrolled pre–post study,[74] which was undertaken in the USA[73] and Australia.[74] A controlled pre–post study on alcohol consumption and smoking behaviour,[75] which also targeted unsafe sex and other behaviours relevant to HIV AIDS, was based in the UK.[75]

Population and intervention characteristics

Table 3 presents details related to the participants, the interventions and their comparators.

Randomised controlled trials

Eighty-one participants of similar age were recruited from the community via the learning disability network and referrals from families, supported living/group home supervisors and primary care physicians.[70,73] They had mild[70,73] to moderate[70] levels of learning disabilities and were associated with physical health, sensory, mobility and incontinence

TABLE 3 Patient characteristics and core components of alcohol consumption and smoking studies

Author, year	Number of participants and age according to intervention and comparator	Core components
RCT		
Alcohol		
Kouimtsidis *et al.*, 2017[70]	30 Extended brief intervention (EBI) + usual care (15); median age = 45 (8–5) Usual care (15); median age = 44 (22.5)	BCT
Smoking		
Singh *et al.*, 2014[73]	51 Mindfulness-based intervention (25); mean age (SD) = 32.56 (10.29) TAU (26); mean age (SD) = 34.40 (10.46)	BCT + mindfulness
Controlled pre–post		
Smoking and alcohol		
Lindsay *et al.*, 1998[75]	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
Uncontrolled pre–post		
Alcohol		
Mendel *et al.*, 2002[71]	Motivational interviewing (7); age = 18–54 years	BCT + mindfulness
Forbat, 1999[72]	Alcohol awareness course (5); age not reported.	BCT + mindfulness
Smoking		
Tracy *et al.*, 1997[74]	Fresh Start smoking education (11); age = under 25 years	BCT

problems.[70] Majority of participants were Caucasian and male.[70] Participants lived alone[70] or with families, in supported living and group homes.[70,73]

Participants were split equally into intervention and comparator groups.[70,73] The alcohol consumption intervention[70] consisted of BCT as a core component. It consisted of five sessions on introduction to the intervention, carer role, practicalities; personalised advice; increasing motivation; identification of high-risk situations; and promotion of positive changes. The smoking behaviour intervention[73] had mindfulness and BCT as core components consisting of basic meditation, mindful observation of thoughts and a technique to focus craving sensations on a focal point of one's body.[73] Both interventions were compared to usual care, with one group receiving therapeutic interventions (e.g. talking therapy for generic coping skills, pharmacotherapy for comorbid mental disorders and social care with advice to modify drinking)[70] and the other group continuing current treatment (e.g. motivational therapy, behaviour therapy, nicotine replacement therapy and non-nicotine medicines).[73]

Interventions were adapted for the learning disability population. Alcohol consumption interventions[70] used input from a service user group and literature such as the cognitive behaviour therapy (CBT) manual. The adaptations included a greater number of longer sessions with various kinds of materials used in intervention delivery. Intervention in smoking behaviour[73] was extended from previous literature by the same authors.[73] Participants were not involved in designing interventions.

The alcohol consumption intervention[70] reported using therapeutic techniques such as CBT and motivational enhancement therapy (MET) (see *Appendix 7*, *Table 17*). Michie *et al.* TCS was not used in RCTs, as theories were not explicitly stated.[56] Behaviour change techniques (see *Appendix 8*, *Table 20*) were coded as goals and planning, feedback and monitoring, social support, shaping knowledge, regulation, antecedents and identity.

Interventions were delivered by trained personnel, including NHS therapists. Sessions were either conducted individually[73,70] or in small groups.[73] Level of personalisation was varied. Both RCTs had social support, but only the alcohol consumption intervention[70] directly targeted social supporters, including families and supported living/group home staff.

Non-randomised controlled trials

Controlled pre–post

One hundred and twenty-four participants with mild to moderate learning disabilities were recruited from an adult resource centre and a hospital for people with learning disabilities.[75] Ethnicity, gender distribution and socioeconomic status were not reported.

The intervention with BCT core component had three subprogrammes targeting alcohol, smoking and HIV AIDS with health education materials on social and health-related consequences.[75] The intervention was compared to a no-treatment control group, which received leaflets covering the same topics. It was developed based on existing literature, but participants were involved in its design. No theories were mentioned. Behaviour change techniques (see *Appendix 8*, *Table 20*) were coded as feedback and monitoring, shaping knowledge, natural consequences and comparison of behaviour. Study investigators provided the intervention to the participants in groups with varying personalisation. No form of social support was reported.

Uncontrolled pre–post

Twenty-three participants in the age range of 18–54 years were recruited from medium secure services (MSS) or tertiary institutions offering vocational courses as nominated by individual key workers.[71,72,74] The study on alcohol consumption[71] included those with mild to moderate learning disabilities associated with autism; another study did not report any level of learning disabilities.[72] The study on smoking behaviour[74] had mostly male participants with severe learning disabilities who were associated with cerebral palsy, autism and spina bifida. Some studies did not report the gender,[72] ethnicity or socioeconomic status of the participants.

Both interventions on alcohol consumption[71,72] consisted of mindfulness and BCT as core components. Interventions included an alcohol awareness course which encouraged participants to develop positive attitudes towards drinking and covered laws, recommended drinking units and the psychological effects of alcohol.[72] Motivational interviewing framework was used to increase self-efficacy.[71] The smoking behaviour interventions consisted of BCTs as a core component. It included smoking education and role-play to increase motivation and positively reinforce it. These interventions had no comparators.

An alcohol consumption intervention was specifically designed to provide participants with information and skills to make informed choices, taking into account their forensic status and living conditions[72] as well as the forensic status of the participants when in offending behaviour. Another intervention was structured on the main element of motivating participants to change as outlined by FRAMES (feedback, responsibility, advice, menu of alternatives, empathy and self-efficacy). Intervention on smoking behaviour adapted the Fresh Start course by focusing on areas of cognitive difficulties such as attention control, analysis and manipulation of information and planning and foresight.[74] However, the studies did not involve participants in designing the intervention.

Alcohol consumption was based on the transtheoretical (stages of change) model[71] and biopsychosocial (see *Appendix 7*, *Table 17*).[72] The smoking intervention was not based on any theories. Similarly, behaviour change taxonomy coding (see *Appendix 8*, *Table 20*) included taxonomies related to goals and planning, feedback and monitoring, shaping knowledge, natural consequences, social support, comparison of behaviour, comparison of outcomes, reward and threat and self-belief. Interventions were provided individually[72] and in groups[71,74] by the investigators,[71,72] which included trainee clinical psychologists and support workers.[71] Level of personalisation was varied. The studies did not report any form of social support.

Outcomes

Table 4 presents details on the intensity of the interventions, outcomes measured and the intervention effect.

Participants received RCT-based interventions on alcohol consumption and smoking behaviour actively for 8 and 40 weeks, respectively. Their follow-up was at 3 months and a year. Non-RCTs-based interventions were received by the participants for 2 weeks to 6 months with follow-up ranging from 3 to 12 months. Some studies did not have any follow-up. No maintenance period was reported. These interventions varied in their intensity. Participants dropped out of the study[70] due to reasons such as the negative impact of therapy (i.e. made the participant crave alcohol or increased psychological distress), hesitation about meeting a new person and difficulty in attendance due to their job. Anxiety was also stated as one of the reasons for dropping out.[71] Moreover, studies did not report any adverse events.

The effect of the interventions on alcohol consumption[70–72,75] was assessed using behavioural, cognitive, knowledge-related, psychosocial, quality-of-life and other outcomes. Similarly, the effect on smoking behaviour[73,74,75] was assessed using behavioural, knowledge-related and psychosocial outcomes. As shown by the direction of effect (see *Table 4*), RCT-based intervention on alcohol consumption[70] led to positive effect on behavioural outcomes but also resulted in a negative effect on the quality-of-life outcome. Whereas RCT-based intervention on smoking[73] led to a strong positive effect in behavioural outcomes. The direction of the effect in the knowledge-related outcome of controlled pre–post study[75] featured a strong positive effect of the intervention on both alcohol consumption and smoking. The interventions in uncontrolled pre–post studies[71,72,74] all led to positive effect in outcomes for alcohol consumption and smoking behaviour, but the strength of effect direction is not as strong. Overall, only two studies showed a statistically significant effect of the interventions on behavioural and knowledge-related outcomes such as number of cigarettes smoked, relapse and retention of knowledge.[73,75] No studies have reported the cost-effectiveness of the interventions. Only one RCT-based study targeting alcohol consumption[70] included a preliminary health economic analysis which explored the costs of delivering the intervention and the feasibility of a cost-effectiveness analysis alongside the full trial. The unit cost of intervention delivery was £430.

TABLE 4 Intervention detail, outcomes and effect direction of alcohol consumption and smoking studies

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
RCT					
Alcohol					
Kouimtsidis *et al.*, 2017[70]	8 weeks 3 months No maintenance period.	5 times a week, for 30 minutes and 1-hour 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) Well-being 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[a]
Smoking					
Singh *et al.*, 2014[73]	40 weeks 1 year No maintenance period.	4-week baseline phase and up to 36-week 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[a], at the conclusion of the treatment phase[a] and follow-up time measuring relapse[a] than the comparator group	Positive[b]
Controlled pre-post					
Smoking and alcohol					
Lindsay *et al.*, 1998[75]	8 weeks 3 months No maintenance period.	1 session per week.	Assessment of knowledge about smoking/alcohol/HIV AIDS	Improved knowledge[a]	Positive[b]
Uncontrolled pre-post					
Alcohol					
Mendel *et al.*, 2002[71]	2 weeks No follow-up and maintenance period.	3 sessions over a 2-week period.	RCQ Self-efficacy	Increase in motivation to change and in confidence in ability to achieve.	Positive[a]
Forbat, 1999[72]	6 months No follow-up and maintenance period.	7-week pilot course, 2-hour sessions	Retention of information 6 months after course completion	Improved retention of information	Positive[a]
Smoking					
Tracy *et al.*, 1997[74]	7 weeks 12 months No maintenance period.	8 weekly, 2-hour sessions. Additional supplementary sessions as required.	Smoking habits Interest in quitting Experience in quitting Knowledge of health effects	Increase in number of participants who stopped smoking, expressed interest in quitting, gave up smoking for at least 1 day and had increased concerns about health effects.	Positive[a]

a Unable to comment on the significance of the results.
b Outcomes which were reported to be statistically significant.

Summary of studies targeting low physical activity only behaviour

Thirty-three studies targeting low physical activity only behaviours in 1413 participants were included in the review.

Studies included 16 RCTs,[76–91] 2 controlled pre-post studies,[27,92] 13 uncontrolled pre-post studies[93–105] and 2 case-control studies.[106,107] Eight studies were undertaken in the USA;[82,86,97–100,104,107] six in Spain;[27,84,85,87,96,105] three in South Africa[76,77,95] and UK;[83,93,94] two in Netherlands,[78,91] Israel,[80,81] Australia[88,89] and Taiwan[102,103] and one in Belgium,[79] Canada,[101] Greece,[106] Italy[81] and Portugal.[90]

Population and intervention characteristics

Table 5 presents details related to the participants, the interventions and their comparators.

Randomised controlled trials

Six hundred and eighty-four participants in their early 20s to late 50s were recruited from care centre,[76,77,79–81,83] residential facility, day program,[82,88] community support group,[84,85,87] occupational and vocational training centre,[88,90] via mailed flyers or e-mails,[89] family,[86] key personnel[82] and recruitment co-ordinator.[86] Participants had mild,[76–78,80–83,85,87–89,91] moderate,[76,77,81–83,88,89,91] severe[78,83,88,91] and profound[78,83] levels of learning disabilities. Few studies did not provide any information related to level of learning disabilities or simply reported the IQ level to be in the range of 50–69.[84] Participants were also associated with Down syndrome[76–78,82,84,86–89,91] and other conditions such as autism,[79,91] sensory loss,[83] foetal alcohol syndrome,[78] epilepsy,[79,83] Prader–Willi syndrome,[78] hydrocephalus,[78] pervasive development disorder[78] and Soto syndrome.[78] Additionally, mental health problems,[80,81,83] behavioural problems[83,91] and the need for a walking aid[91] were highlighted. Most participants' ethnicity was Caucasian.[82,86] Other ethnicities included black,[82,86] Hispanic[82,86] and Native American.[82] Participants were mostly female,[79,80,82,86,91] mostly male,[76,77,81,83,88] female only[78,84] or male only.[76,77,87] Studies also equally balanced gender.[89] Socioeconomic status was not reported. Participants also resided at home with family[81–84,86,88,89] or lived independently.[82,83,88]

Five interventions consisted of aerobic exercise only as a core component.[76,77,79,80,84] These interventions included intermittent or continuous cycling and walking on treadmill,[76,77] aerobic group focusing on endurance[79] and bicycle/treadmill sessions with a leisure activity involving games.[80] Four interventions[79,86,87,90] consisted of aerobic exercise and resistant exercise core component, which featured combined exercise entailing endurance and strength training with equipment[79,86] and a Wii-based exercise programme involving balance and isometric strength exercises.[90] Two interventions consisted of aerobic exercise, resistance exercise and BCT as core components.[82,91] This covered structured cardiovascular, strength and endurance fitness programmes with health education component.[82] Two interventions with resistance exercise as core components[78,88] included power-assisted interventions[78] and community-based progressive resistance training programmes.[88] One intervention involved sending smartphone reminders with educational advice to increase physical activity had only BCT as core component.[85] Similarly, two Walkabout and Walkwell interventions, including walking and health education,[83,89] were based on aerobic exercise and BCT as

TABLE 5 Patient characteristics and core components of low physical activity only studies

Author, year	Number of participants and age according to intervention and comparator	Core components
RCT		
Boer *et al.*, 2016[76]	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
Boer *et al.*, 2018[77]	Same as above	Same as above
Bossink *et al.*, 2017[78]	37 Power-assisted exercise (19) Care as usual (18) Mean age (SD) = 32.1 (14.6)	Resistance exercise

TABLE 5 Patient characteristics and core components of low physical activity only studies (*continued*)

Author, year	Number of participants and age according to intervention and comparator	Core components
Calders *et al.*, 2011[79]	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
Carmeli *et al.*, 2009[80]	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
Carraro *et al.*, 2012[81]	27 Exercise programme (14) Minimal activity control (13) Mean age (SD) = 40.1 (6.2)	Aerobic exercise + resistance exercise + mindfulness
Heller *et al.*, 2004[82]	53 Fitness and health education programme (32); mean age (SD) = 39.41 (6.92) No training control (21); mean age (SD) = 40.22 (6.38)	Aerobic exercises + resistance exercises + BCT
Melville *et al.*, 2015[83]	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
Ordonez *et al.*, 2014[84]	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
Pérez-Cruzado *et al.*, 2017[85]	8 Smartphone reminders (4) No smartphone (4) Age not reported	BCT
Rimmer *et al.*, 2004[86]	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
Rosety-Rodriguez *et al.*, 2013[87]	40 Resistance circuit training (24) No exercise control (16) Mean age (SD) = 23.7 (3.1)	Aerobic exercise + resistance exercise
Shields *et al.*, 2008[88]	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
Shields *et al.*, 2015[89]	16 Walkabout programme (8); mean age (SD) = 21.6 (3.4) Usual activities (8); mean age (SD) = 21.2 (3.2)	Aerobic exercise + BCT
Silva *et al.*, 2017[90]	25 Wii-based exercise programme (14) Usual daily activities (13) Age = 18–60 years	Aerobic exercise + resistance exercise
Van Schijndel-Speet *et al.*, 2017[91]	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

continued

TABLE 5 Patient characteristics and core components of low physical activity only studies (*continued*)

Author, year	Number of participants and age according to intervention and comparator	Core components
Controlled pre-post		
Carmeli *et al.*, 2004[92]	14 Structural walking A1 (without intermittent claudication) (8) Structural walking A2 (with intermittent claudication) (6) Mean age (SD) = 65.5(3.6) No exercise control (12); mean age (SD) = 62 (2.8)	Aerobic exercise
Oviedo *et al.*, 2014[27]	72 CPAP (3); mean age (SD) = 41 (11) No training control (29); mean age (SD) = 46 (12)	Aerobic exercise + resistance exercise
Uncontrolled pre-post		
Jones *et al.*, 2007[93]	Rebound therapy-based exercise programme (8); mean age (SD) = 41.3 (6.5)	Aerobic exercises
Messent *et al.*, 1998[94]	Community-based exercise (24); mean age (range), male = 35.4 (26–47), female = 32.9 (24–38)	Aerobic exercise
Moss, 2009[95]	Walking programme (100); mean age (SD), male = 39.2 (8.9), female = 37.5 (10.1)	Aerobic exercise + BCT exercise
Pérez-Cruzado *et al.*, 2016[96]	Physical activity and educational programme (40); mean age (SD) = 35.86 (9.93)	Aerobic exercise + Resistance exercise + BCT
Pitetti *et al.*, 1991[97]	Minimally supervised exercise programme (12); mean age (SD) = 25 (3)	Aerobic exercise
Podgorski *et al.*, 2004[98]	Physical activity programme (15); age = 40–80 years	Aerobic exercise + resistance exercise
Pommering *et al.*, 1994[99]	Aerobic exercise programme (14); mean age (SD) = 29.1 (7.4)	Aerobic exercise
Przysucha *et al.*, 2020[100]	Progressive and combined training programme (7); mean age (SD) = 23.1 (2.29)	Aerobic exercise + resistance exercise
Stanish *et al.*, 2001[101]	Video-directed aerobic dance (17) Leader-directed aerobic dance (17) Mean age (range) = 42.6 (30–65)	Aerobic exercise + BCT
Wu *et al.*, 2010[102]	Healthy Physical Fitness Programmes in a Disability Institution (HPFPDI) programme (146); age = 19–67 years	Aerobic exercise
Yen *et al.*, 2012[103]	Same as above; mean age (SD), male = 33.66 (10.02), female = 33.69 (9.22)	Same as above
Yan *et al.*, 2015[104]	Education curriculum (22); mean age = 26.7	Aerobic exercise + resistance exercise + BCT
Zurita-Ortega *et al.*, 2020[105]	Kin-Ball sports programme (47); mean age (SD) = 29.85 (10.41)	Aerobic exercise + resistance exercise
Case control		
Giagkoudaki *et al.*, 2010[106]	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
Mendonca *et al.*, 2011[107]	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

core components.[89] Only one intervention with exercise sessions using various equipment such as dumbbells and ropes ended with relaxation, and breathing exercises had aerobic exercise, resistance exercise and mindfulness as core components.[81]

Comparator groups received either no programme (training, exercise, reminders or activities), only vocational activities or usual care. Participants carried on with normal daily activities without supervised exercise training or did not receive smartphone reminders.[85] Minimal activity control had participants follow a painting activity programme, which was chosen because of the low level of physical involvement and social interaction.[80] Social activities included actions that would not be expected to have a training effect, such as watching movies, crafts, baking, music, etc.[80,89] No description of waitlist control was provided by a study.[83] Usual care was characterised by a considerable number of hours in which no activities take place,[78] typical daily activities which included employment, leisure and sporting activities,[88] vocational rehabilitation, life-skill training and art-related activities.[90]

The interventions were developed or adapted for the learning disability population, following international guidelines and existing literature on physical fitness and health.[76,77,82,84,86,91] The adaptations focused on chronically ill and people over 65 years;[78,83] impact of power-assisted exercises,[78] resistance training[87,88] and exergames;[90] impact of physical activity on anxiety and depression[80,81,89] and ways to empower and enable the environment for long-term life satisfaction.[89] The RCTs did not involve participants in designing the intervention.

Interventions were based on social cognitive theory,[82,91] transtheoretical model of behaviour change[82,83] and theory of planned behaviour(see *Appendix 7*, *Table 18*).[91] Behaviour change taxonomy coding (see *Appendix 8*, *Table 21*) included goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, repetition and substitution, reward and threat, self-belief, antecedents and covert learning. Interventions were delivered by investigators,[78,84–86,90] residential facility carers,[78] tutors and student mentors[82,89] and other trained personnel such as physical education teachers,[80] fitness trainers and instructors[83,88,89] and exercise specialists.[76–81,87,88,91] Sessions were conducted individually[78,80,83,84,88,89] or in groups.[76,77,79,81,82,85,87,88,90,91] Levels of personalisation differed and incorporated individualised training consultations[83] or regimens,[80] for example, participants could complete an hour of independent walking or walking with family or friends.[89] Smaller groups also allowed a close level of supervision.[81,87,88,90] Some studies reported or suggested social support,[78,80,82,85,88,89,91] but none of the studies directly targeted the social supporters, which included families, friends and caregivers,[78,82,87–89] study partners,[83] staff in residential facilities and day centres,[78,82,91] test assistants and direct support persons[78,80] and student mentors.[89]

Non-randomised controlled trials

Controlled pre–post

Eighty-six male and female participants with mild[27,92] levels of learning disabilities were recruited from occupational day centres[27] and via referrals from in-house physicians.[92] They were also associated with Down syndrome,[27,92] autism,[27] cerebral palsy,[27] conduct disorder,[27] Cornelia de Lange syndrome,[27] epilepsy,[27] microcephaly,[27] Lennox syndrome,[27] West syndrome,[27] vascular disease,[92] cardiac disease,[92] hypertension,[92] diabetes,[92] respiratory disease[92] and renal disease.[92] Ethnicity and socioeconomic background were not reported. Participants lived in foster homes.[92]

The structural treadmill walking intervention had aerobic exercise as core component.[92] The combined physical activity programme (CPAP) on aerobic, strength and balance training[27] included aerobic exercise and resistance exercise as core components. Interventions were compared to matched control groups without any further explanation[92] or no exercise training group where participants were asked to continue with daily regular activities and visited weekly by the research staff to ensure their daily activities were not changing.[27] Interventions were adapted based on previous literature to design training programmes involving pain-free, low-intensity walking in elderly population[92] and to encompass a larger sample size.[27] Participant involvement in design of intervention is not mentioned. There is no mention of whether the intervention was based on theories. Behaviour change taxonomy coding (see *Appendix 8*, *Table 21*) features shaping knowledge, comparison of behaviour and repetition and substitution. Interventions were delivered individually[92] by investigators[92] and exercise scientists with assistants.[27] No form of social support has been reported.

Uncontrolled pre–post

Five hundred and ninety-eight participants in their early 20s to late 40s were recruited from residential facilities,[93–95] day centres,[94,98] disability institutions,[102–104] sheltered workshops,[97,99] vocational training centres[97] and local Special Olympics programme.[100] Participants had mild,[94,97,98,100,102,103] moderate,[94,97,98,100,102–104] severe[98,101–103,105] and profound[93,98,102,103] levels of learning disabilities. A study simply reported the mean IQ to be 54.[99] Participants were associated with Down syndrome,[95] epilepsy,[98] sensory impairment,[98] hypertension[95] and other accompanying disabilities.[103] Majority of studies did not report ethnicity, but a study had predominantly Caucasian participants.[98] Participants were mostly males.[94,96–101,103,104] Socioeconomic status was not reported. Participants also resided in family homes.[94,104]

Most interventions[93,94,97,99,102,103] included only aerobic exercise as a core component. These interventions featured minimal supervision[97] with active and passive exercises such as walking, swimming and community games.[93,94,102,103] Interventions[98,100,105] with aerobic exercise and resistance exercise core components consisted of progressive/combined training focusing on balance, mobility, gait, strength and flexibility[98,100] and alternative sports using Kin-Ball.[105] Interventions with aerobic exercise and BCT as core components[95,101] featured walking sessions[95] and a video-leader-directed dance aerobic programme.[101] A multimodal intervention consisting of physical activity and educational advice[96] had aerobic exercise, resistance exercise and BCTs as core components. A peer education programme[104] aimed at increasing physical activity participation and promoting fitness and balance had resistance exercise and BCTs as core components. These interventions had no comparators.

Interventions[98,101–104] were developed based on existing literature and guidelines on effectiveness of aerobic dance,[101] use of one-to-one educational curriculum,[104] ways to enable inclusive community-based access to exercise with minimal supervision,[94,97,99] on benefits of progressive training,[100] use of Kin-Ball, etc.[105] Participant involvement is not mentioned in the design of the intervention, but one study[93] consisted of developers who were extremely familiar with participants and their preferences. Participants were also allowed to add more weights to the intervention[100] or change routines following pilot sessions that evaluated their skills and interests.[101]

Most interventions were not based on theories, except for one intervention on peer education, which was based on social learning theory that is social cognitive theory[104] (see *Appendix 7*, *Table 18*). Behaviour change taxonomy coding (see *Appendix 8*, *Table 21*) featured goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, repetition and substitution, reward and threat and antecedents.

Interventions were delivered individually[93,95,97,99,101,102,104,105] or in groups[98] by investigators,[95–101] residential and institutional caregivers,[94,102,103] matched peers[104] and other key personnel such as nurses,[93,98] physiotherapists,[93,105] fitness trainers, etc.[98,105] The level of personalisation varied and focused on considering the mental and physical disabilities of each participant[93,104] and their physical activity habits.[95] Pre-test sessions were also scheduled on an individual basis[100] and the content of exercise sessions was adapted based on the participants' responses.[104,105] The level of social support differed in the studies.[93–96,100–105]

Case control

Forty-five participants of similar age, who were mostly female[106] and had mild[106,107] to moderate[106,107] learning disabilities associated with Down syndrome[106,107] were recruited from vocational centres[107] and specific organisations.[106] Ethnicity and socioeconomic background were not reported by the studies. All participants resided in family homes.[106,107]

Studies had aerobic exercise[106] or aerobic exercise and resistance exercise as core components.[107] Interventions included walking, jogging, traditional dancing, simple basketball, rhythmic gymnastics with balls/ribbons[107] and exercise with gym equipment.[107] These studies were all compared to participants without learning disabilities.

Both interventions were adapted[106,107] from the existing literature to fill the gap by comparing the effect of the intervention with an unmatched population. Studies do not mention the involvement of participants in intervention design. None of the interventions were based on theories. Behaviour change taxonomy coding (see *Appendix 8*, *Table 21*) includes goal and planning, shaping knowledge, comparison of behaviour and repetition and substitution.

Interventions were delivered by exercise trainers,[106] physiologists[107] and exercise assistants.[107] Interventions were delivered in groups, so not much information is available about levels of personalisation. The groups contained a maximum of five participants. No form of social support was reported.

Outcomes

Table 6 presents details on the intensity of the interventions, outcomes measured and the intervention effect.

Participants received RCT-based interventions for 12–32 weeks (8 months). Only one study followed up with the participants at 4 weeks.[89] Studies did not have a maintenance period; however a 3-month follow-up study[77] was considered as 'detraining' time. Non-RCT-based interventions were received by the participants for 8 weeks to 36 weeks (9 months). Studies did not follow up participants, except for one study[93] which had 3-month follow-up. No maintenance period was reported. All interventions varied in their intensity.

Participants dropped out due to medical conditions related (soreness/injury) or unrelated to intervention, death, behavioural problems, feeling overwhelmed by the studies, lack of willingness, conflict in schedules (vacation time) and logistic reasons and lack of release by their primary care provider. Moreover, programmes were interrupted due to illness in three participants.[79,91] Most studies did not report any adverse events,[78,83,88,107] and few reported that the adverse events were mild and rare,[79,89] such as musculoskeletal complaints[79,89] and falls.[91]

Effects of interventions on low physical activity only behaviours were assessed using anthropometric, cardiorespiratory, functional and general health outcomes. As shown by the direction of effect (see *Table 6*), RCT-based interventions led to positive effect in a range of outcomes but in some cases, it resulted in no change or a negative effect, which could be attributed to the presence of a single core-component or a combination of similar core-components. Similar results were observed for non-RCT-based interventions. Overall, majority of studies had interventions with positive effects on outcomes but of varying statistical significance. This also featured positive effects in outcomes related to mental health, specifically reducing levels of anxiety and depression, as well as improving quality of life and life satisfaction. In few studies, outcomes were statistically significant. Cost-effectiveness was not assessed by any studies.

Summary of studies targeting multiple behaviours

Forty-one studies targeting multiple behaviours that is low physical activity, sedentary behaviour and poor diet on 3164 participants were reviewed.

Studies consisted of 17 RCTs,[109–125] 8 controlled pre–post studies,[126–133] 12 uncontrolled pre–post studies[21,108,134–142,147] and 4 case-control studies.[143–146] Twenty-five studies were undertaken in the USA,[21,109–111,113–115,121,122–126,129–132,135–138,141,143,145,147] 10 studies in UK,[108,116,117,120,127,128,139,140,146,148] 2 studies in Spain[133,144] and 1 each in Sweden,[112] Australia,[118] Slovenia[119] and Turkey.[142]

Population and intervention characteristics

Table 7 presents details related to the participants, the interventions and their comparators.

Randomised controlled trials

One thousand four hundred and thirty participants in their early 20s to late 50s were recruited from local or community-based day centres,[110,112,116,121] sheltered workshops,[114,115] special development schools,[118] adult therapy centres,[118] vocational training centres,[125] Special Olympics programmes,[119] networks of disability and special needs agencies,[110,111,116,120] etc. It involved the use of mailed flyers, postings or referrals by staff working in primary care and community services.[109,113,117,123] Participants had mild,[109–112,114,116,117,119–121,122–125] moderate,[109–112,114,116–123,125] severe[118] and profound[116] levels of learning disabilities. Two studies[113] simply reported IQ ranging from 42.1 to 49.1. They were associated with Down syndrome,[116,119,122,123] fragile X syndrome,[116,119] Prader–Willi syndrome,[119] autism,[110,119,123] movement disability,[117] sensory loss,[116,117] epilepsy,[116,117] seizures,[116] allergy or asthma,[117] diabetes,[116,117] problem behaviour,[116] mental health problems,[116] etc. Most participants' ethnicity was Caucasian.[109–111,116,117,120–123] Other ethnicities included black,[110,111,121,123] Hispanic,[110,111,113,121,123] Asian,[117,123] Native American[110,121,123] and mixed

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
RCT					
Boer *et al.*, 2016[76]	12 weeks; no maintenance period.	3 sessions per week, 30 minutes	Weight (kg) BMI (kg/m^2) Waist circumference (cm) Hip (cm) Fat mass (kg) Blood pressure (SBP- mmHg, DBP- mmHg)	Decrease in weight in both groups,[a] decrease in BMI in IT group[a] and no change in CAT group, decrease in weight circumference, hip and fat mass in both groups. Increase in peak VO_2, relative VO_2, time to exhaustion in both groups.[a] Increase in VE (l/minute) in IT[a] and CAT group.	Mix of positive, negative and no change[c]
			Blood profile (T-Chol – mg/dL, Glucose – mg/dL) Physical fitness (peak VO_2 –l/minute, relative peak VO_2 –ml/kg/minute, VE – l/minute, time to exhaustion – seconds, peak heart rate – bpm) Functional ability (6-minute walking distance – m, hand grip strength – kg, 8-ft up and go – seconds, sit-to-stand-amount/30 seconds)	Increase in 6-minute walking distance and decrease in 8-ft up and go and increase in sit-to-stand in IT and CAT[a] group. Increase in peak HR in IT group and no change in CAT group. Increase in HGS in both groups.	
Boer *et al.*, 2018[77]	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/m^2) Physical fitness (Peak VO_2 – l/minute, relative peak VO_2 – ml/kg/minute, VE – l/minute, time to exhaustion – seconds, peak heart rate – bpm) Functional ability (6-minute walking distance – m, hand grip strength – kg, 8-ft up and go – seconds, sit-to-stand – amount/30 seconds)	Decrease in weight in both groups,[a] decrease in BMI in IT group[a] and no change in CAT group. Decrease in relative peak VO_2, time to exhaustion, 6-minute walking distance for both groups[a] Increase in 8-ft up and go for both groups[a] Decrease in peak VO_2, VE, peak HR in IT[a] 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[c]
Bossink *et al.*, 2017[78]	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 subgroup, increase in BMI in normal subgroup and no change in BMI in overweight subgroup 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[c]

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Calders *et al.*, 2011[79]	20 weeks; no follow-up and maintenance period.	2 sessions per week, 70 minutes	Physical fitness (peak VO_2 -l/minute), relative peak VO_2- ml/kg/minute, peak power- Watt, peak heart rate – #/minute, 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 seconds)	Increase in peak VO_2, relative peak VO_2, maximal strength lower and upper limb, abdominal muscle, hand grip and sit-to-stand in COT[a] and AET group Increase in peak power, 6-minute walk distance and muscle fatigue in both groups[a] Increase in low back muscle in both groups Decrease in peak heart rate in both groups	Mix of positive, negative and no change[c]
			Weight (kg) BMI (kg/m^2) Waist (cm) Fat mass (kg) Fat-free mass (kg) Blood pressure (SBP, DBP) Lipid profile (total cholesterol, high- and low-density lipoprotein)	Increase in weight in COT and no change in AET group No change in BMI, waist in either group Decrease in fat mass in both groups Increase in fat-free mass in both groups Decrease in SBP in both COT and AET groups[a] Decrease in DBP in both groups Decrease in total cholesterol in COT[a] but AET group Increase in HDL in both groups Decrease in LDL in both groups	
Carmeli *et al.*, 2009[80]	26 weeks; no maintenance period.	3 sessions per week, 20–30 minutes Leisure session: 20–40 minutes	Hamilton Anxiety Scale (HAM-A)	Decrease in HAM-A in both groups[a]	Positive[b]
Carraro *et al.*, 2012[81]	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[a]	Positive[c]
Heller *et al.*, 2004[82]	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, depression, life satisfaction)	Decrease in cognitive emotional barriers[a] and increase in outcome expectation[a] and performance self-efficacy[a] Increase in community integration and life satisfaction[a] Decrease in depression	Positive[b]

continued

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Melville *et al.*, 2015[83]	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/m^2) Waist circumference (cm) Subjective Vitality Scale Self-efficacy for Activity for Persons with Intellectual Disability EQ-5D	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 Increase in subjective vitality and self-efficacy No change in EQ5D	Mix of positive and negative[a]
Ordonez *et al.*, 2014[84]	10 weeks; no follow-up and maintenance period.	3 sessions per week	Fat mass (%) BMI (kg/m^2) Waist-to-hip ratio Waist circumference (cm) $VO_{2\ max}$ Heart rate (minutes) Fitness (ml/kg/minute) Plasmatic levels (tumour necrosis factor, interleukin, high sensitive C-reactive protein, waist-to-hip ratio, waist circumference)	Decrease in fat mass,[a] BMI, waist-to-hip ratio,[a] BMI, waist circumference[a] Decrease in plasmatic levels[a]	Positive[c]
Pérez-Cruzado *et al.*, 2017[85]	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,[a] moderate, walking[a] and total.[a] Increase in quality of life,[a] self-efficacy Decrease in family support, professional support[a] Increase in peer support	Positive[c]
Rimmer *et al.*, 2004[86]	12 weeks; no follow-up and maintenance period.	4 sessions per week, 30–45 minutes of cardiovascular exercise and 15–20 minutes of muscular strength and endurance training	Peak VO_2 (ml/minute/1) Peak heart rate (beat/minute) Time to exhaustion (seconds) Maximum workload (W) Respiratory exchange ratio Bench press (lbs) Leg press (lbs) Hand grip (left and right) Body weight (kg) BMI (kg/m^2) Total skinfold measure (mm)	Increase in peak VO_2,[a] peak heart rate,[a] time to exhaustion,[a] max workload[a] and respiratory exchange ratio Increase in bench press,[a] leg press[a] and hand grip Decrease in body weight,[a] BMI and total skinfold	Positive[c]

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Rosety-Rodriguez *et al.*, 2013[87]	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[a] Decrease in fat-free mass[a] and waist circumference[a] Increase in timed get up and go	Positive[c]
Shields *et al.*, 2008[88]	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 solving task	Positive (not significant)
Shields *et al.*, 2015[89]	8 weeks; 4 weeks; no maintenance period.	Walkabout programme: 2 sessions per week, 150 minutes Social programme: once a week; 90 minutes	Waist circumference (cm) Weight Self-selected walking speed (cm/second) Fast walking speed (cm/second) 6-minute walk distance (m) Physical activity counts (7-day accelerometry) 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[a]
Silva *et al.*, 2017[90]	2 months; no follow-up and maintenance period.	3 sessions per week, an hour each	Body weight (kg) BMI (kg/m^2) Body fat (%) Visceral fat Muscle mass Waist circumference Limb movement (Plate Tapping Test) Static arm strength (hand grip test)	Decrease in weight,[a] body fat %, visceral fat, muscle mass, waist circumference Increase in BMI Decrease in limb movement,[a] running speed and agility Increase in static arm strength, balance, flexibility, explosive leg power, trunk strength,[a] muscular endurance, aerobic endurance Increase in right-hand co-ordination and response speed Decrease in left-hand co-ordination and functional time up and go test[a]	Mix of positive and negative[c]

continued

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
			Running speed and agility (shuttle run) Balance (Flamingo balance test) Flexibility (sit and reach test) Explosive leg power (standing broad jump) Trunk strength (30-second sit-ups) Muscular endurance (bent arm hang) Aerobic endurance (6-minute walk) Right-hand co-ordination Left-hand co-ordination Bruininks–Oseretsky Response Speed Subtest Functional – timed up and gotest		
Van Schijndel-Speet *et al.*, 2017[91]	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 (m/second) Walk speed fast (m/second) Blood pressure (DBP, SBP) Aerobic performance minimum: second ISWT 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 Signalising Depression List for people with Intellectual Disabilities (SDL-ID) Dementia Questionnaire for Persons with Mental Retardation (DMR) Cognitive subscale (0–50)	Increase in NL-1000 steps/day[a] Decrease in StepWatch steps/day[a] Increase in strength[a] and balance Decrease in walk speed fast (m/second) No change in walk speed comfortable (m/second) Increase in SBP[a] and aerobic performance Decrease in DBP[a] Increase in weight Decrease in waist circumference Increase in glucose Decrease in cholestrol[a] Increase in mobility and depressive symptoms SDL-ID Decrease in ADL Barthel index, IADL Lawton scale Increase in cognitive functioning[a]	Mix of positive, negative and no change[c]
Controlled pre–post					
Carmeli *et al.*, 2004[92]	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 0–5 scale Photoplethysmography (PPG) Ankle-Brachial Index ratio (ABI) Heart pulse – 1 minute Blood pressure (mm Hg) Respiration rate	Increase in walking performance, PPG, ABI in A1[a] and A2 groups Decrease in pain in both groups[a]	Positive[b]

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Oviedo *et al.*, 2014[27]	14 weeks; no follow-up and maintenance period.	3 sessions per week, for an hour each	Weight BMI Waist circumference Body density Body fat percentage VO_2 peak (l/minute) Relative VO_2 peak (ml/kg/minute) Minute ventilation (VE, VE, l/minute) Respiratory exchange ratio (RER) 6-minute walk test (6MWT) Timed up and go test (TUGT) Handgrip strength Leg strength Sit and reach test (SRT) Functional shoulder rotation (FSRT) test Single leg stand test (SLST) Postural sway (centre of pressure total travel distance, antero-posterior displacements, radial area, medio-lateral displacements)	Decrease in weight,[a] BMI,[a] waist circumference, fat mass and fat-free mass Increase in bone mass, residual mass Increase in VO_2 peak,[a] peak heart rate, VE, peak workload,[a] RER, blood pressure,[a] 6-minute walk test[a] Increase in handgrip and leg strength[a] Increase in SRT,[a] FSRT,[a] SLST[a] Decrease in TUGT[a] Increase in SLST[a] Increase in COP TTD Decrease in COP APD, RA, MLD[a]	Mix of positive and negative[c]
Uncontrolled pre-post					
Jones *et al.*, 2007[93]	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 Learning Disabilities (BILD) Life Experiences Check List, Aberrant Behavior Checklist (ABC), Alertness Scale- daily % unengaged]	No change in physiological outcomes. Increase in BILD freedom[a] and decrease in Aberrant Behavior Checklist (ABC) total score[a] and alertness scale	Mix of positive and no change[c]
Messent *et al.*, 1998[94]	10 weeks; no follow-up and maintenance period.	Once a week for 1 hour	Weight (kg) BMI (kg/m^2) $VO_{2\ max}$	Decrease in body mass[a] and BMI Increase in $VO_{2\ max}$ [a]	Positive[c]

continued

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Moss, 2009[95]	12 weeks; no follow-up and maintenance period.	3 days per week	BMI (kg/m^2) Waist-to-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 waist-to-hip ratio in males and decrease in females Decrease in body fat in both sexes[a] Increase in physical work capacity in both sexes[a]	Mix of positive and negative[c]
Pérez-Cruzado *et al.*, 2016[96]	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, hand grip test, single-leg stance with opened eyes, single-leg stance with closed eyes, functional reach test, 2-minute step test_before exercise, 2-minute step test_after exercise, 2-minute step test_2 minute after)	Increase in METs, [a] professional support,[a] peer support,[a] quality of life[a] Decrease in self-efficacy,[a] family support[a] Decrease in time-stands test and 2-minute step test before exercise Increase in rest	Mix of positive and negative[c]
Pitetti *et al.*, 1991[97]	16 weeks; no follow-up and maintenance period.	3 days per week	VO_2 (ml/kg/minute) Heart rate (bpm) Body weight (kg) Body fat (%) RQ (VCO_2/VO_2)	Decrease in weight and body fat[a] Increase in VO_2, heart rate, VE, RQ	Positive[c]
Podgorski *et al.*, 2004[98]	12 weeks; 1 year; no maintenance period.	4 sessions per week, 30–45 minutes	Upper and lower body strength (number of curls in 30 seconds and chair rises) Range of motions (left and right shoulders; left and right hip) Mobility gait (seconds)	Increase in upper and lower body strength and range of motions Decrease in mobility gait	Mix of positive and negative[a]
Pommering *et al.*, 1994[99]	10 weeks; 1 week; no maintenance period.	4 times per week	$VO_{2\,max}$ (ml/kg) Maximum oxygen pulse (ml/beat) Maximum vent (l/minute) Maximum time (minute)	Increase in $VO_{2\,max}$,[a] maximum oxygen pulse,[a] maximum vent[a] and max time[a] Increase in flexibility[a] No change in weight, BMI, lean mass, body water	Mix of positive and no change[c]

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
			Heart rate (watts) Sit and reach test Flexibility (cm) Weight (kg) Body fat (%) Lean mass (%) Body water or hydration (%)		
Przysucha *et al.*, 2020[100]	6 weeks; no follow-up and maintenance period.	3 sessions per week, an 1 hour each	Upper body strength (10RM chest press) Lower body strength (10RM seated leg press) Cardiorespiratory fitness (Leger 20-meter shuttle run) $VO_{2\ max}$	Increase in upper and lower body strength,[a] cardiorespiratory fitness, $VO_{2\ max}$[a]	Positive[b]
Stanish *et al.*, 2001[101]	10 weeks; 14 weeks Maintenance period: 4 weeks.	3 sessions per week, 15–17 minutes The number of sessions in the final reversal was extended to 12, duration based on time constraints	Engagement in MVPA Attendance to physical activity sessions	Increase in MVPA engagement and attendance	Positive (not significant)
Wu *et al.*, 2010[102]	6 months; no follow-up and maintenance period.	4 times per week, 40 minutes	Weight (kg) BMI (kg/m^2) V shape sit and reach test (cm) Sit-up (30s and 60s) Shuttle run (seconds)	Decrease in weight[a] and BMI[a] Increase in V-shape sit and reach test,[a] sit-ups[a] and shuttle runs[a]	Positive[b]
Yen *et al.*, 2012[103]	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[a] and BMI[a] Increase in V-shape sit and reach test, sit-ups[a] and shuttle runs[a]	Positive[c]
Yan *et al.*, 2015[104]	6 weeks; no follow-up and maintenance period.	2 days a week	BMI (kg/m^2) Waist circumference (cm) Physical activity (steps/hour) Handgrip (kg) Sit–stand test (seconds) 6 minutes walking (m) Balance (errors)	Increase in BMI, physical activity,[a] handgrip, 6 minutes walking Decrease in waist circumference,[a] sit–stand test[a] and balance[a]	Mix of positive and negative[c]

continued

TABLE 6 Intervention detail, outcomes and effect direction of low physical activity only studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Zurita-Ortega *et al.*, 2020[105]	12 weeks; no follow-up and maintenance period.	1 hour session per week	BMI 6-minute test 50 m speed test Hand-grip dynamometer Endurance (6-minute test, 50 m speed test, hand-grip dynamometer) Speed Balance and co-ordination	Decrease in BMI[a] and speed[a] Increase in strength,[a] balance,[a] endurance[a] and co-ordination[a]	Positive[b]
Case control					
Giagkoudaki *et al.*, 2010[106]	6 months; no follow-up and maintenance period.	3 sessions per week, 60 minutes	Body weight (kg) BMI (kg/m^2) Resting heart rate	Decrease in body weight[a] and no change in BMI	Mix of positive and no change[c]
Mendonca *et al.*, 2011[107]	12 weeks; no follow-up and maintenance period.	3 days per week	Body mass (kg) Body surface area (m^2) BMI (kg/m^2) Fat mass (kg) Fat-free mass (kg) Relative fat mass (%) VO_2 (ml/kg/minute) Body surface area (l/minute/m^2) Respiratory exchange ratio Heart rate (beats/min)	Decrease in body mass,[a] body surface area[a] and fat-free mass[a] Decrease in BMI, fat mass and relative fat mass	Positive[c]

a Unable to comment on the significance of the results.
b Outcomes which were reported to be statistically significant.
c Varying level of significance.

TABLE 7 Patient characteristics and core components of multiple behaviour studies

Author, year	Number of participants and age according to intervention and comparator	Core components
RCT		
Bergström *et al.*, 2013[112]	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
Curtin *et al.*, 2013[113]	21 Nutrition activity education + behavioural intervention (NAE + BI) (11); mean age (SD) = 20.5(4.1) NAE (10); mean age (SD) = 20.5(2.4)	NAE + BI: diet advice + aerobic exercise + BCT NAE: diet advice + aerobic exercise
Fisher, 1986[114]	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
Fox *et al.*, 1984[115]	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
Harris *et al.*, 2017[116]	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
House *et al.*, 2018[117]	82 Supported self-management + TAU (41); mean age (SD) = 54.8 (10.83) TAU (41); mean age (SD) = 57.3 (12.26)	BCT
Jackson *et al.*, 1982[118]	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
Kovacic *et al.*, 2020[119]	150 Fun fitness + multicomponent balance-specific exercise programme (MBSEP) (50) Wellness programme (50) Special Olympics training (50) Age = 18–49 and above 50	Fun fitness + MBSEP: aerobic exercise + resistance exercise + diet advice Wellness: aerobic exercise + resistance exercise + diet advice + mindfulness
Lally and Wilson *et al.*, 2021[120]	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
McDermott *et al.*, 2012[111]	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
Marks *et al.*, 2013[121]	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
Neumeier *et al.*, 2021[122]	35 POWERSforID (17) Minimal information control (18) Mean age (SD) = 34.6 (5.7)	POWERSforID: BCT + diet advice + aerobic exercise Control: BCT

continued

TABLE 7 Patient characteristics and core components of multiple behaviour studies (*continued*)

Author, year	Number of participants and age according to intervention and comparator	Core components
Pett *et al.*, 2013[110]	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
Ptomey *et al.*, 2018[123]	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
Ptomey *et al.*, 2018[123]	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
Rotatori *et al.*, 1980[124]	18 Multicomponent behaviour therapy (10) No exercise control (8) Age not reported	Aerobic exercise + energy-deficit diet + BCT
Rotatori *et al.*, 1986[125]	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 programme: energy-deficit diet + aerobic exercise + BCT Post-treatment maintenance control: BCT
Controlled pre-post		
Bodde *et al.*, 2012[126]	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
Chapman *et al.*, 2005[127]	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
Chapman *et al.*, 2008[128]	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
Fox *et al.*, 1985[129]	15 Parent involvement (8); mean age (SD) = 27 (2.7) Subject involvement (7); mean age (SD) = 29 (2.2)	Energy-deficit diet + BCT
Mauro-Martín *et al.*, 2016[133]	47 Nutrition and physical exercise workshop (11) Control (36) Mean age (SD) = 37 (9.4)	BCT + energy-deficit diet + aerobic exercises
Niemeier *et al.*, 2021[131]	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
Norvell *et al.*, 1987[132]	13 Weight-loss intervention (7); mean age (SD) = 30.2 (3.9) Attention-placebo, wait-list control (6); mean (SD) = 30.1 (8.1)	Diet advice + BCT
Steele McCarran *et al.*, 1990[130]	8 Home help (4); mean age = 27 No help patched-up control (4); mean age = 31	Home-help group: BCT + energy-deficit diet No home-help group: BCT + energy-deficit diet

TABLE 7 Patient characteristics and core components of multiple behaviour studies (*continued*)

Author, year	Number of participants and age according to intervention and comparator	Core components
Uncontrolled pre-post		
Bazzano *et al.*, 2009[135]	Health lifestyle change program (44) Age = 18–65 years	Diet advice + aerobic exercise + BCT
Croot *et al.*, 2018[108]	Slimming World (9) Age not reported	BCT
Geller *et al.*, 2009[21]	Empowerment-based model (45) Mean age (SD) = 42.6	Aerobic exercises + BCT
Harris *et al.*, 1984[136]	Behavioural weight control programme (21); mean age (SD) = 25.3 (6.37)	BCT + energy-deficit diet
Mann *et al.*, 2006[137]	Steps to your health (STYH) programme (192); mean age (SD) = 38.6 (11.5)	Aerobic exercise + energy-deficit diet + BCT
Marks *et al.*, 2019[138]	HealthMessages Peer-to-Peer Program (311); mean age (SD) = 41.2 (16.1)	BCT
Marshall *et al.*, 2002[139]	25 Health promotion in local leisure centres (10) Day-centre programme (9) Facility residents (6) Age = less than 20, 30–60, over 60	BCT
Melville *et al.*, 2011[134]	TAKE 5 (54) Mean age (SD) = 48.3 (12.01)	Energy-deficit diet + aerobic exercise + BCT
Spanos *et al.*, 2016[140]	TAKE 5 (28) Age not reported	Same as above
Saunders *et al.*, 2011[147]	Stop light diet (SLD) guide (73) 18–62 years	Energy-deficit diet + aerobic exercise + BCT
Wilson *et al.*, 1993[141]	Healthy eating programme (10) Age not reported	BCT + diet advice + aerobic exercise
Yilmaz *et al.*, 2014[142]	Nutrition and activity programmes (37) Mean age (SD) = 26.61 (7.87)	BCT
Case control		
Ewing *et al.*, 2004[143]	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
Martínez-Zaragoza *et al.*, 2016[144]	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
Spanos *et al.*, 2014[146]	156 TAKE 5 ID (52); median age (range) = 51 (26–73) No learning disabilities (104); median age (range) = 51 (28–73)	Energy-deficit diet + aerobic exercise + BCT
Ptomey *et al.*, 2020[145]	124 Enhanced stop light diet (eSLD) (24) No Down syndrome (103) 18–62 years	Energy-deficit diet + aerobic exercise + BCT

ethnicities.[111,117,123] Participants were mostly female.[109–113,116,120,121,123,125] Few studies reported the socioeconomic status of participants: they belonged to families from low-income status with little formal education[116,118] or their families were employed,[122] well-educated[110] and reported incomes between US $60,000 and US $105,000/year.[110] Participants resided in community residences,[111,120,121,122,124] host homes,[122] at home with family and carers[110,111,113,115,116,118,120–122,125] or lived independently living.[111,116,117,120–123]

Most interventions had EDD, aerobic exercise and BCT as core components.[109,112,116,123–125] This consisted of multicomponent interventions with a health course; health ambassadors and study circles for caregivers; EDD and health education principles;[116] colour-coded, portion-controlled diets;[109,123] behaviour therapy[124] and weight reduction maintenance strategies.[125] Interventions with diet advice, aerobic exercise and BCTs as components[113,114,120,122] featured a nutrition activity education with behavioural intervention,[113] weight reduction programme,[114] supported learning of new behaviours and weight management[120] and a personalised online weight and exercise response system for individuals.[122] Interventions with aerobic exercise, resistance exercise, diet advice and BCT as core components consisted of exercise and health education programme[121] and recreation centre-based healthy lifestyle interventions also involving parents.[110] Aerobic exercise, EDD and BCTs were core components of a health promotion programme.[111] Fun fitness with multicomponent balance-specific exercise[119] had aerobic exercise, resistance exercise and diet advice as core components. Studies on programmes with streamlined weight loss, supported self-management[117] and behavioural weight reduction[118] had EDD and BCT BCTs only[117] or BCT combined with diet advice,[118] respectively. Few comparators also had sufficient information to code for BCTs.[109–111,113,114,116,118–120,123]

Comparator groups included active comparators,[116,119] wait-list control,[110,121,122] no exercise[124] or treatment control.[118] Active comparators groups received Special Olympics training[119] and mainstream Waist Winners weight management programme.[116] Wait-list controls included participants placed in secondary intervention groups.[110] Controls were weighed weekly and received social recognition for weight loss[125] or received laboratory measures, a consultation with a medical professional and a discussion about overall health management strategies with the health coach.[122] No exercise or treatment groups were informed that the weight reduction programme was already filled and that they should try to lose weight on their own[124] or whether they gained or lost weight with verbal reinforcements.[118] There were also TAU/usual care groups.[109,112,117,120,123] Community residents who continued to work as usual were promised the possibility of taking part in the intervention after completion of the study, leaflets were posted by nurses[117] and included a short 30-minute discussion about eating and exercise choices where participants received a leaflet and a DVD developed by learning disabilities services.[120] Conventional diet as usual care included 500–700 kcal/day energy deficit.[109,123] Individuals were recommended food servings to meet their energy intake goals, instructions regarding appropriate serving sizes of food items and measuring foods to ensure compliance with serving size recommendations. Interventions were also compared to groups which received education on nutrition and activity only and safety and hygiene classes,[111,113] or to those who received the same intervention but without walking and direct involvement of buddies.[56]

Intervention was also designed using the literature and manual published by the coauthors[109,111,113,114,117,118,120,123] and was adjusted for responding to self-care barriers in learning disability population;[120] to include strategies for bolstering weight loss;[125] to combine well-established models;[122] to eliminate previously used strategies and increase applicability in the population without added external support systems; to include new behavioural change techniques;[117] to address staff training, knowledge and motivation of the target group and organisational factors within community-based organisations, etc. Most studies do not clearly mention if participants were involved in design of the intervention. However, during the intervention's development, regular consultation meetings involving members of the research team, people with learning disabilities and their representatives, as well as clinical experts, were involved.[111,117] Intervention was also adapted based on ability levels of the participants.[116] Participant involvement in design was explicitly stated by only one study,[110] where health education content was streamlined and additional lessons added (e.g. stress management) per the request of the participants in preparation of the study.

Interventions were based on social cognitive theory,[109–112,120,121,123] control theory,[120] transtheoretical model,[110,121,122] person-centred theory,[122] socioecological model[122] and Bronfenbrenner's ecological theory of human development[110] (see *Appendix 7*, *Table 19*). Behaviour change taxonomy coding (see *Appendix 8*, *Table 22*) includes goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, associations, repetition and substitution, reward and threat, regulation, antecedents and self-belief.

Interventions were delivered by investigators,[109,114,115,119,120,123,124] parents,[118] health ambassadors chosen by the manager and caregivers themselves and other trained professionals, including dietitians,[110,113,116] therapists,[116,118,119] personal trainers,[119] social workers,[110] etc. Intervention was also delivered remotely through information and communication technology and personalised coach calls.[122] Sessions were conducted individually[111,113,116–119,121–125] or in groups.[112,114,115,120] Level of personalisation differed. For example, some interventions considered the individual levels of learning disabilities;[118] strategies such as diet were personalised;[116] goals were modified according to participants' current level of physical activity, abilities and preferences[110,116] and the level of caregiver involvement was altered according to individual needs and abilities.[116] Studies also directly targeted parents, buddies, caregivers, health ambassadors and study partners.[109,110,112,113,115,116,118–120,123] Social supporters included family member,[111,113,115,116,118,120,123,125] paid caregivers,[112,116,120] staff at residents,[109,111] teachers[118] and key supporters.[117]

Non-randomised controlled trials

Controlled pre–post

Three hundred and fifty-two participants in their mid-20s to early 40s were recruited from disability services agencies,[126] Special Olympics,[126,131] day resource centres,[127,128] sheltered workshop[129,132] and vocational programmes.[130] The process included recruitments that were voluntary,[129,130] through direct referrals to the investigators[127,128] or by using promotional flyers[126] and word-of-mouth recommendation.[126] Most participants had mild[126,132] to moderate[129,132,133] levels of learning disabilities. However, only one study included participants with severe level of learning disabilities.[133] The studies did not report the level or stated the IQ range as 50–80.[130] Participants were associated with cerebral palsy, borderline intelligence, autism spectrum disorder, epilepsy and other conditions such as alterations of language, character and behaviours.[130,133] Only one study[131] recorded that ethnicity of participants' majority was Caucasian. None of the studies mention the socioeconomic status, but one study[131] stated that the participants were of similar status. Studies[126–129,133] mostly had almost equal distribution of males and females. Participants resided in their homes with parents, roommates or caregivers[129–132] and other living situations such as dispersed housing provided by public or private providers,[127,128] assisted living homes[131] or independently on their own.[131]

The studies mostly consisted of two core components only. BCT and aerobic exercise core components were included by a health education curriculum-based study[126] focusing on physical activity both independently and with others, safety and nutrition. Interventions with diet advice and BCTs core components[127,128] addressed topics on main barriers to physical activities and diet via educational sessions and sessions on self-monitoring food and exercise.[132] Whereas interventions with EDD and BCT core components[129,130] directly taught dietary strategies specific to self-control, decreasing overeating and burning calories through exercise. Two interventions had BCT, EDD and aerobic exercise[131,133] as core components and consisted of nutritional and exercise workshops on hydration, calories throughout the day, culinary techniques and games with exercise components, as well as a coach-led training session for the Special Olympics team.

Interventions were compared to wait-list control, no activity controls or groups which received majority of the elements of the interventions but no support from health practitioners or parents. One study[130] included a patch-up waitlist control group made of four participants who could not participate due to scheduling conflicts. Waitlist groups were also weighed regularly and received feedback.[132]

Interventions were developed or adapted for this population to include a tailored health education approach with empowerment techniques,[126–128,131] to involve parents when new BCTs were introduced every 2 weeks[129] and to assess the impact of home-help group.[130] Studies do not clearly mention if participants were involved in design of the intervention. Some state inclusion of intervention materials which were developed by the authors alongside a panel of adults with ID and an expert panel of researchers.[126]

There is no mention of any theories that were used in the intervention in controlled pre-post study. Behaviour change taxonomy (see *Appendix 8*, *Table 22*) included identity, goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, repetition and substitution, comparison of outcome, reward and threat, antecedents and self-belief.

Interventions were delivered by investigators[126,130,131] with assistance from experienced graduate students and undergraduates,[130] parents and carers[127–129] and other trained personnel such as physiotherapists,[127,128] trained dietitians–nutritionists[133] and professionals.[131,133]The sessions were conducted individually[127–130] or in groups,[126,131] but the level of personalisation varied between studies. Some studies provided one-to-one home visits[127,128] and modified interventions based on assessments[127,128] Not all studies reported or were clear about social supporters, including support staff,[127,128] parents and relatives.[127–130] Few studies directly targeted parents, health co-ordinators, exercise specialists and coaches.[127–130]

Uncontrolled pre-post

Eight hundred and forty-nine participants aged mid-20s to late 40s were recruited from community organisations,[135,138] institutions/vocational training schools,[136,142] local day rehabilitation[21] via recruitment notices by contacting a member of the research team or referral from a network of local disability service providers[137] and other specialist intellectual disability professionals.[134,140,141] Participants had mild,[21,134,135,140,141] moderate,[21,134,135,140] severe[21,134] and profound[134] levels of learning disabilities. Three studies reported only the IQ[136,137] scores of the participants ranging from 50.7 to 52.5. Participants were also associated with general learning disabilities,[108] autism,[108,135] cerebral palsy,[135] epilepsy,[134] seizures and fits,[134] sensory loss,[134] mental retardation,[135] ADHD,[108] dyslexia,[108] Down syndrome,[134,137] high blood pressure,[134] high cholesterol[134] and type 2 diabetes. More participants were Caucasian[134,135,137,138] followed by African American,[135,137,138] Latino and multiple ethnicities, including Asians.[135] Studies mostly included female participants[21,135–138] or equally split the genders.[134] None of the studies reported the socioeconomic status of the participants. Residential settings consisted of community residents (group home and supported living),[21,108,135–137,139] homes with family and carers[21,108,134,135–137] or independent living.[108,135,137]

Four of the interventions[134,137] had aerobic exercise, EDD and BCT as core components. These interventions targeted exercise and nutritional intake via walks, activity in home environment and education. Another four interventions had only BCT as core component,[108,138,142] which included education topics on health, physical activity, nutrition and hydration[108,138] and promoting motivation.[142] Interventions with diet advice, BCT and aerobic exercise[135] core components focused on improving nutrition and fitness. An intervention had BCT and EDD core components[136] focused on behavioural and nutritional principles consisting of stimulus control with selecting well-balanced meals and aerobic fitness. Another intervention[21] included aerobic exercise and BCT core component, which empowered participants in making choices and guided their activities. All these studies had no comparators.

Number of interventions were developed and adapted in the studies.[121,134,135,138,142] This included a community-based healthy lifestyle change programme for obese or overweight individuals with vulnerability to metabolic syndrome and diabetes,[135] personalised multicomponent intervention developed using the Glasgow and Clyde Weight Management Service (GCWMS) approach,[77,134] dietary programmes which followed stoplight guides[109,123,137,145,147] and nutritional and physical activity programme prepared based on an exercise and nutrition curriculum.[142] Studies also adapted commercial weight-management interventions like Slimming World[108] and incorporated collaborative community empowerment,[138] empowerment model, kinaesthetic learning style[137] and BCTs.[21,136] One health promotion intervention was nurse-led and adapted from the ‘Activate’ materials produced by the Health Promotion Agency in Northern Ireland. Studies do not clearly state if participants were involved in design of the interventions, but they mention involvement of people with developmental disabilities, family members, care providers, academic researchers and key experts.[134,135,138,140] Interventions also took suggestions from the participants and adapted based on their ability levels.[108,134]

The interventions were based on empowerment theory,[21] social cognitive theory[135,138] and transtheoretical model of behaviour change (see *Appendix 7*, *Table 19*).[138] Similarly, behaviour change taxonomy coding (see *Appendix 8*, *Table 22*) included goal and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, associations, repetition and substitution, reward and threat, regulation and antecedents.

Interventions were delivered by investigators[108,135,136] and trained personnel such as slimming work consultants,[108] peer health coaches,[138] mentors,[138] dietitians,[134] physicians,[21] sports medicine professionals,[134] physical education teachers, etc.[142] Sessions were conducted individually[21,108,134,137,138] or in groups.[108,135,136,142] Studies established personalised exercise programmes and dietary plans and[137,140] intervention providers reviewed strategies to support or modify

physical activity[21,138] and hydration choices within their daily activities of participants,[138] spent 5–10 minutes[21] taking notes of activities[134,140] and held regular meetings for feedback.

Not all studies reported or were clear about social supporters, which included families,[108,134,135–137,142] paid carers,[77,108,134,136] support staff,[108,126,147] group home staff,[137] peer health coaches[138] and mentors.[138] Studies also directly targeted parents, peer mentors, carers, peer health coaches and nurses.[108,134,138,142]

Case control

Five hundred and thirty-three similarly aged participants were recruited from family practice centres,[143] occupational day centres or via routinely collected referrals from ongoing specialist services.[146] They had mild,[143,145,146] moderate,[143,145,146] severe[146] and profound[146] levels of learning disabilities. IQ level of 53 was reported in one study.[144] Participants were associated with Down syndrome, autism,[145] diabetes,[143,146] high blood pressure,[146] heart disease,[146] arthritis,[146] asthma,[146] obstructive sleep apnoea[146] and other mental disorders (mainly schizophrenia).[144] Two studies had majority of Caucasian participants,[145,146] while one had an equal split with non-Caucasian participants.[143] Only one study reported that participants belonged to middle socioeconomic status.[144] Participants resided with family and paid carer or independently.[145,146]

Intervention with combination of aerobic exercise and BCT core components included a health education learning programme which emphasised nutritional choices and stress reduction along with exercise.[143] Two interventions with EDD, aerobic exercise and BCT core components consisted of an energy-deficit or portion-controlled diet with exercises, including walking and use of goal setting to facilitate these changes.[145,146] An intervention[144] with aerobic exercise, resistance exercise, EDD and BCT as its core components had participants go through education and exercise phases of subaerobic and aerobic physical activity. These studies were all compared to group with no learning disability.

Interventions were adapted to mimic real community conditions[143] and add actions related to diet, physical activity and health and encourage participation and retention. Two studies were follow-up studies whose interventions, TAKE5 and eSLD, were initially developed by Melville *et al.*[116,134] and Ptomey *et al.*[109,123] Studies do not mention the involvement of participants in the design of the intervention.

Only one study[145] reported its intervention to be based on social cognitive theory (see *Appendix 7*, *Table 19*). Behaviour change taxonomy coding (see *Appendix 8*, *Table 22*) included goal and planning, natural consequences, regulation, identity, feedback and monitoring, shaping knowledge, comparison of behaviour, repetition and substitution, antecedents, social support and reward and threat.

Interventions were delivered by investigators,[145] health educators,[143] professional carers of participants[144] and other trained personnel such as dietitians,[145] psychologists,[144] a pedagogue[144] and physical activity technicians.[144] Some studies had individual sessions[144–146] or in groups.[143] However, the level of individualisation varied between the studies. For example, studies divided participants into different groups according to physical status (e.g. movement co-ordination and comprehension) and provided personalised reports.[144] Not all studies reported or were clear about social support. Social supporters included staff, families and carers, including paid carers. Studies also directly targeted social supporters, including parents, carers and study partners.

Outcomes

Table 8 presents details on the intensity of the interventions, outcomes measured and the intervention effect.

Participants received RCT-based interventions for 6 weeks to 16 months. Maintenance period for studies differed and ranged from 5 weeks to a year. It included weekly meetings with participants and second parent in-service,[115] sessions on knowledge retention, questions and support,[116] continuation with physical activity[109,123] and review meetings of behaviour techniques and homework assignments.[124] Longest follow-up was for a year.[111,113,115,118] Non-RCTs-based interventions were received by the participants for 6 weeks to a year. Some studies only reported six sessions.[126,134,141] Maintenance period ranged from 10 weeks to 18 months and included follow-up time simply treated as period of maintenance,[132] opportunities for maintenance training,[130] monthly meetings[129] or continuation with physical activity.[145]

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
RCT					
Bergström *et al.*, 2013[112]	12–16 months No follow-up and maintenance period.	10 sessions, 90 minutes	Physical activity (steps/day) BMI (kg/m^2) Waist circumference (cm) Dietary quality: [Food diversity (groups/day), vegetable consumption (occasions/day), lunches complying with the plate model and 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)]	Increase in physical activity[a] Decrease in BMI, waist circumference Increase in work routines[a] No change in satisfaction in life	Mix of positive and no change[c]
Curtin *et al.*, 2013[113]	6 months; 1 year No maintenance period.	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 of 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,[a] body fat, fruit intake, vegetable intake, treats intake Increase in MVPA in NAE + BI group[a]	Mix of positive and negative[c]
Fisher, 1986[114]	8 weeks; 4 weeks No maintenance period.	Behavioural self-control + PA: 2 sessions per week + every 2 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)
Fox *et al.*, 1984[115]	10 weeks; 1 year after maintenance period 5 weeks maintenance period	A session per week	Body weight (pounds/per cent overweight)	Decrease in weight in both groups	Positive (not significant)

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
House *et al.*, 2018[117]	6–8 weeks; 6 months No maintenance period.	3–4 sessions, 30–60 minutes	HbA_{1c} (mmol/mol) BMI Waist measurement (cm) Waist-to-hip ratio	Decrease in HbA_{1c} Increase in BMI, weight, waist measurement, waist-to-hip ratio	Mix of positive and negative[a]
			Blood pressure (SBP, DBP) Lipids (total cholesterol, triglycerides) Renal function Patient Health Questionnaire-2	Decrease in SBP, DBP, total cholesterol, triglycerides, creatinine Increase in eGFR, urea Increase in PHQ-2 score	
Jackson *et al.*, 1982[118]	14 weeks; 6 months, 12 months No maintenance period.	Parents group: Fortnightly, an hour each Treatment group: 6 sessions held weekly between weeks 3 and 8 of treatment	Weight loss (kg) Percentage of bodyweight loss Reduction quotient	Decrease in weight, percentage body weight and reduction quotient[a]	Positive[c]
Kovacic *et al.*, 2020[119]	16 weeks No follow-up and maintenance period.	Fun fitness + MBSEP: once a week, 60 minutes for 60 minutes Wellness: once a week, 60 minutes (all together 12 sessions) 0.15–35 minutes fitness session	Dynamic balance tests – functional reach tests Static balance tests – single leg stance test with eyes opened and eyes closed Falls assessment – frequency of falls in the 4 months	Increase in functional reach for intervention groups MBSEP[a] and Wellness[a]; no change in SO group[a] Increase in dynamic balance for intervention groups[a]; no change in SO group[a] Decrease in frequency of falls in the 4 months previous in intervention groups[a]; no change in SO group	Positive[b]
		All groups: once a week, 60 minutes of regular Special Olympics athletic training Twice a week, 60 minutes same as above but individually			

continued

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Lally *et al.*, 2021[120]	3 months, 6 months No maintenance period.	Shape UP LD: A session per week, 120 minutes Usual care: short 30-minute discussion	Weight (kg) Body fat (%) Waist circumference (cm) Acceptability of following outcome measures: Mental health (Clinical Outcomes in Routine Evaluation for Learning 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 (adapted measure from Change4Life Survey) Service use (adapted Client Service Receipt Inventory) Changes in food purchasing (Shopping receipts)	No change in weight Increase in waist circumference Decrease in body fat	Mix of positive and no change[a]
McDermott *et al.*, 2012[111]	9 weeks; 6 months, 12 months No maintenance period.	Steps to your health (STYH): a session every alternate week, 90 minutes	Knowledge questionnaire (diet, exercise, healthy weight) includes: Life stress survey	Increase in MVPA in both groups Decrease in BMI in both groups Positive response to knowledge questionnaire	Positive (not significant)
		Hygiene and safety classes control: a session per week, 90 minutes	Food availability (availability of fruits, vegetables, grains, high-fat foods, sweetened beverages and snacks and low-fat/reduced-calorie foods) MVPA Weight BMI (kg/m^2)		
Marks *et al.*, 2013[121]	12 weeks No follow-up and maintenance period.	3 days a week, 2 hours	Psychosocial and physiological health status: Perceived general health Social/environmental support for exercise (SESE) Social/environmental support for nutrition (SESN)	Increase in perceived general health, social/environmental supports for exercise (SESE),[a] social/environmental supports for nutrition (SESN),[a] perceived health behaviours[a]	Positive[c]

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
			Perceived health behaviours Weight (lbs) Total cholesterol (TC) Glucose Knowledge and skills:	Decrease in weight Decrease in cholesterol and glucose	
			Self-efficacy to exercise Nutrition and Activity Knowledge Scale Fitness level:	Increase in self-efficacy to exercise[a] and NAKS total[a] (NAKS nutrition subscale, NAKS weight subscale[a])	
			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	Decrease in shoulder flexibility,[a] sit and reach, timed get-up-and-go (TGUG) test Increase in 6-minute walk and 1-minute timed sit-to-stand	
Harris *et al.*, 2017[116]	12 months No follow-up. 6-month maintenance period; considered within active intervention.	9–12 sessions, 40–60 minutes	Weight (kg) Weight loss of 5% or more of initial body weight BMI (kg/m^2) Waist circumference (cm)	Decrease in weight, % weight, BMI, waist circumference, body fat in Take 5[a] and WWToo	Mix of positive and negative[c]
			Body fat (%) Sedentary behaviour (% time spent/day) Light PA (% time spent/day) MVPA (% time spent/day) Total (% time spent/day) European Quality of Life-5 dimensions (EQ-5D) youth version	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 No change in EQ5D in Take 5 and decrease in WWToo	
Neumeier *et al.*, 2021[122]	24 weeks No follow-up and maintenance period.	Weekly (weeks 1–12) Biweekly (weeks 13–24)	Weight (kg) BMI (kg/m^2) Waist circumference (cm) Body fat (%)	Decrease in body weight,[a] BMI,[a] waist circumference[a] Decrease in body fat	Positive[c]
			Blood pressure – SBP, DBP (mmHg) A1C (%) Heart rate Lipid profile (mg/dL) – high-density lipoprotein, low-density lipoprotein, triglycerides, cholesterol	Increase in SBP, high-density lipoprotein and decrease in A1C, DBP, low-density lipoprotein, triglycerides and cholesterol	

continued

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Pett *et al.*, 2013[110]	12 weeks; 3 months No maintenance period.	YWC: 2 times per week, 1.5 hours. Total 36 hours. Yes We Can (YWC) + We Can Too! (WCT)	Weight (lb) BMI Waist and hip circumference (inches) Blood pressure	Decrease in weight, BMI in YWC[a] and YWC + WCT[a] Increase in hip circumference in YWC[a] and decrease in YWC + WCT[a] Decrease in blood pressure, blood sugar in YWC[a] and increase in YWC + WCT[a]	Mix of positive and negative[c]
		Once a week, an hour. Total 18 hours. We Can Too! (WCT): Once a week, 1K hours per session. Total 18 hours.	Resting heart rate Cholesterol Blood glucose Sit-to-stand muscular endurance test Handgrip Bench press (reps × weight)	Increase in 6-minute walk[a], sit to reach, timed get up and go[a] in YWC and decrease in YWC + WCT Increase in Tinetti balance[a] in both Decrease in bench press, leg press in YWC[a] and increase in YWC + WCT[a] Decrease in barriers to exercise in both[a]	
			Maximum leg press (1 repetition maximum, lb) 6-minute walk (ft) Sit and reach test Timed get up and go 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		

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Ptomey *et al.*, 2018[109]	18 months No follow-up 12-month maintenance period after 6 months of weight loss; considered within active intervention.	Once a month, 45–60 minutes	Body weight (kg) BMI (kg/m^2) 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,[a] BMI, waist circumference[a] 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[c]
Ptomey *et al.*, 2018[123]	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),[a] fat,[a] carb,[a] protein, % energy from fat[a] Increase in % energy from carb and protein[a] Increase in total healthy eating index	Positive[c]
Rotatori *et al.*, 1980[124]	7 weeks; 10 weeks after the maintenance 6-week maintenance period.	A session per week, 50 minutes	Weight loss	Decrease in weight[a]	Positive[b]
Rotatori *et al.*, 1986[125]	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)

continued

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Controlled pre–post					
Bodde *et al.*, 2012[126]	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 groups combined[a] Increase in MVPA in immediate group, decrease in delayed group,[a] both groups combined.	Mix of positive and negative[c]
Chapman *et al.*, 2005[127]	1 year No follow-up and maintenance period.	Once every 6 months	Weight (kg) BMI (kg/m^2)	Decrease in weight[a] and BMI[a] in input group.	Positive[b]
Chapman *et al.*, 2008[128]	1 year; 6 years No maintenance period.	Once every 6 months	Weight (kg) BMI (kg/m^2)	Decrease in weight and BMI in input group.	Positive (not significant)
Fox *et al.*, 1985[115]	10 weeks; 22 weeks, 3 months 22-week maintenance period.	10 weeks with 1-hour treatment meeting held for each group twice weekly	Body weight (pounds)	Decrease in weight in PI[a] and SI groups	Positive[b]
Mauro-Martín *et al.*, 2016[133]	3 months No follow-up and maintenance period.	5 sessions each (2 workshops) Once a week, for an hour	Weight (kg) BMI Body fat (%) Visceral fat (%) Food consumption: KidMed questionnaire on adherence to Mediterranean diet	Decrease in weight, BMI, body fat, visceral fat[a] Increase in KidMed score	Positive[c]
Niemeier *et al.*, 2021[131]	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[a] Decrease in SBP,[a] DBP,[a] resting heart rate[a]	Positive[b]
Norvell *et al.*, 1987[132]	10 weeks; 6 months for first treatment group and 3 months for second treatment group. Maintenance period; considered as follow-up.	Weekly, an hour	Weight loss Weight reduction quotient (kg)	Decrease in weight	Positive (not significant)

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Steele McCarran *et al.*, 1990[130]	14 weeks; 1-, 3-, 6- and 12-month follow-up 5-week maintenance period.	3 sessions, 60 minutes	Weight (lbs) Per cent overweight Weight reduction quotient BMI Calliper 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, per cent overweight[a], weight reduction quotient[a], BMI[a] and calliper measurement[a] Increase in time taken to consume a meal and decrease in speed of eating[a]	Positive[b]
Uncontrolled pre–post					
Bazzano *et al.*, 2009[135]	7 months No follow-up and maintenance period.	2 sessions, 2 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 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 and 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 eating 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 (%)	Decrease in weight,[a] BMI[a] and abdominal girth[a] Increase in exercise,[a] nutrient-dense food, fruit[a] and water[a] Increase in self-efficacy related to exercise and eating habits Increase in knowledge related to cooking,[a] buying, ordering healthy food Decrease in belief that healthy food is easier to buy[a] Increase in healthcare access[a]	Positive[c]

continued

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Croot *et al.*, 2018[108]	8 weeks No follow-up and maintenance period.	Once a week	Weight loss BMI	Decrease in weight and BMI	Positive[a]
Geller *et al.*, 2009[21]	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[a]	Positive[b]
Harris *et al.*, 1984[136]	7 weeks; 1 year No maintenance period.	A session per week 5–10 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[a] and girth[a] of hips, waist, thighs, arms Increase in knowledge of nutrition[a] and self-management of behaviour[a]	Positive[b]
Mann *et al.*, 2006[137]	8 weeks; 1 week No maintenance period.	8 sessions, 90 minutes	BMI Knowledge score (% correct) Exercise frequency Dietary intake	Decrease in BMI[a] Increase in exercise frequency[a], knowledge score,[a] intake of healthy meals[a]	Positive[b]
Marks *et al.*, 2019[138]	12 weeks No follow-up and maintenance period.	Weekly, 75-minute sessions in Phase 1 and 30-minute sessions in Phase 2 Additional 1-hour surveys every week	Peer participants: Physical activity knowledge (Activity Knowledge Scale) Hydration knowledge (Hydration Knowledge Scale) Social support and total health behaviour (Health Behaviours Questionnaire)	Peer participants: Increase in physical activity knowledge,[a] hydration knowledge,[a] social support,[a] total health behaviour[a]	Positive[b]
Marshall *et al.*, 2002[139]	6 weeks (2 groups) or 8 weeks (one group) No follow-up or maintenance period.	2 hours per week	Weight loss (kg) BMI (kg/m^2)	Decrease in weight[a] and BMI[a]	Positive[b]

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Melville *et al.*, 2011[134]	9 sessions; Approximately 24 weeks. No maintenance period.	Every 2–3 weeks	Weight (kg) BMI Waist circumference Light-intensity physical activity/day at 24 weeks (minutes) Moderate-to-vigorous-intensity physical activity/day at 24 weeks (minutes)	Decrease in weight,[a] BMI,[a] waist circumference[a] Increase in light-intensity physical activity, moderate-to-vigorous-intensity, percentage of time spent in light-intensity physical activity,[a] percentage of time spent in moderate-to-vigorous-intensity physical activity, moderate-to-vigorous-intensity physical activity in previous 7 days at 24 weeks,[a] time walking in previous 7 days at 24 weeks	Positive[c]
			Sedentary behaviour/day at 24 weeks (minutes) Percentage of time spent in light-intensity physical activity (minutes) Percentage of time spent in moderate-to-vigorous-intensity physical activity (minutes) Percentage of time spent in sedentary behaviour (minutes) Moderate-to-vigorous-intensity physical activity in previous 7 days at 24 weeks (minutes) Time walking in previous 7 days at 24 weeks (minutes) Time sitting/days at 24 weeks (minutes)	Decrease in sedentary behaviour[a] and percentage of time spent in sedentary behaviour,[a] time sitting/day at 24 weeks	
Spanos *et al.*, 2016[140]	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% of participants Decrease in sedentary time Increase in physical activity	Positive (not significant)
Saunders *et al.*, 2011[147]	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[a]

continued

TABLE 8 Intervention detail, outcomes and effect direction of multiple behaviour studies (*continued*)

Author, year	Duration of active intervention; follow-up	Intensity	Outcome	Intervention effect	Effect direction
Wilson *et al.*, 1993[141]	6 sessions No follow-up and maintenance period.	6 sessions, 2 hours	Weight (lbs) Exercise tolerance test Meal time 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)
Yilmaz *et al.*, 2014[142]	15 weeks No follow-up and maintenance period.	Families' education programme: 2 hours/day for 2 days Educational programmes: Sessions, 25–30 minutes. Activity: 3 days a week, 30 minutes	Nutrition and Activity Knowledge Scale	Increase in nutrition and knowledge[a]	Positive[b]
Case control					
Ewing *et al.*, 2004[143]	8 weeks No follow-up and maintenance period.	8 sessions, 90 minutes	BMI (kg/m^2) Self-reported fruit and vegetable intake (% increased) Self-reported exercise (% increased) Knowledge scores relating to healthy eating and physical activity (% increased)	Decrease in BMI[a] Increase in self-reported exercise,[a] fruit and vegetable intake and knowledge score	Positive[c]
Martínez-Zaragoza *et al.*, 2016[144]	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[a] and DBP[a] Increase in heart rate and SBP	Positive[c]
Spanos *et al.*, 2014[146]	16 weeks No follow-up and maintenance period.	10 optional structured supervised activity classes	Weight (kg) BMI (kg/m^2)	Decrease in weight and BMI	Positive (not significant)
Ptomey *et al.*, 2020[145]	18 months No follow-up 12-month maintenance period after 6 months of 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)

a Unable to comment on the significance of the results.
b Outcomes which were reported to be statistically significant.
c Varying level of significance.

A study also classified maintenance period into three categories of weight changes that is a weight gain of > 3%, who maintained their weight ≤3% and who had a weight loss of >3%. All interventions varied in their intensity.

Participants dropped out of the study due to scheduling conflicts including vacation, job-related conflicts, refusal of consent by parents or guardians, illness (broken leg), anxiety, not wanting to receive negative responses from people without learning disabilities, preference to go on outings with family or disability agency staff, carer withdrew the participant, unable to arrange transport and lack of interest. A study reports weight gain as an adverse event. Few studies explicitly report that there were no adverse events.[112,113,117,131,134]

Effect of interventions on multiple behaviours was assessed using anthropometric, behavioural, cardiorespiratory, functional, cognitive, food and nutrition, psychosocial, physical activity and sedentary behaviour, quality-of-life and general health outcomes. As shown by the direction of effect (see *Table 8*), RCT-based interventions led to positive effect in a range of outcomes. In some cases, it resulted in no change or a negative effect which could be attributed to the presence of a single core-component or a combination of similar core-components. Similar results were observed for non-RCT-based interventions. The level of significance of the effect varied.

Studies acknowledge the importance of costing the interventions. However, none of the studies conducted a cost-effectiveness analysis. One study[117] assessed the feasibility of collecting cost-effectiveness outcomes, while another study[120] analysed the cost of delivering the intervention to service users, which was estimated to be £14,960 (£2230 for staff training, £4680 for staff time, £7800 for room hire and £250 for resources) or £598.40 per service user. Some studies highlighted the necessity of doing a cost–benefit analysis.[146]

Risk of bias

The risk of bias was assessed in each included study using the Cochrane Risk of Bias (ROB) version 2[58] for RCTs and ROBINS-I for the non-randomised trials with or without a control group.[59]

Randomised controlled trials

The assessment for 33 RCTs[70,73,76,78,79–91,109–122,124,125] is available in *Figures 2* and *3*.

Bias due to randomisation process: RCTs were regarded as low risk if they provided sufficient details about the randomisation process and allocation concealments. Eighteen RCTs (1 smoking behaviour; 9 low physical activity only; 7 on multiple behaviours)[73,76,78,79–82,85,90,91,110,111,113–115,118,124,125] were assessed to have some concerns about the randomisation process.

Bias due to deviation from intended intervention: Deviation from intended intervention includes the effect of assignment and adhering to the intervention. The judgements were based on the information provided by the RCTs about the blinding of the participants and personnel, balance of the non-protocol interventions across the groups, any deviations from the intended interventions and if the appropriate analyses were carried out by the investigators to account for any of the above. Eight RCTs (4 low physical activity only; 4 multiple behaviours)[76,78,82,83,89,112,120,121] had some concerns towards assignment and adherence of the interventions and 14 RCTs (6 low physical activity only; 8 multiple behaviours)[80,81,84–87,109–111,114,115,118,124,125] were at a high risk for this domain.

Bias due to missing outcome data: 27 RCTs were at a low risk for missing data because of having a low attrition or used appropriate methods to account for the missing data. Three studies (2 low physical activity only; 1 multiple behaviours)[78,80,83] had some concerns and three studies (1 low physical activity only; 2 multiple behaviours)[91,111,125] were at high risk for missing outcome data.

Bias in the measurement of outcome: The assessment of bias in the measurement of outcome was based on the blinding/masking of the outcome assessors, methods used for outcome measurements and their effect on the outcomes. Six RCTs (2 low physical activity only; 4 multiple behaviours)[87,110,114,115,124,125] were assessed to be at a high risk

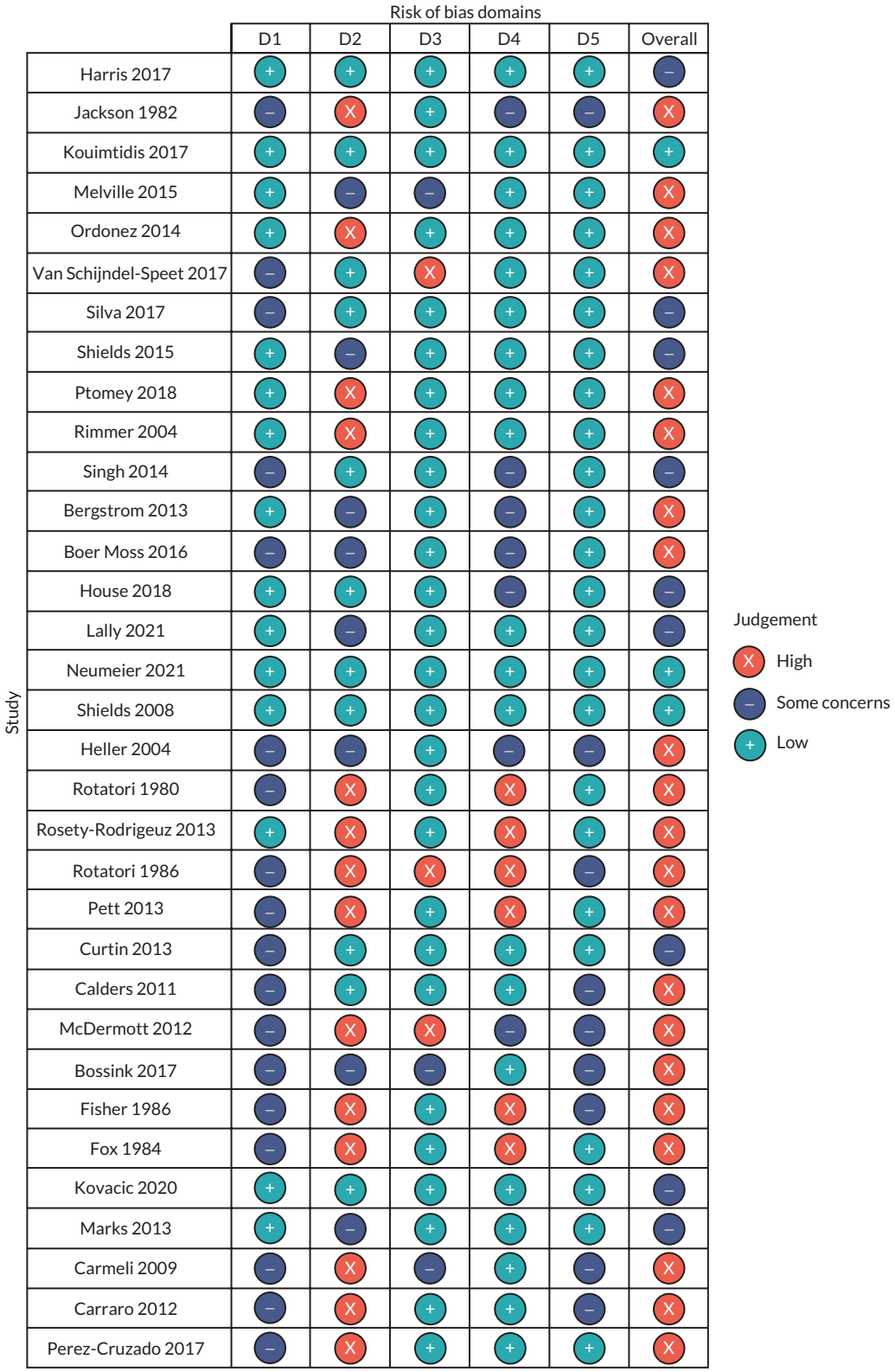

FIGURE 2 Risk of bias summary for RCTs.

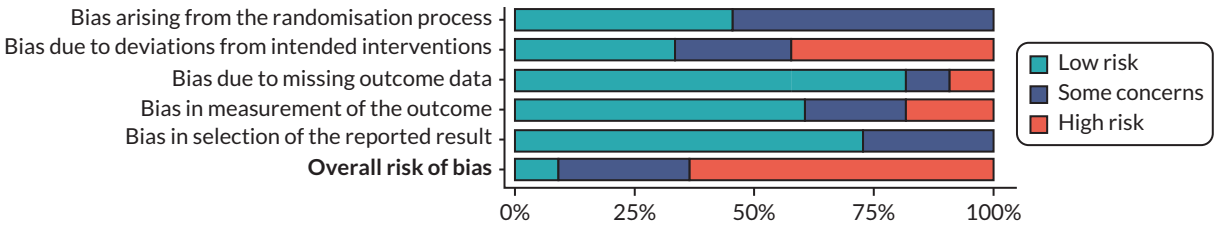

FIGURE 3 Risk of bias item as percentages across all RCTs.

and 7 RCTs (1 smoking behaviour; 2 low physical activity only; 4 multiple behaviours)[73,76,82,111,112,117,118] were assessed to have some concerns of bias in this domain.

Bias in the reporting of results: The protocols of the included studies (where available) or the methods section of the published report were compared with reported outcomes in the results section to assess if the planned outcomes were reported and if the analyses were done according to a prespecified plan. Nine studies (five on low physical activity only; four multiple behaviours)[78–82,111,114,118,125] were assessed to have some concerns for this domain.

Overall: 21 RCTs (12 low physical activity only; 9 multiple behaviours)[76,78–87,91,109–112,114,115,118,124,125] were at overall high risk of bias, 9 RCTs (5 multiple behaviours; 4 low physical activity only; 1 smoking behaviour)[73,89,90,113,116,117,119–121] had some concerns overall and only 3 RCTs (1 alcohol consumption, 1 low physical activity only; 1 multiple behaviours)[70,88,122] were at overall low risk of bias.

Non-randomised controlled trials (controlled pre–post, uncontrolled pre–post and case control)

The assessment of 43 non-RCTs[21,27,71,72,74,75,92–108,126,127,129–144,146] is available in *Figures 4* and *5*.

Bias due to confounding: 10 non-RCTs (2 alcohol consumption and smoking; 6 low physical activity only; 7 multiple behaviours)[27,71,74,100,104,107,127,134,137,143] had moderate risk of bias, 20 non-RCTs (7 low physical activity only; 11 multiple behaviours)[21,72,75,93,95–97,101,102,106,108,114,126,129–132,135,136,144] had a serious risk of bias and a non-RCT (1 multiple behaviours)[133] had critical risk of bias due to confounding owing to the lack of description about the appropriate analysis to control for the confounders.

Bias due to selection of participants: 4 non-RCTs (1 alcohol consumption and smoking; 1 low physical activity only; 2 multiple behaviours)[74,127,132,141] had moderate risk of bias and 3 studies (2 low physical activity only; 1 multiple behaviours)[21,133] had serious risk of bias for participant selection owing to the lack of description about processes of selecting participants in the study and any corrections for selection bias.

Bias due to classification of interventions: 16 non-RCTs (2 alcohol consumption and smoking; 6 low physical activity only; 8 multiple behaviours)[21,71,74,98,100,102,106,107,114,127,135,139,141–144] had a moderate risk of bias and 1 non-RCT (1 low physical activity only)[94] had serious risk of bias and 1 had critical risk of bias (1 multiple behaviours)[133] due to classification of intervention, as the reports lacked the information about the knowledge of risk of outcome that had any influence on classification of intervention.

Bias due to deviations from intended interventions: 11 non-RCTs (2 alcohol consumption and smoking; 4 physical activity only; 8 multiple behaviours)[21,71,72,94,95,105,107,140–142,144] were at moderate risk and 3 non-RCTs (1 alcohol consumption and smoking; 1 low physical activity only; 1 multiple behaviours)[74,106,130] were at serious risk as the information about the deviations from the interventions was missing.

Bias due to missing data: 6 non-RCTs[92,104,127,130,140,143] (2 physical activity only; 5 multiple behaviours) were at a serious risk and 5 non-RCTs (2 low physical activity only; 6 multiple behaviours)[98,102,126,142,146] were at a moderate risk due to high attrition rates and lack of statistical methods to adjust for attritions.

Bias in measurement of outcomes: 32 non-RCTs (1 alcohol consumption and smoking; 11 studies on low physical activity only; 19 multiple behaviours)[21,72,74,75,93–97,99,101–105,108,126,127,129–132,134,135,137,139,140,142–144,146] were at moderate risk and

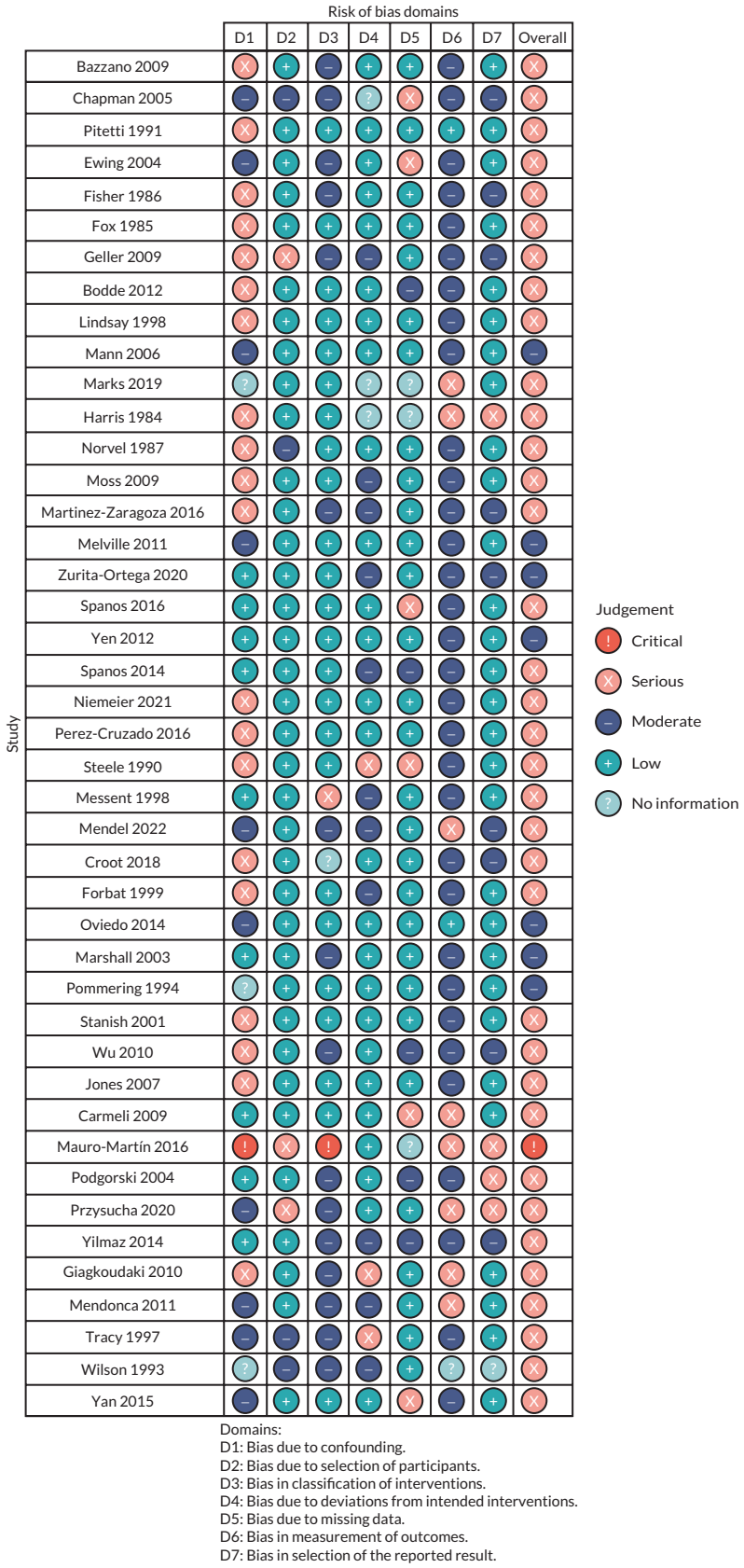

FIGURE 4 Risk of bias summary for non-RCTs.

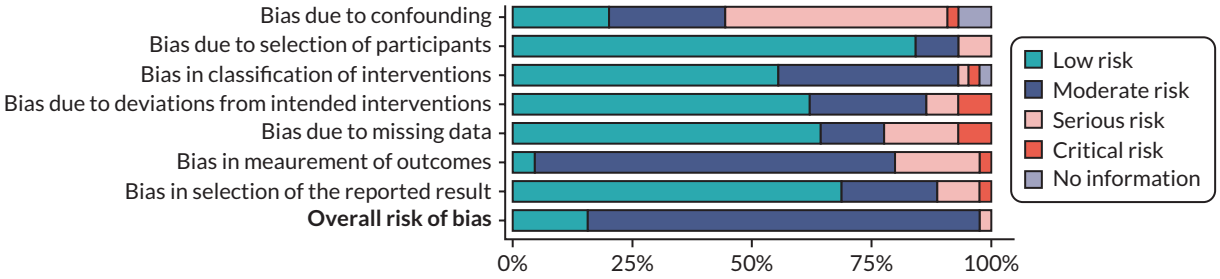

FIGURE 5 Risk of bias item as percentages across all non-RCTs.

8 non-RCTs (1 alcohol consumption and smoking; 4 low physical activity only; 3 multiple behaviours)[71,80,100,106,107,133,136,138] at serious risk of bias due to measurement of outcomes as the outcomes could have been influenced by assessor's knowledge about the intervention and lack of any blinding or masking of the outcome assessors.

Bias in selection of reported results: As the protocols were not available for most of the non-RCTs, we compared the statistical plan and the outcomes in the published report with the results and assessed 9 non-RCTs (1 alcohol consumption and smoking; 2 low physical activity only; 7 multiple behaviours)[21,71,102,105,108,127,142,144] at moderate risk and 4 non-RCTs at a serious risk of bias (2 low physical activity only; 2 multiple behaviours)[98,100,133,136] for the domain due to lack of a clear statistical plan or mention of the outcomes.

Overall: 35 non-RCTs (3 consumption and smoking; 14 physical activity only; 16 multiple behaviours)[21,71,72,74,75,80,93–98,100–102,104,106–108,114,126,127,129–132,135,136,138,140–144,146] were at overall serious risk of bias, a non-RCT(1 multiple behaviours)[133] had overall critical risk of bias and 7 non-RCTs (3 on low physical activity only; 3 multiple behaviours)[27,99,103,105,134,137,139] had overall moderate risk of bias.

Results of meta-analysis

The quantitative synthesis included meta-analysis of 15 RCTs targeting low physical activity only or multiple behaviours of 920 participants whose intervention effect was reported as weight management outcomes.

Intervention-level meta-analysis

The interventions were classified into 10 categories depending on the combinations of core components as described in the Methods (see *Chapter 2*, section *Systematic review and meta-analysis*).

Pairwise meta-analysis

Change in weight (kg)

The meta-analysis of nine RCTs including 542 participants found that lifestyle modification interventions for weight management did not result in a significant change in weight compared to TAU (MD −0.46; 95% CI −1.25 to 0.33). There was no statistical heterogeneity (I^2 = 0%, τ^2 = 0.00) reported. The core component-based subgroup analysis found that exercise-only interventions (MD = −2.39, 95% CI −5.04 to 0.27) and multicomponent interventions (MD = −0.27, 95% CI −1.10 to 0.56) did not show a significant difference in weight change compared to TAU (see *Figure 6*).

Change in BMI (kg/m^2)

The meta-analysis of 11 RCTs including 721 participants found that lifestyle modification interventions for weight management did not result in a significant change in BMI compared to TAU (MD 0.06, 95% CI −0.20 to 0.31). There was no evidence of statistical heterogeneity (I^2 = 0%, τ^2 = 0.00). The core component-based subgroup analysis of exercise-only interventions (MD = −0.45, 95% CI −1.05 to 0.15), multicomponent interventions (MD = 0.16, 95% CI −0.12 to 0.45) and BCT-only interventions (0.60, 95% CI −2.93 to 4.13) also did not show a significant difference in BMI change compared to TAU (see *Figure 7*).

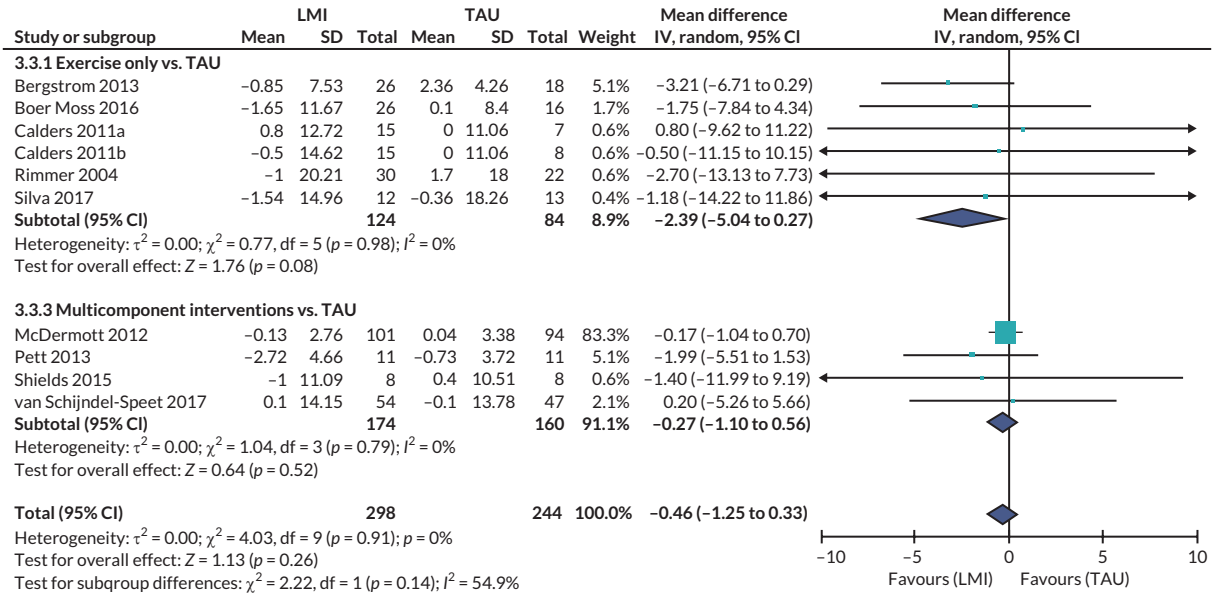

FIGURE 6 Forest plot comparing the lifestyle modification interventions and treatment as usual for mean change in weight (kg).

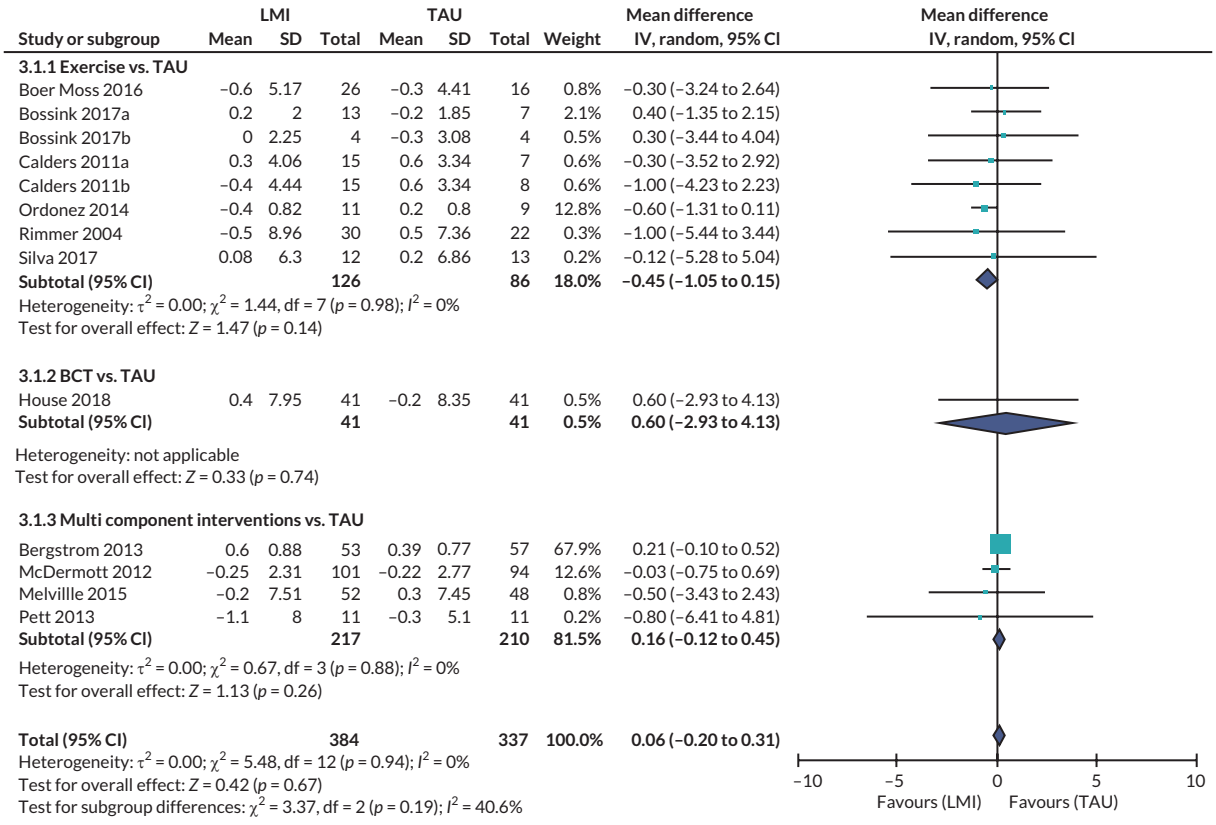

FIGURE 7 Forest plot comparing the lifestyle modification interventions and treatment as usual for mean change in BMI.

Network meta-analysis

The NMA included 15 RCTs whose core components were categorised under 11 distinct categories, as follows:

1. treatment as usual (TAU);
2. diet advice with aerobic exercise and BCTs (DA + A + BCT);

3. aerobic exercises only (A);
4. resistance exercises only (R);
5. energy-deficit diet with aerobic exercises and BCTs (EDD + A + BCT);
6. aerobic and resistance exercises (A + R);
7. behaviour change techniques;
8. diet advice with aerobic exercises (DA + A);
9. aerobic exercises with BCTs (A + BCT);
10. diet advice with aerobic and resistance exercises and BCTs (DA + A + R + BCT);
11. aerobic and resistance exercises with BCTs (A + R + BCT).

Change in BMI (kg/m^2)

The analysis included 13 RCTs with 798 participants evaluating nine interventions on change in BMI. Seven of the nine interventions were compared head to head with TAU. Two interventions – dietary advice + aerobic exercises (DA + A) and energy deficit diet + aerobic exercises + behaviour change techniques (EDD + A + BCT) – were compared directly with dietary advice + behaviour change technique (DA + BCT). The studies formed a star-shaped network (see *Figure 8*).

The forest plot (see *Figure 9*) shows that when compared with TAU, the change in BMI ranged from a decrease of 1 unit in EDD + aerobic exercise + BCT to a gain of 0.6 units in dietary advice + aerobic exercise. None of the estimates were conclusive. The credible intervals for each comparison crossed the line of no effect, thereby indicating that none of the interventions had significant effect when compared to the TAU. The league table below summarises the effects of the interventions. (see *Table 9*).

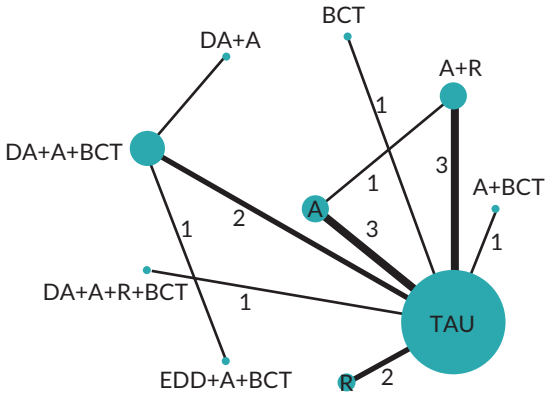

FIGURE 8 Network plot showing the geometry of network for the change in BMI. The size of the node is proportional to the number of participants receiving the treatment/intervention and the thickness of edges is proportional to the number of studies with head-to-head comparisons.

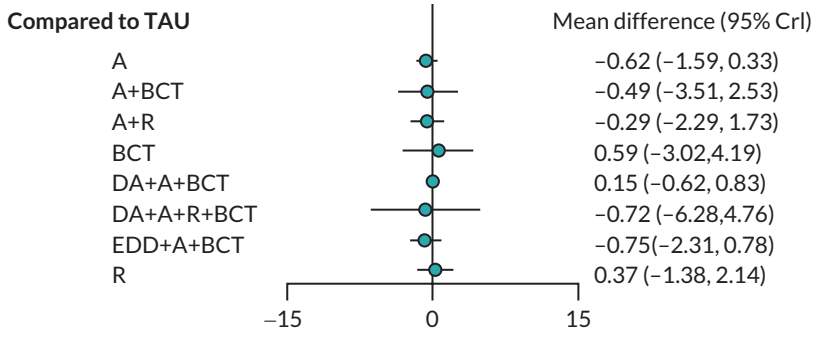

FIGURE 9 Forest plot showing the change in BMI (kg/m^2) in comparison with TAU. The dots on the left of the line of no effect indicate decrease in BMI and on the right indicate gain in BMI. The horizontal lines represent the credible intervals (Bayesian equivalent of confidence intervals).

TABLE 9 League table with NMA estimates for change in BMI (kg/m^2)

EDD + A + BCT	0.22 (−1.58 to 2.04)	0.09 (−5.70 to 5.81)	0.34 (−3.02 to 3.72)	0.52 (−2.02 to 3.06)	0.84 (−0.69 to 2.41)	1.39 (−2.47 to 5.30)	0.98 (−0.40 to 2.35)	1.51 (−3.07 to 6.21)	1.22 (−1.07 to 3.53)
−0.22 (−2.04 to 1.58)	A	−0.14 (−5.87 to 5.45)	0.11 (−3.04 to 3.30)	0.30 (−1.86 to 2.46)	0.62 (−0.32 to 1.58)	1.17 (−2.52 to 4.91)	0.76 (−0.45 to 1.92)	1.30 (−3.28 to 5.91)	1.00 (−0.95 to 2.94)
−0.09 (−5.81 to 5.70)	0.14 (−5.45 to 5.87)	D-A + A + R + BCT	0.24 (−6.05 to 6.61)	0.42 (−5.44 to 6.36)	0.75 (−4.75 to 6.36)	1.30 (−5.31 to 7.96)	0.88 (−4.67 to 6.53)	1.40 (−5.64 to 8.61)	1.15 (−4.64 to 6.99)
−0.34 (−3.72 to 3.02)	−0.11 (−3.30 to 3.04)	−0.24 (−6.61 to 6.05)	A + BCT	0.18 (−3.50 to 3.85)	0.51 (−2.53 to 3.53)	1.07 (−3.64 to 5.77)	0.65 (−2.46 to 3.73)	1.17 (−4.21 to 6.61)	0.89 (−2.57 to 4.37)
−0.52 (−3.06 to 2.02)	−0.30 (−2.46 to 1.86)	−0.42 (−6.36 to 5.44)	−0.18 (−3.85 to 3.50)	A + R	0.32 (−1.72 to 2.37)	0.86 (−3.28 to 5.03)	0.45 (−1.71 to 2.60)	1.01 (−3.89 to 5.96)	0.69 (−2.00 to 3.36)
−0.84 (−2.41 to 0.69)	−0.62 (−1.58 to 0.32)	−0.75 (−6.36 to 4.75)	−0.51 (−3.53 to 2.53)	−0.32 (−2.37 to 1.72)	TAU	0.55 (−3.03 to 4.17)	0.14 (−0.61 to 0.83)	0.67 (−3.78 to 5.20)	0.38 (−1.34 to 2.09)
−1.39 (−5.30 to 2.47)	−1.17 (−4.91 to 2.52)	−1.30 (−7.96 to 5.31)	−1.07 (−5.77 to 3.64)	−0.86 (−5.03 to 3.28)	−0.55 (−4.17 to 3.03)	BCT	−0.41 (−4.10 to 3.23)	0.12 (−5.67 to 5.93)	−0.16 (−4.16 to 3.83)
−0.98 (−2.35 to 0.40)	−0.76 (−1.92 to 0.45)	−0.88 (−6.53 to 4.67)	−0.65 (−3.73 to 2.46)	−0.45 (−2.60 to 1.71)	−0.14 (−0.83 to 0.61)	0.41 (−3.23 to 4.10)	DA + A + BCT	0.54 (−3.85 to 5.03)	0.24 (−1.60 to 2.09)
−1.51 (−6.21 to 3.07)	−1.30 (−5.91 to 3.28)	−1.40 (−8.61 to 5.64)	−1.17 (−6.61 to 4.21)	−1.01 (−5.96 to 3.89)	−0.67 (−5.20 to 3.78)	−0.12 (−5.93 to 5.67)	−0.54 (−5.03 to 3.85)	DA + A	−0.29 (−5.18 to 4.48)
−1.22 (−3.53 to 1.07)	−1.00 (−2.94 to 0.95)	−1.15 (−6.99 to 4.64)	−0.89 (−4.37 to 2.57)	−0.69 (−3.36 to 2.00)	−0.38 (−2.09 to 1.34)	0.16 (−3.83 to 4.16)	−0.24 (−2.09 to 1.60)	0.29 (−4.48 to 5.18)	R

Note
When read from left to right, the effectiveness estimate (mean change in BMI) is located at the intersection of the column-defining treatment and the row-defining treatment. To obtain MDs for comparisons in the opposing direction, negative values should be converted into positive values and vice versa.

Change in weight (kg)

The analysis included 13 RCTs with 690 participants evaluating interventions on change in weight. Six of the eight interventions were compared head-to-head with TAU. Two interventions – dietary advice + aerobic exercise (DA + A) and energy deficit diet + aerobic exercise + behaviour change technique (EDD + A + BCT) – were compared directly with dietary advice + behaviour change technique (DA + BCT) to form a star-shaped network (see *Figure 10*).

The forest plot (see *Figure 11*) shows the mean change in weight (kg) by the interventions when compared to TAU. The mean change in weight ranges from a decrease of 3.7 kg in EDD + aerobic exercise + BCT to an increase of 700 g in dietary advice + aerobic exercise. The credible intervals crossed the line of no effect, indicating the change in weight caused by the interventions was not significant in comparison to TAU. The league table below summarises the effects obtained from the NMA (see *Table 10*).

Change in waist circumference (cm)

The analysis included 8 RCTs with 378 participants evaluating six interventions on change in waist circumference. The network of studies reporting the change in waist circumference was a disconnected network (see *Figure 12*). Each subnetwork was dealt with separately.

Subnetwork 1 (see *Figure 13*) had 5 RCTs with 275 participants evaluating 3 interventions on change in waist circumference. The interventions aerobic exercise + resistance training exercise (A + R), aerobic exercise + behaviour change technique (A + BCT) and aerobic exercise (A) were compared head-to-head with TAU. The forest plot (see *Figure 14*) shows the mean decrease in waist circumference (cm). The mean change in waist circumference ranged from

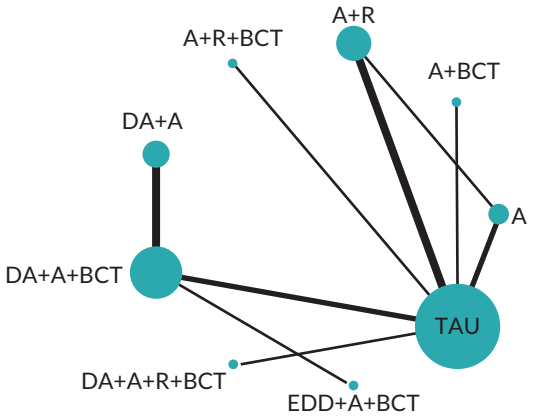

FIGURE 10 Network plot showing the geometry of network for changes in weight. The size of the node is proportional to the number of participants receiving the treatment/intervention and the thickness of edges is proportional to the number of studies with head-to-head comparisons.

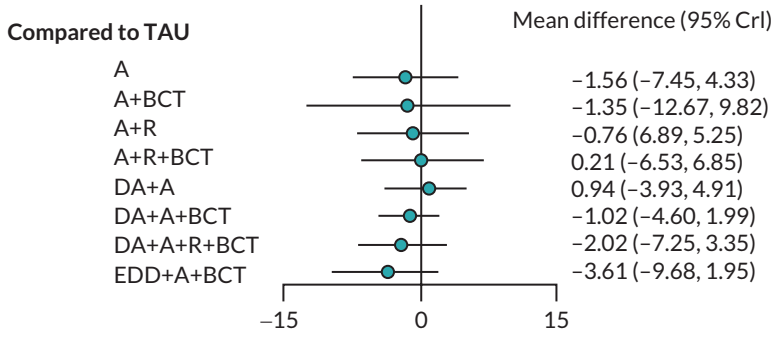

FIGURE 11 Forest plot for change in weight in comparison with TAU. The dots on the left of the line of no effect indicate decrease in weight and on the right indicate gain in weight. The horizontal lines represent credible intervals (Bayesian equivalent of confidence intervals) for each comparison. A, aerobic exercise, BCT, behaviour change therapy, DA, dietary advice, EDD, energy-deficit diet, R, resistance training.

TABLE 10 League table with NMA estimates for change in weight (kg)

EDD+A+BCT	1.62 (−5.95 to 9.67)	2.08 (−5.96 to 10.44)	2.56 (−2.22 to 7.34)	2.29 (−10.29 to 15.04)	2.91 (−5.39 to 11.37)	3.85 (−4.79 to 12.76)	3.61 (−1.95 to 9.68)	4.53 (−1.18 to 10.02)
−1.62 (−5.95 to 9.67)	DA+A+R+BCT	0.44 (−7.55 to 8.38)	0.94 (−5.52 to 6.91)	0.67 (−11.80 to 12.94)	1.17 (−6.86 to 9.25)	2.19 (−6.30 to 10.70)	2.02 (−3.35 to 7.25)	2.91 (−4.29 to 9.43)
−2.08 (−10.44 to 5.96)	−0.44 (−8.38 to 7.55)	A	0.47 (−6.39 to 7.03)	0.18 (−12.46 to 12.85)	0.76 (−6.59 to 8.18)	1.76 (−7.22 to 10.68)	1.56 (−4.33 to 7.45)	2.42 (−5.11 to 9.49)
−2.56 (−7.34 to 2.22)	−0.94 (−6.91 to 5.52)	−0.47 (−7.03 to 6.39)	DA+A+BCT	−0.26 (−11.98 to 11.52)	0.33 (−6.52 to 7.29)	1.28 (−6.03 to 8.90)	1.16 (−1.93 to 4.59)	1.98 (−1.10 to 4.77)
−2.29 (−15.04 to 10.29)	−0.67 (−12.94 to 11.80)	−0.18 (−12.85 to 12.46)	0.26 (−11.52 to 11.98)	A+BCT	0.57 (−12.26 to 13.39)	1.58 (−11.44 to 14.63)	1.35 (−9.82 to 12.67)	2.18 (−9.97 to 14.18)
−2.91 (−11.37 to 5.39)	−1.17 (−9.25 to 6.86)	−0.76 (−8.18 to 6.59)	−0.33 (−6.52 to 7.29)	−0.57 (−13.39, 12.26)	A+R	0.98 (−8.06 to 10.00)	0.76 (−5.25 to 6.89)	1.62 (−6.07 to 8.97)
−3.85 (−12.76 to 4.79)	−2.19 (−10.70 to 6.30)	−1.76 (−10.68 to 7.22)	−1.28 (−8.90 to 6.03)	−1.58 (−14.63 to 11.44)	−0.98 (−10.00 to 8.06)	A+R+BCT	−0.21 (−6.85 to 6.53)	0.66 (−7.62 to 8.49)
−3.61 (−9.68 to 1.95)	−2.02(−7.25 to 3.35)	−1.56 (7.45 to 4.33)	−1.16 (−4.59 to 1.93)	−1.35 (−12.67 to 9.82)	−0.76 (−6.89 to 5.25)	0.21 (−6.53 to 6.85)	TAU	0.94 (−3.93 to 4.91)
−4.53 (−10.02 to 1.18)	−2.91 (−9.43 to 4.29)	−2.42 (−9.49 to 5.11)	−1.98 (−4.77 to 1.10)	−2.18 (−14.18 to 9.97)	−1.62 (−8.97 to 6.07)	−0.66 (−8.49 to 7.62)	−0.94 (−4.91 to 3.93)	DA+A

Note
When read from left to right, the effectiveness estimate is located at the intersection of the column-defining treatment and the row-defining treatment. To obtain MDs for comparisons in the opposite direction, negative values should be converted into positive values and vice versa.

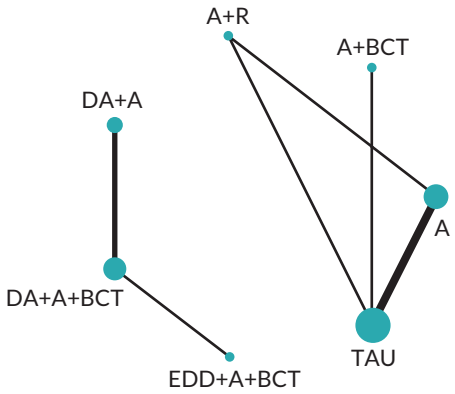

FIGURE 12 Network plot showing the disconnected network for the outcome change in waist circumference.

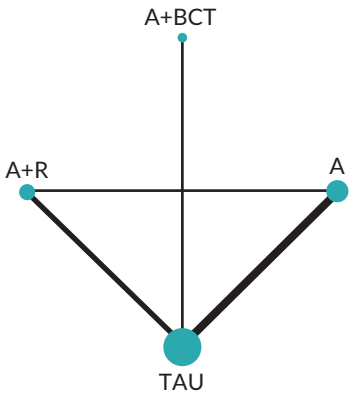

FIGURE 13 Subnetwork 1 plot showing the geometry of the studies for three interventions for change in waist circumference.

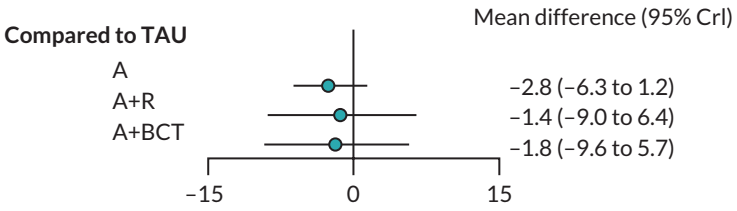

FIGURE 14 Forest plot subnetwork 1 intervention compared with TAU for change in waist circumference.

decrease of 2.8 cm to a decrease of 1.8 cm, but the credible intervals included the line of no effect, therefore none of the interventions reduced the waist circumference significantly when compared to the TAU.

The subnetwork 2 (see *Figure 15*) is a triangular network that does not involve TAU. The network had 3 trials, with 103 participants evaluating 3 interventions on change in waist circumference. The interventions dietary advice + aerobic exercise (DA + A) and energy deficit diet + aerobic exercise + behaviour change technique (EDD + A + BCT) were compared in a head-to-head comparison with dietary advice + aerobic exercise + behaviour change technique (DA + A + BCT). As DA + A + BCT was the common treatment, it was used as the comparison for subnetwork 2. The forest plot (see *Figure 16*) shows the decrease in waist circumference by the interventions in comparison to dietary advice + aerobic exercise + behaviour change technique (DA + A + BCT). The decrease in waist circumference ranged from a decrease of 1.78 cm to a decrease of 0.9 cm, but the credible intervals were too wide and included the line of no effect, and therefore none of the interventions in the subnetwork 2 reduced the waist circumference significantly when compared to dietary advice + aerobic exercise + behaviour change technique (DA + A + BCT).

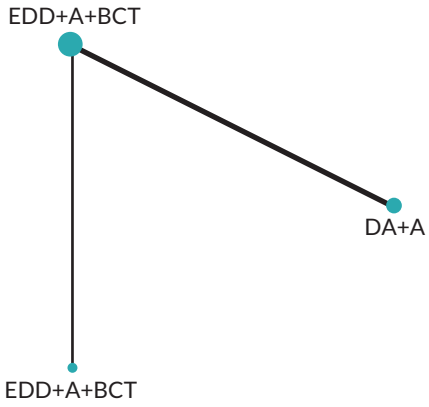

FIGURE 15 Subnetwork 2 showing the geometry of the studies for three interventions for change in waist circumference.

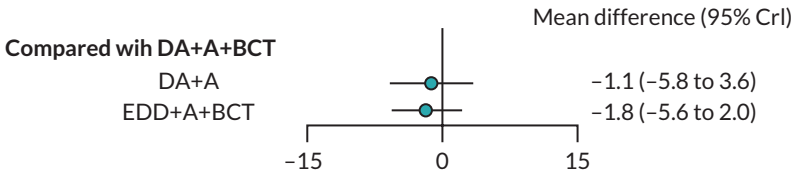

FIGURE 16 Forest plot subnetwork 2 comparing the interventions for change in waist circumference.

Change in body fat (%)

The analysis included four RCTs with 139 adults with learning disabilities that evaluated four interventions on change in body fat percentage. The four studies formed a disconnected network (see *Figure 17*).

The subnetwork 1 (see *Figure 18*) that had three RCTs with 97 participants and evaluated 3 interventions, dietary advice + aerobic exercise (DA + A) and energy deficit diet + aerobic exercise + behaviour change technique (EDD + A + BCT) were compared in a head-to-head comparison with dietary advice + aerobic exercise + behaviour change technique (DA + A + BCT). The forest plot (see *Figure 19*) shows the mean change in body fat percentages, and it ranged from a decrease of 1.5% to increase of 1%. The credible intervals for the point estimates were too wide, and therefore changes in body fat percentage were not significant in comparison to dietary advice + aerobic exercise + behaviour change technique (DA + A + BCT).

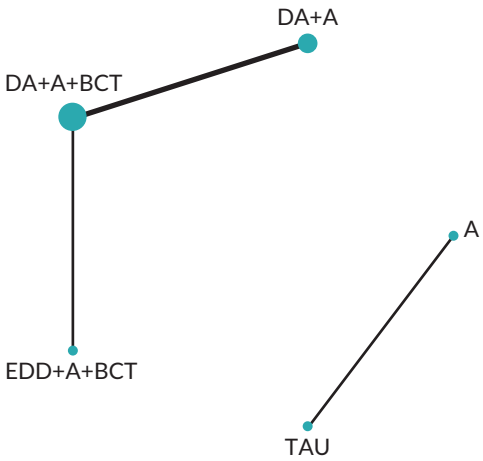

FIGURE 17 Network plot showing the disconnected network for change in body fat.

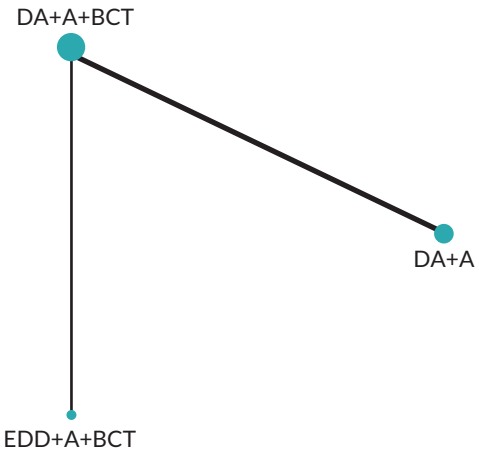

FIGURE 18 Subnetwork 1 showing the geometry of the studies for three interventions for change in body fat.

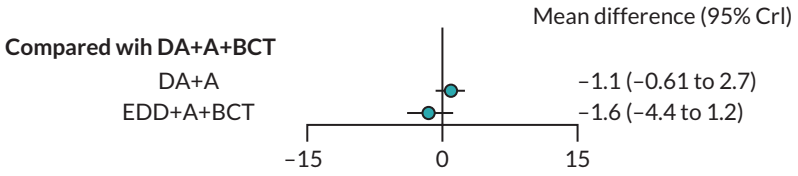

FIGURE 19 Forest plot comparing the interventions for change in body fat.

Details related to the sensitivity analysis on change in BMI outcome by excluding the study by Bergström *et al.*,[112] assumptions of transitivity, model fit and consistency are available in the Appendix (see *Appendix 9*, *Table 23*, *Figures 33–36*).

Component-level network meta-analysis

For the weight management outcomes, the NMA revealed that none of the interventions showed meaningful treatment benefits when compared with TAU. Therefore, it is expected that the CNMA would likely produce similar results. For completeness, we present the results of the CNMA here. We conducted CNMA only on mean change in BMI, as it had the maximum number of trials (n = 13), interventions (n = 11) and participants (n = 798). It was based on core components and additional components, including mode of delivery of interventions – whether they were delivered in groups or individually and the availability of support mechanisms such as presence of caregivers involvement and residence status (living in a supported setting or independently). *Table 11* shows the breakdown of components for each intervention in the included studies.

The additive model was found to be the most parsimonious model. The CNMA showed that the most frequent component was exercise (12 studies, 15 arms, with 420 participants). Individual delivery of interventions produced the largest decrease in BMI, but the change was not significant (MD = −0.65; 95% CrI −2.065, 0.746). The CNMA using the additive model, for the present available data, found the same results as the NMA (see *Table 12*).

Although not significant, the intervention with combination of components – exercise, individual delivery and support mechanisms – has shown the highest decrease in BMI (MD −1.0; 95% CIs −2.29, 0.303) in comparison to the TAU. For all the component effect estimates, CrIs were wide and included the possibility of no change in BMI between the components and TAU (see *Figure 20*).

TABLE 11 Components of interventions in each study arm (✓represents the component and × means the component is absent)

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

TABLE 12 Estimated component effects for additive model

Components	CNMA (Additive model)		
	Mean Difference	95% CrI	
Exercise[a]	−0.64	−1.36	0.14
BCT	0.06	−0.94	1.07
DA	0.30	−0.85	1.31
EDD	0.05	−1.89	1.96
ID	−0.65	−2.06	0.74
Support	0.29	−0.64	1.19
Combination of components			
Exercise + BCT + DA	−0.28	−1.44	0.82
Exercise + Support	−0.35	−0.87	0.19
Exercise + BCT + Diet Advice + Support	0.01	−0.69	0.62
Exercise + BCT + EDD + ID + Support	−0.89	−1.91	0.13
Behaviour + Support	0.35	−0.52	1.21
Exercise + BCT + Support	−0.29	−1.11	0.58
Exercise + ID + Support	−1	−2.29	0.30
Exercise + BCT + Diet Advice + ID + Support	−0.64	−2.23	0.86

a Exercise includes both Aerobic/Resistance or both.

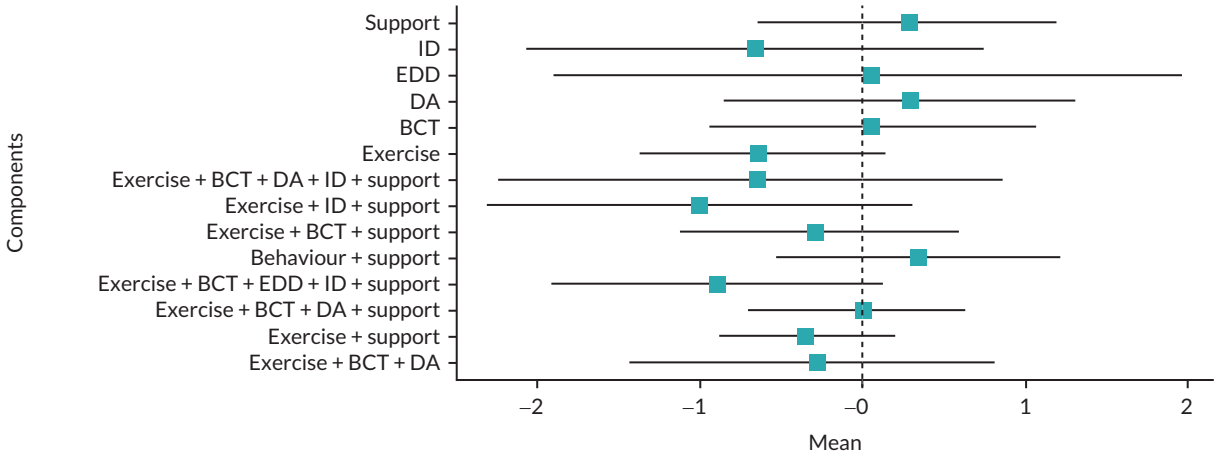

FIGURE 20 Component network meta-analysis forest plot showing the component effect estimates and effect estimates of components combined as interventions from additive effects model.

Chapter 4 Results of the realist evidence synthesis

Search results

An adapted PRISMA flow chart has been developed to display the flow of papers during the selection process (see *Figure 21*). Following the formal searching and screening process conducted in conjunction with the systematic review and NMA, a total of 166 were selected for relevance and rigour appraisals. Additional searches conducted in February 2022 resulting in 33 studies appraised for relevance and rigour. A total of 79 studies were included in the evidence synthesis, with 14 appraised as being the richest sources.

Study and participant characteristics of the included studies are presented in *Realist synthesis* (see *Tables 13* and *14* at the end of section). Across the studies, data were available for 3604 adults with learning disabilities, and 490 caregivers/other sources of support participated. Of the people with learning disabilities, only 10 studies included people with severe and profound learning disabilities. Most of the studies were based in the UK (*n* = 35) and the USA (*n* = 21).

Within the included studies, 55 were directly related to a lifestyle change intervention. These included reports of intervention effectiveness (e.g. RCTs), process evaluations, feasibility studies, pilot studies and qualitative research that was used to inform the development of an intervention or to understand participant experiences of taking part. The focus of most of the studies was on physical activity and diet (*n* = 32), followed by physical activity alone (*n* = 13), di *et al.*one (*n* = 6), alcohol (*n* = 7), unspecified 'healthy lifestyles' or 'health promotion' (*n* = 4), smoking (*n* = 3), physical activity and sedentary behaviour (*n* = 2) and finally, smoking and alcohol (*n* = 1). No studies were exclusively focused on sedentary behaviour.

Programme theory

A programme theory was developed to explain what works for whom, in what context and why for lifestyle modification interventions for adults with learning disabilities. It consisted of 33 CMOCs developed from the included literature (see *Table 15*) and informed by the PPI committee feedback. The PPI group agreed with the CMOCs developed and helped to identify the important contexts and mechanisms for the overarching programme theory. These CMOCs were clustered into partial programme theories relating to support involvement, autonomy and freedom of choice, accessibility of intervention strategies and delivery of the interventions, interventions fostering social connectedness and fun and the broader behavioural pathways. An overarching programme theory was produced which focused on the core aspects of the programme theory, with an accessible and usable overarching model also synthesised. These are presented and discussed in the following sections.

Lifestyle behaviour-specific aspects of programme theory

The CMOCs developed from papers relating to specific lifestyle behaviours are presented in *Table 16*. A majority of the CMOCs were developed based on evidence from articles focusing on physical activity and diet (labelled as 'weight-related behaviours'). For all lifestyle behaviours, accessibility of the intervention strategies and support involvement were most important. However, it is necessary to single out the CMOCs associated with lifestyle behaviours that receive less attention within the literature, such as alcohol and smoking.

For studies that focused on alcohol (*n* = 7), difficulties using measurement methods in intervention strategies (3/7 alcohol articles; CMOC 14), the use of self-monitoring (3/7 alcohol articles; CMOC 17), employing concrete health promotion messages (3/7 alcohol articles; CMOC 18), adopting flexible delivery (3/7 alcohol studies; CMOC 22) and using strategies to promote fun and enjoyment to increase motivation (3/7 alcohol articles; CMOC 25) were important. Significantly, the broader behavioural pathway of mental health and maladaptive coping mechanisms (4/7 alcohol articles; CMOC 27) had a higher score for alcohol compared to other lifestyle behaviours. Emphasising the need to consider this when developing programmes specific to alcohol. For smoking alone (*n* = 3), the importance of selecting

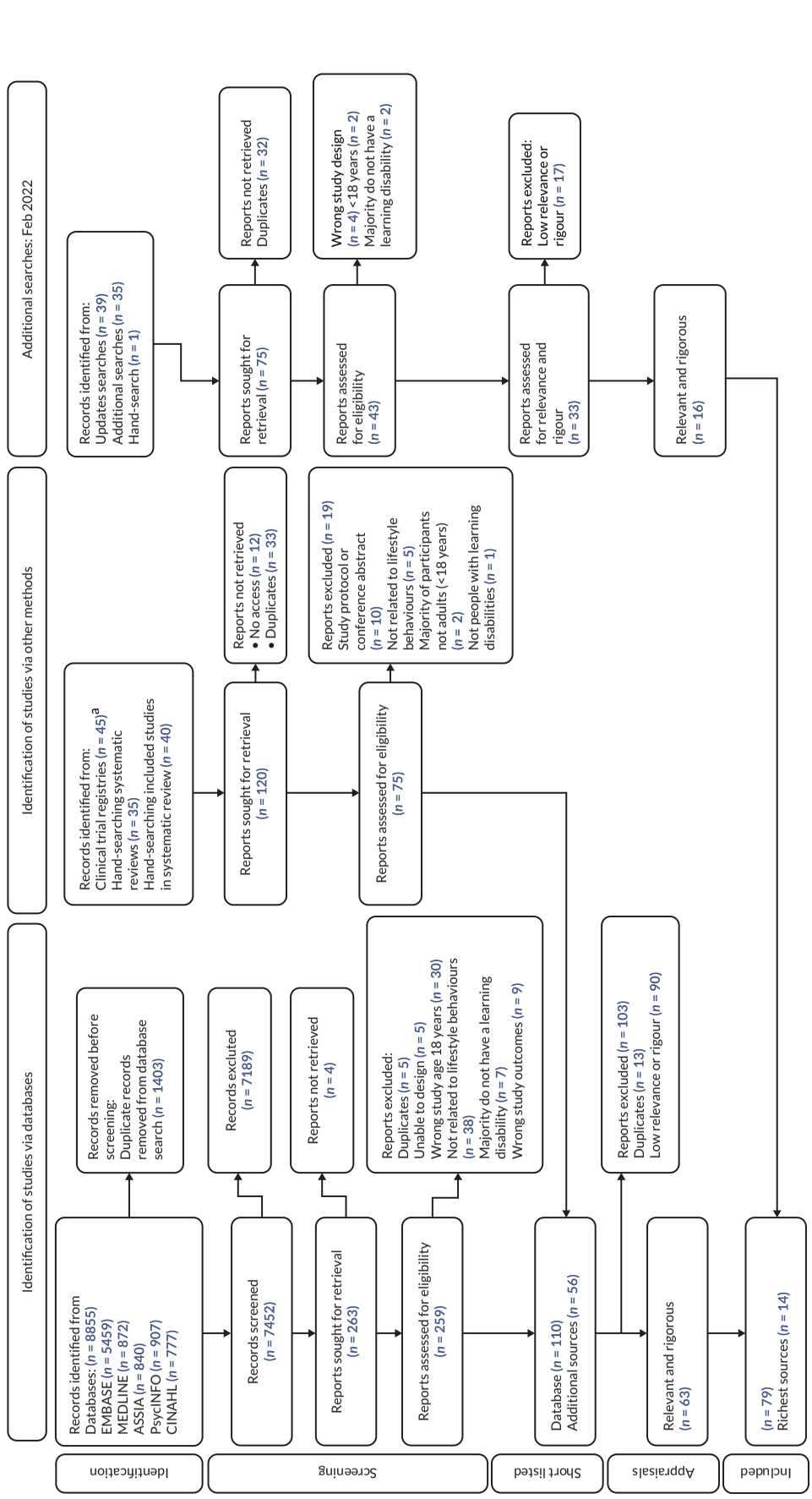

FIGURE 21 Adapted PRISMA flow chart for realist evidence synthesis. Differences in numbers between PRISMA flow chart for the systematic review and realist synthesis are a result of the additional screening for selection in both studies. Database search outlined in 'identification of studies via database' refers to the main searches conducted in 2021 with limits (human and study type). a, Clinical trial registries were included in the main searching process for the systematic review and meta-analysis; however, were treated as additional searches for the realist evidence synthesis.

TABLE 13 Participant characteristics for studies included in realist evidence synthesis

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Croot *et al.* (2018)[a]	Adults with learning disabilities and caregivers/supporters	Identifying barriers and facilitators to Slimming World: *n* = 54 people with learning disabilities, *n* = 12 carers; *n* = 8 current members with learning disabilities in Slimming World group; *n* = 11 Slimming World group leaders took. Exploring experiences of adjustments of the programme: *n* = 9 people with learning disabilities; *n* = 7 carers	Mild	*n* = 2 with Down syndrome; *n* = 1 with severe autism spectrum disorder; *n* = 1 with ADHD, dyslexia and general learning disabilities	16–65 years	51.9%
Elinder *et al.* (2018)[a]	Community residences for people with learning disabilities	*N* = 53 in intervention group and *n* = 31 in comparison group	Mild to severe learning disabilities	People with learning disabilities also described as having ASD, cerebral palsy; epilepsy	Intervention group: 31.4% under 35 years; 29.5% aged 35–50 years; 38.3% aged > 50 years. Comparison group: 23.9% under 35 years; 29.8% aged 35–50 years; 45.7% > 50 years	Intervention group 44.1%; comparison group 43.1%
Harris *et al.* (2019)[a]	Adults with learning disabilities and obesity living in the Greater Glasgow area	*n* = 26 intervention; *n* = 24 in control	30.8% mild; 42.3% moderate; 15.4% severe; 11.5% profound	15.4% with Down syndrome	*M* = 40.6 (SD = 15.0) years	Not reported
House *et al.* (2018)[a]	Adults with mild to moderate learning disabilities, type 2 diabetes, living in the community and able to participate in research	*n* = 127 took part in the feasibility randomised controlled trial	Mild to moderate	Not specified	*M* = 54.4 (SD = 12.82) years	49.7%
Kerr *et al.* (2017)[a]	People with mild to moderate learning disabilities, caregivers of people with learning disabilities and health/social care professionals	*n* = 16 people with intellectual disabilities; *n* = 2 family carers; *n* = 15 health and social care professionals	Mild to moderate	Not specified	People with learning disabilities: median = 38; range 18–64 years/health and social care professionals: median = 44; range 27–58 years	People with learning disabilities: *n* = 4 (25%)/health and social care professionals *n* = 13 (87%)

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Kouimtsidis *et al.* (2017)[a]	Adults with mild to moderate learning disabilities living in the community	*n* = 15 intervention/*n* = 15 control/*n* = 7 in qualitative interviews (from intervention group)	Mild to moderate	Not specified	Intervention mean = 45 years/ control mean = 44 years	33.4% in both groups
Kuijken *et al.* (2016)[a]	Adults with mild to moderate learning disabilities	*n* = 21	Mild to moderate	Not specified	19–65 years; mean = 45.1 (standard deviation = 14.4) years)	42.9%
Maine *et al.* (2019)[a]	Adults with learning disabilities	*n* = 48	Not explicitly specified; however, recruitment through further education colleges would indicate mild learning disabilities.	Not specified	18–39 years; mean = 20.9 (standard deviation = 5.02) years	37.5%
Matthews *et al.* (2019)[a]	Adults with learning disabilities and caregivers involved in walk-well study (Melville *et al.* 2015)	*n* = 54 in the walk-well intervention	Mild to profound	Not specified	Mean = 45 (standard deviation = 14) years	46.0%
Mitchell *et al.* (2018)[a]	Adults with learning disabilities who took part in the walk-well study (Melville *et al.* 2015)	*n* = 7 participants took part in semistructured interviews; *n* = 12 took part in the focus groups.	Not explicitly stated; however, the participant section states that all participants 'had the capacity to understand and respond to straightforward questions' indicating people with mild to moderate learning disabilities	Not specified	18–80 + years	Not reported
O'Leary *et al.* (2018)[a]	Support staff and managers of adults with learning disabilities	*n* = 30 staff and *n* = 15 managers	Not specified	Not specified	20–65 years	86.0%
Spassiani *et al.* (2019)[a]	Residents with learning disabilities in a group home setting; management of the group home; direct support staff in the group home	*n* = 35 management and direct support staff/*n* = 35 adults with intellectual and developmental disabilities	Not specified	Not specified	People with learning disabilities *M* = 52 years (range: 26–98 years); management *M* = 44 years (range: 28–64 years); direct support staff *M* = 43 years (range: 18–65 years)	People with learning disabilities = 53%; management = 72%; direct support staff = 77%

continued

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
van Schijndel-Speet *et al.* (2014a)[a]	Older (>50 years) adults with mild to moderate learning disabilities	*n* = 14 (interviews); *n* = 26 (focus groups)	Mild to moderate	Not reported	50–80 years	Interview = 65%/ focus groups = 65%
Sundblom *et al.* (2015)[a]	Adults with learning disabilities recruited from community residences	*n* = 12 health ambassadors; *n* = 5 managers	Not reported	Not reported	30–60 years old	Not reported
Bazzano *et al.* (2009)	Adults with learning disabilities recruited from a community organisation providing services for people with developmental disabilities	*n* = 431	Not reported	Autism *n* = 7 (15.9%); mental retardation *n* = 30 (68.2%); cerebral palsy *n* = 8 (18.2%)	18–59 years	Not specified
Bergstrom and Wihlman (2011)	Managers and caregivers of adults with learning disabilities in community residences	*n* = 6 managers/*n* = 6 caregivers	Not reported	Not reported	Not reported	Not reported
Bergström *et al.* (2013)	Adults with learning disabilities recruited from community residences	Intervention *n* = 63 (inc. analysis)/control *n* = 66 (inc. analysis)	Mild to moderate	Not reported	Intervention mean (*M*) = 36.2 years (Standard deviation (SD) = 10.1) / Control M = 39.4 years (SD=11.3) (standard deviation (SD) = 10.1) years/ control M = 39.4 (SD = 11.3) years	Intervention 57.8%/ control 56.1%
Bodde *et al.* (2012a)	Adults with mild to moderate intellectual disabilities	*n* = 42	Mild to moderate	Not specified	19–62 years	50.0%
Bodde *et al.* (2012b)	Adults with mild to moderate learning disabilities	*n* = 42	Mild to moderate	Not specified	19–62 years	50.0%
Burns *et al.* (2011)	Adults with mild to moderate learning disabilities that were 'compulsorily detained under criminal sections of the Mental Health Act'	*n* = 34	Mild to moderate	Not specified	Mean = 33 years; range = 21–55 years	26.0%

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Cartwright *et al.* (2015)	'Service users' with learning disabilities, paid and family caregivers and project leaders at the day care services	*N* = 43 (*n* = 10 paid carers; *n* = 10 family carers; *n* = 10 service users; *n* = 12 project leaders of day care services)	Not reported	Not reported	Not reported	Not reported
Dixon-Ibarra *et al.* (2017)	Adults with learning disabilities living in a group home setting	*n* = 14 programme co-ordinators; *n* = 22 staff; *n* = 18 residents with learning disabilities	Not reported	Not reported	Not reported	Not reported
Doherty *et al.* (2019)	Healthcare practitioners	*n* = 14 healthcare practitioners	Not reported	Not reported	Not reported	Not reported
Dunkley *et al.* (2018)	People with learning disabilities with increased BMI at risk of developing type 2 diabetes and/or cardiovascular disease	Pilot 1: *n* = 4; pilot 2: *n* = 7	Mild to moderate	Not reported	Pilot 1: median = 35 (range = 29–60)/pilot 2: median = 43 (range = 29–50)	Pilot 1 (*n* = 2; 50%); Pilot 2 (*n* = 3; 43%)
Guerra *et al.* (2019)	Participants in the 'Powers of ID' programme with learning disabilities	*n* = 15	Mild to moderate	Not reported	18–55 years	47.0%
Edwards *et al.* (2014)	Care staff (directly) and people with complex disabilities (indirectly) from a rehabilitation centre	*n* = 23	Not reported	Not reported	Mean = 34 years (range 25–56)	78.2%
Ewing *et al.* (2004)	Adults with learning disabilities recruited from university-linked family practice centres	*n* = 92 with learning disabilities/*n* = 97 without learning disabilities	Not specified; indicates mild to moderate IQ score mean = 50.2 (standard deviation = 14.3)	Not reported	People with learning disabilities mean (*M*) = 39.7 [standard deviation (SD) = 11.5] years/people without learning disabilities *M* = 49.9 (SD = 11.48)	People with learning disabilities = 54.4%/people without learning disabilities = 84.5%
Harris *et al.* (2017)	Adults with learning disabilities and obesity living in Greater Glasgow area	*n* = 26 intervention; *n* = 24 in control	Intervention 30.8% mild; 42.3% moderate; 15.4% severe; 11.5% profound	15.4% with Down syndrome	Intervention mean = 40.6 (standard deviation = 15.0) years	Not reported

continued

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Heller *et al.* (2004)	Adults with Down syndrome	*N* = 53 (*n* = 32 intervention/*n* = 21 control)	Mild to moderate	Down syndrome	Mean (*M*) = 39.7 Standard deviation (SD = 6.67) range = 30–58 years/ intervention *M* = 39.41 (SD = 6.92); range = 30–58/ control *M* = 40.22 (SD = 6.38); range = 30–53 years	55%/intervention = 53%/ control = 57%
Humphries *et al.* (2009)	Community group homes for adults with learning and developmental disabilities	*n* = 32	Not reported	*M* = 52 (range 21–82) years	*M* = 52 (range 21–82) years	50.0%
Janson *et al.* (2021)	People with learning disabilities living in supervised residences and their caregivers	*n* = 5 people with intellectual disabilities; *n* = 7 caregivers	Not reported	Not reported	Adults with learning disabilities mean = 48 (range 29–62)/ caregivers (not specified)	Adults with learning disabilities 40%
Jenkins and McKenzie (2011)	Carers of people with learning disabilities	*n* = 112	Not reported	Not reported	Not reported	Not reported
Jones *et al.* (2015)	Adults with learning disabilities and carers	*n* = 39 adults with learning disabilities; *n* = 42 carers	Mild to profound: mild (%28); moderate (42%); severe (22%); profound (8%)	Not reported	Not reported	53.8% of adults with learning disabilities (*n* = 21)
Kellman *et al.* (1997)	People with learning disabilities interested in learning about smoking. *Note: four participants and only one participant was an active smoker*	*n* = 4	Borderline to moderate	Not reported	26–40 years	50.0%
Kouimtsidis *et al.* (2017b)	Adults with mild to moderate learning disabilities with alcohol problems	*n* = 30	Mild to moderate	Not reported	*M* = 45 (SD = 8.6) years	33.4%
Lally *et al.* (2022)	Adults with mild to moderate learning disabilities with overweight or obesity	*n* = 50 (*n* = 25 in each group)	Mild to moderate	Not reported	Intervention = mean (*M*) = 40 [standard deviation (SD) = 15] years/control *M* = 41 (SD = 13) years	Intervention = 44%/ control = 52%

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Lindsay *et al.* (2014)	Adults with Down syndrome	*n* = 4	Mild	Not reported	Not reported	25.0%
Mahy *et al.* (2010)	Adults with Down syndrome	*n* = 18 (*n* = 6 people with Down syndrome and *n* = 12 caregivers)	Not reported	Down syndrome	People with Down syndrome: 21–44 (median = 23) years	Total: *n* = 15 women
Mann *et al.* (2006)	Adults with learning disabilities and overweight and/or obesity	*n* = 192	Mild to severe	Down syndrome *n* = 14 (7.3%)	Mean = 38.6 (standard deviation = 11.5) years	66.7% (*n* = 128)
Marks *et al.* (2010)	Special Olympics athletes who took part in the specified health promotion pilot programmes	*n* = 56	Not reported	Not reported	*M* = 32 years	54.0%
Marks *et al.* (2013)	Adults with mild to moderate learning disabilities and care staff at community-based organisations	*n* = 67 (*n* = 32 intervention/*n* = 35 control)	Mild to moderate	Not reported	Overall: mean (*M*) = 45.2 [standard deviation (SD) = 7.6] range = 31–64 years/ intervention: *M* = 42.6 (SD 7.4) range = 31–64 years/ control: *M* = 47.6 (SD = 7) range 35–62 years	52%/ intervention = 50%/ control = 54%
Marks *et al.* (2019)	Support staff of adults with learning disabilities	*n* = 48 support staff (intervention *n* = 28; control *n* = 20)	Not reported	Not reported	Mean = 38.26 (standard deviation = 11.4) years	Not reported
Martínez-Zaragoza *et al.* (2016)	Adults with learning disabilities and overweight and/or obesity	*n* = 32	Mild to moderate	Not reported	Mean = 52 (range 21–82) years	50.0%
McLaughlin *et al.* (2007)	Professionals working in both intellectual disabilities services and alcohol and drug services	*n* = 13	Not reported	Not reported	Not reported	Not reported
Melville *et al.* (2009)	Carers/supports of people with learning disabilities	*n* = 63	Not reported	Not reported	Not reported	Not reported

continued

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Melville *et al.* (2011)	Adults with learning disabilities with obesity requesting support to reduce their weight	*n* = 54	Mild to profound	Down syndrome (24.1%)	Mean = 48.3 (standard deviation = 12.01) years; range: 23–71 years	59.0%
Melville *et al.* 2015	Adults with learning disabilities recruited participants from day centres and care services for adults with learning disabilities	*n* = 54 (intervention)/*n* = 48 (control)	Mild to profound	Not reported	Intervention mean (*M*) = 44.9 [standard deviation (SD) = 13.5] years; control = *M* = 47.7 (SD = 12.3) years	Not reported
Mendel and Hipkins (2002)	Men with learning disabilities who had alcohol-related problems which contributed to committing a criminal offence	*n* = 7	Mild	Not reported	18–54 years	0% all male
Pett *et al.* (2013)	Young adults (age 18–35 years) with learning disabilities living at home with parents	*n* = 31	Mild to moderate	Not reported	18–35 years	Not reported
Ptomey *et al.* (2017)	Overweight/obese adults with mild to moderate intellectual disabilities	*n* = 149	Mild to moderate	Down syndrome (17.4%); Autism (13.4%); Unknown/ not specified (68.1%)	Mean = 36.5 (standard deviation = 12.2) years	57.0%
Ptomey *et al.* (2018)	Adults with mild to moderate learning disabilities classified as being overweight or obese	*n* = 78 intervention; *n* = 72 conventional diet control	Mild to moderate	Intervention Down syndrome (19.5%); autism (7.8%) 'other' (72.7%)	Mean = 36.1 (standard deviation = 12.0) years	59.7%
Rostad-Tollefsen *et al.* (2021)	Support staff for adults with learning disabilities	*n* = 13	Most caregivers supported people with mild to moderate learning disabilities; two staff members worked with adults with moderate to severe learning disabilities	Not reported	22% aged 20–39 years/68% aged 40–59 years	69.0%

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
van Schijndel-Speet *et al.* (2014b)	Older (>50 years) adults with mild to moderate learning disabilities	*n* = 86 people with intellectual disabilities in intervention; *n* = 65 controls with intellectual disabilities; *n* = 21 staff at the day centres; *n* = 11 physical activity instructors	Mild to moderate	Not reported	>44 years	Not reported
Shields and Taylor (2015)	Young adults with Down syndrome	*n* = 16 (*n* = 8 in each group)	Mild to moderate	Down syndrome	Mean = 21.4 (standard deviation = 3.2) years	50.0%
Singh *et al.* (2014)	Adults with mild learning disabilities were referred to the study because they wanted to stop smoking	*n* = 137 (*n* = 25 intervention group; *n* = 26 control group)	Mild	Not reported	Intervention mean (*M*) = 32.56 [standard deviation (SD) = 10.29] years/control *M* = 34.4 (SD = 10.46) years	19.2%
Singh *et al.* (2013)	Three men with mild learning disabilities with a history of smoking	*n* = 3	Mild	Not reported	23–31 years	0% – all male
Skelly *et al.* (2020)	Adults with learning disabilities who were overweight or had successfully lost weight	*n* = 6 who successfully lost weight; *n* = 6 who were overweight	Mild to moderate	Not reported	Group 1: mean = 49 (range 38–59 years)/Group 2: mean = 45 (range 25–73 years)	*n* = 4 in both groups (approx. 66%)
Spanos *et al.* (2013)	Caregivers who supported adults with learning disabilities who took part in the TAKE-5 intervention	*n* = 24 carers of participants who took part in the study	Not reported	Not reported	Not reported	Not reported
Spanos *et al.* (2014)	Adults with learning disabilities and adults without learning disabilities	*n* = 52	Mild to severe	Not reported	median = 51 years; range = 26–73 years	Not reported
Spanos *et al.* (2016)	Adults with learning disabilities with obesity referred to the intervention by health specialists (e.g. GPs, dietitians)	*n* = 28	Mild to moderate: mild (*n* = 10; 36%); moderate (*n* = 9; 32%); severe (*n* = 9; 32%)	Not reported	>18 years	64%

continued

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
Taggart *et al.* (2007)	People with learning disabilities who were misusing alcohol and drugs	*n* = 10	Mild to moderate	Not reported	28–52 years	77.0%
Wahlstrom *et al.* (2014)	Professionals (support staff and managers) working in group homes for people with learning disabilities	*n* = 7	Mild to severe	Not reported	Not reported	57.1% (*n* = 4)
Abbott and McConkey (2006)[b]	Adults with intellectual disabilities	*n* = 68	Not reported	Not reported	Mean = 46 years (21–82 years)	66.0%
Bigby *et al.* (2009)[b]	Care staff of adults with severe and profound learning disabilities	*n* = 25	Severe to profound	Not reported	Not reported	Not reported
Bjornsdottir *et al.* (2015)[b]	Adults with intellectual disabilities	*n* = 41	Not reported	Not reported	26–66 years	60.1%
Borthwick *et al.* (2021)[b]	Caregivers of people with Down syndrome	*n* = 9 (*n* = 5 paid support staff; *n* = 4 family caregivers)	Not reported	Down syndrome	Not reported	Not reported
Ferguson *et al.* (2011)[b]	People with learning disabilities	*n* = 4 people with learning disabilities; *n* = 13 primary carers	Mild to profound	Not reported	Not reported	Not reported
Jahoda *et al.* (2010)[b]	Young adults with intellectual disabilities	*n* = 2	Mild to moderate	Not reported	Not reported	Not reported
Neumeier *et al.* (2021)[b]	Obese adults with mild to moderate intellectual disabilities	*n* = 17 (experimental) *n* = 18 (control)	Mild to moderate	Not reported	Mean = 34.6 (standard deviation = 5.7) years	45.7%
Jingree *et al.* (2008)[b]	Paid caregivers of people with learning disabilities	*n* = 15 support staff	Not reported	Not reported	22–59 years	Not reported
Mauro *et al.* (2021)[b]	People with mild to moderate learning disabilities	*n* = 24 with mild to moderate learning disabilities; *n* = 67 paid caregivers; *n* = 3 participant observations	Mild to moderate	Not reported	Mean = 44 (range = 21–68) years (interview participants)	62.5% (interview participants)

TABLE 13 Participant characteristics for studies included in realist evidence synthesis (*continued*)

Author (year)	Basic description of sample	Sample size	Level of learning disabilities	Presence of developmental disabilities (specify)	Age	% Female
McDonald and Stack (2016)[b]	Scientists and community members taking part in a community-based participatory research project with people with developmental disabilities	*n* = 26	Not reported	Not reported	Not reported	Not reported
Overwijk *et al.* (2022)[b]	Direct support professionals for people with moderate to profound intellectual disabilities	*n* = 24 (people with learning disabilities); *n* – 32 (direct support staff)	Moderate to profound	Not reported	Mean = 34 (standard deviation = 11) years	Not reported
Pols *et al.* (2017)[b]	Community caregivers of people with learning disabilities	*N* = 11	Mild to moderate	Not reported	Not reported	Not reported
Petner-Arrey and Copeland (2015)[b]	Support staff	*n* = 10	Not reported	Not reported	Not reported	30.0%
Umb Carlsson (2021)[b]	Residents with intellectual disabilities and staff members in the residential setting	*n* = 5 residents; *n* = 6 staff members; *n* = 5 rehabilitation professionals	Mild to moderate	Not reported	Not reported	Residents (*n* = 3; 60%); staff members (*n* = 3; 50%); rehabilitation professionals (*n* = 5; 100%)
Whitehead *et al.* (2016)[b]	Adults with intellectual disabilities and diabetes	*n* = 8 people with learning disabilities and type 1 diabetes; *n* = 6 people with type 2 diabetes; *n* = 17 support workers	Mild to moderate	Not reported	Not reported	Not reported

a Indicates studies that are classified as key papers during the familiarisation stage of the realist evidence synthesis.
b Indicates studies identified during the additional searching conducted in February – this includes searches for papers not specific to lifestyle behaviours and an updated search of the literature.

Note
Most studies did not report race/ethnicity. Only *n* = 21 of *n* = 79 reported this, and a majority of participants were Caucasian/Caucasian (52–100% Harris *et al.* 2019; Harris *et al.* 2017; House *et al.* 2018; Kouimtisids *et al.* 2017; Bazzano *et al.* 2009; Heller *et al.* 2004; Humphries *et al.* 2009; Kouimtisdis *et al.* 2017b; Lally *et al.* 2022; Mann *et al.* 2006; Marks *et al.* 2013; Marks *et al.* 2019; Melville *et al.* 2011; Ewing *et al.*2004; Pett *et al.* 2013; Ptomey *et al.* 2017a; Ptomey *et al.* 2017b; Spanos *et al.* 2016; Neumeier *et al.* 2021) and only one study had a sample where a majority were from minority ethnic groups (Spassiani *et al.* 2019: 44% African American; 40% Hispanic, non-Caucasian).

TABLE 14 Characteristics of articles included in the realist evidence synthesis

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Croot *et al.* (2018)[108,a]	UK	Diet	Mixed-methods study, including interviews, focus groups and collecting descriptive quantitative data	Aimed to identify adjustments to the Slimming World weight management programme to improve accessibility and assess acceptability and feasibility for use with adults with learning disabilities.	
Elinder *et al.* (2018)[172,a]	Sweden	Diet and physical activity	Mixed-methods process evaluation	Evaluated the effectiveness of the intervention and explored barriers/facilitators to the implementation of the intervention.	Bergström *et al.* (2013)[112]
Harris *et al.* (2019)[157,a]	UK	Physical activity and sedentary behaviour included as outcomes; however, diet was targeted in intervention to reduce weight	Mixed-methods process evaluation	Investigate the processes that contributed to the overall effectiveness of a weight management programme.	Harris *et al.* (2017);[116] Jones *et al.* (2015)[171]
House *et al.* (2018)[153,a]	UK	Diet and physical activity	Mixed-methods study describing an individually randomised parallel-group feasibility randomised controlled trial with qualitative data collected through interviews with participants and through researcher and nurse journals	Examine the feasibility of a Phase III randomised controlled trial.	
Kerr *et al.* (2017)[168,a]	UK	Alcohol and smoking	Qualitative: semistructured focus groups with people with learning disabilities and telephone interviews with caregivers, health and social care professionals	Aimed to gain an understanding of the tobacco and alcohol-related health promotion needs of people with mild to moderate learning disabilities.	
Kouimtsidis *et al.* (2017)[70,a]	UK	Alcohol	Mixed-methods feasibility study of a randomised controlled trial with qualitative semistructured interviews to collect data relating to acceptability and usefulness	(1) Develop an adapted manualised extended brief intervention for adults with learning disabilities and (2) test the feasibility of the intervention and assess the perceived acceptability and usefulness of the intervention.	
Kuijken *et al.* (2016)[173,a]	Netherlands	Physical activity and diet	Qualitative study collecting data through semistructured focus groups	Gain insight into the perspectives of people with mild to moderate learning disabilities on healthy living.	

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Maine *et al.* (2019)[163,a]	UK	Physical activity	Mixed-methods process evaluation	Assess the feasibility of recruiting for and delivering the programme in this setting and qualitatively assess its acceptability and accessibility through focus groups.	
Matthews *et al.* (2019)[154,a]	UK	Physical activity and sedentary behaviour	Mixed-methods process evaluation	Explore the feasibility and evaluate the process of a 12-week walking intervention for adults with learning disabilities.	Mitchell *et al.* (2018); Melville *et al.* (2015)
Mitchell *et al.* (2018)[166,a]	UK	Physical activity and sedentary behaviour	Qualitative study with semistructured interviews and focus groups	Gain insight into adults with intellectual disabilities' experiences of participating in and self-monitoring their physical activity behaviour in the first community-based randomised controlled trail walking programme.	Matthews *et al.* (2019); Melville *et al.* (2015)
O'Leary *et al.* (2018)[7,a]	UK (Northern Ireland)	Physical activity and diet	Qualitative study with semistructured focus groups and telephone interviews	Exploration into the perspectives of organisational influences on healthy lifestyle behaviours by caregivers and managers	
Spassiani *et al.* (2019)[169,a]	Canada	Physical activity	Qualitative study using semistructured interviews and photovoice methodology	Investigate the different influences of older adults with learning disabilities to participate in health and participation initiatives in the community. Additionally, to develop improved inclusion and representation of adults with learning disabilities in knowledge production.	
van Schijndel-Speet *et al.*[174,a]	Netherlands	Physical activity	Qualitative study with semistructured interviews	Explore preferences, barriers and facilitators for physical activity of older adults with learning disabilities.	van Schijndel-Speet *et al.* (2014b)
Sundblom *et al.*[156,a]	Sweden	Diet and physical activity	Qualitative study with semistructured interviews	Explore aspects important to the implementation process of an intervention.	Bergström *et al.* (2013)
Bazzano *et al.*[139]	USA	Diet and physical activity	Uncontrolled pre–post design	Exploring the effectiveness of an intervention and the impact it has on multiple outcomes.	
Bergstrom and Wihlman[151]	Sweden	Not specific; focused on healthy lifestyles	Qualitative study with semistructured interviews	Explore views of managers and caregivers on their role in health promotion and describe barriers to healthy lifestyles for adults with learning disabilities in community residences.	

continued

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Bergström *et al.*[112]	Sweden	Diet and physical activity	Cluster randomised controlled trial	Investigate effectiveness of an intervention targeting residents with learning disabilities and caregivers.	Elinder *et al.* (2018); Sundblom *et al.* (2015)
Bodde *et al.*[175]	USA	Physical activity as target behaviour; however, diet knowledge is also measured	Mixed-methods process evaluation	Describe the development of a physical activity education curriculum for adults with intellectual disabilities.	Bodde *et al.*[176]
Bodde *et al.*[176]	USA	Physical activity	Controlled pre–post design	Assess impact of health education curriculum on the physical activity of adults with intellectual disabilities.	Bodde *et al.*[175]
Burns *et al.*[177]	UK	Alcohol	Pre–post intervention	Evaluate the effectiveness of intervention for alcohol problems among adults with learning disabilities in a secure setting.	
Cartwright *et al.*[158]	UK	Diet	Qualitative study with semistructured interviews and focus groups	Understand how service users with learning disabilities and carers perceive issues of diet and healthy living.	
Dixon-Ibarra *et al.*[178]	USA	Physical activity	Mixed-methods process evaluation	Describe the preliminary outcomes and feasibility of using the Menu-Choice Physical Activity Program with the goal of using the results to refine the programme.	
Doherty *et al.*[159]	UK	Physical activity and diet	Qualitative study with semistructured interviews	Explore general practitioners' (GPs) and other healthcare practitioners' (HCPs') views and experiences of barriers and facilitators to providing evidence-based weight management interventions for adults with learning disabilities.	
Dunkley *et al.*[179]	UK	Physical activity and diet	Mixed-methods study reporting the development, piloting and initial evaluation of a behaviour change intervention	Develop a lifestyle education programme for people with learning disabilities having increased body mass index and at high risk of developing type 2 diabetes and/or cardiovascular disease.	
Guerra *et al.*[160]	USA	Physical activity	Qualitative analysis of data collected during the intervention, including observational data and coaching logs	Understand what influenced participation in a weight loss intervention for people with learning disabilities.	Neumeier *et al.* (2021)

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Edwards *et al.*[180]	Canada	Diet	Time series/pre–post trial	Describe and investigate the development and initial impact of a nutritional programme for people with learning disabilities.	
Ewing *et al.*[143]	USA	Physical activity and diet	Case-control study design	Evaluate a health education intervention on promotion of health behaviours of people with and without learning disabilities.	
Harris *et al.*[116]	UK	Physical activity and diet	Cluster randomised controlled trial	Report on a cluster randomised controlled trial comparing two interventions focused on physical activity and diet.	Harris *et al.* (2019); Jones *et al.* (2015)
Heller *et al.*[82]	USA	Physical activity	Randomised controlled trial	Examine the impact of a health education programme for physical activity on psycho-social outcomes.	
Humphries *et al.*[181]	USA	Diet	Pilot study – pre–post	Investigate the effectiveness of a support and education intervention with paid caregivers involved in food provision on improving healthy food choices.	Maine *et al.* (2019)
Janson *et al.*[182]	Norway	Diet	'Explorative design' using qualitative methods, including dyadic interviews with people with learning disabilities and caregivers and focus group interviews with caregivers and managers	Explore feasibility of the nutrition tablet app APPetitus among persons with learning disabilities and their caregivers.	
Jenkins and McKenzie[183]	UK	Diet	Cross-sectional quantitative predictive study	Investigate whether theory of planned behaviour can predict the intentions of care staff to encourage healthy eating in the people with learning disabilities they support.	
Jones *et al.*[171]	UK	Physical activity and sedentary behaviour	Mixed methods (described as qualitative, but there is a quantitative analysis of the data referring to percentages, etc.)	Explore the reasons that obese adults with learning disabilities give for wanting to lose weight and whether their motivations differ from those given by caregivers.	Harris *et al.* (2017); Harris *et al.* (2019)
Kellman *et al.*[162]	UK	Smoking	Case series	Investigating a health education programme focused on tobacco use for adults with learning disabilities.	

continued

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Kouimtsidis *et al.*[70]	UK	Alcohol	Feasibility study	Describe the adaptation of the extended brief intervention manual for alcohol misuse.	Kouimtsidis *et al.* (2017a)
Lally *et al.*[120]	UK	Diet and physical activity	Randomised controlled trial	Pilot an adapted manualised weight management programme for persons with mild–moderate intellectual disabilities with overweight or obesity.	
Lindsay *et al.*[75]	UK	Alcohol	Case series	Aimed to describe a treatment for alcohol-related difficulties among people with learning disabilities.	
Mahy *et al.*[161]	Australia	Physical activity	Qualitative study collecting data through semistructured interviews	Identify barriers and facilitators to physical activity from the perspectives of adults with Down syndrome and their caregivers.	
Mann *et al.*[137]	USA	Diet and physical activity	Uncontrolled pre-post design	Estimate effectiveness of programme participation on body mass index and weight loss.	
Marks *et al.*[165]	USA	Physical activity and diet	Mixed-methods programme evaluation.	Evaluation of community-based health promotion programmes.	
Marks *et al.*[121]	USA	Physical activity and diet	Uncontrolled pre–post design	Evaluate the efficacy of a HealthMatters Program: Train-the-Trainer Workshop.	Marks *et al.* (2019)
Marks *et al.*[184]	USA	Physical activity	Uncontrolled pre–post design	Examine the impact of a HealthMatters Program intervention on caregivers psychosocial health status.	Marks *et al.* (2013)
Martínez-Zaragoza *et al.* (2016)	Spain	Diet and physical activity	Case-control study design	Assess the effects of multicomponent intervention programme targeting over-weight and obesity.	
McLaughlin *et al.* (2007)	UK	Alcohol	Qualitative study with semistructured interviews	Understand experience and perceptions of staff working in both learning disabilities services and alcohol and drug services on meeting needs of people with learning disabilities.	

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Melville *et al.* (2009)	UK	Diet and physical activity	Cross-sectional correlational study	Examine carer's knowledge and beliefs around dietary intakes and physical activity.	
Melville *et al.* (2011)	UK	Physical activity and sedentary behaviour were outcomes; however, diet was included in intervention.	Uncontrolled pre–post design	Examine the effectiveness of multicomponent weight-loss intervention.	Spanos *et al.* (2016); Spanos *et al.* (2013)
Melville *et al.* (2015)	UK	Physical activity and sedentary behaviour	Cluster randomised controlled trial	Examine the effectiveness of a behaviour change programme to support adults with learning disabilities to walk more, to increase levels of physical activity and to reduce time spent sedentary.	Matthews et al. (2019); Mitchell *et al.* (2018)
Mendel and Hipkins, (2002)	UK	Alcohol	Uncontrolled pre–post design	Evaluate the effectiveness of the pilot 'motivational' group on alcohol consumption of adults with learning disabilities.	
Pett *et al.* (2013)	USA	Physical activity and diet	Pilot randomised controlled trial	Examine the effectiveness of a 12-week healthy lifestyle intervention on behaviour change and weight loss in young adults with learning disabilities.	
Ptomey *et al.* (2017)	USA	Physical activity	Feasibility study	Determine the feasibility of using pedometers for self-monitoring of physical activity and outcome measures for physical activity in an 18-month intervention.	Ptomey *et al.* (2018)
Ptomey *et al.* (2018)	USA	Diet and physical activity	Randomised controlled trial	Compare the effectiveness of an enhanced stop light diet and a conventional diet as part of a multicomponent for adults with mild to moderate learning disabilities.	Ptomey *et al.* (2017)
Rostad-Tollefsen *et al.* (2021)	Norway	Diet	Mixed-methods 'concept mapping'	Assess the support staff's thoughts and experiences on factors influencing caregivers' ability to support healthy diets of adults with learning disabilities.	
van Schijndel-Speet *et al.* (2014)	Netherlands	Physical activity	Mixed-methods process evaluation	Conduct a process evaluation of a physical activity intervention.	van Schijndel-Speet *et al.* (2014)

continued

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Shields and Taylor[89]	Australia	Physical activity	Feasibility of a randomised controlled trial	Determine the feasibility of a physical activity programme among young adults with Down syndrome.	
Singh *et al.*[185]	USA	Smoking	Randomised controlled trial	Assess a three-component mindfulness-based smoking cessation intervention.	Singh *et al.*[186]
Singh *et al.*[186]	USA	Smoking	Small-scale intervention – used a criterion design	Mindfulness-based smoking cessation intervention piloted with three men.	Singh *et al.*[185]
Skelly *et al.*[170]	UK	Physical activity and diet (weight loss)	Qualitative study with focus groups to collect data	Explore the similarities and differences between two groups with different weight status and lifestyles.	
Spanos *et al.*[149]	UK	Diet and physical activity	Qualitative study with semistructured interviews	Explore experiences of caregivers taking part in a multicomponent weight loss intervention.	Spanos *et al.* (2016); Melville *et al.* (2011)
Spanos *et al.*[146]	UK	Diet and physical activity	Non-randomised intervention	Determine the effectiveness of a multicomponent weight loss intervention adapted to needs of adults with learning disabilities compared to a group of people without learning disabilities.	
Spanos *et al.*[140]	UK	Physical activity and diet	Uncontrolled pre–post design	Assess the second phase of a weight management programme.	
Taggart *et al.*[187]	Northern Ireland; UK	Alcohol	Qualitative study with semistructured interviews	Examine reasons behind alcohol misuse and the impact of this behaviour and explore the services they receive.	
Wahlstrom *et al.*[188]	Sweden	General 'health promotion'	Qualitative study with semistructured interviews	Explore aspects important to consider when promoting health among persons with intellectual disabilities in group homes, from the perspective of professionals.	
Abbott and McConkey[189,b] (2006)	UK	Relating to social inclusion	Qualitative study with focus groups to collect data	Gain insight into barriers to social inclusion and how to reduce these.	

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Bigby *et al.*[190]	Australia	Relating to autonomy and freedom of choice	Mixed-methods study with two parts: an ethnographic study followed by a group comparison design quantitatively assessing staff attitudes	Explore attitudes of staff in community-based services towards the current policy vision for people with more severe intellectual disabilities.	
Bjornsdottir *et al.*[191,b]	Iceland	Relating to autonomy and freedom of choice	Qualitative study collecting data through semistructured interviews and observations	Explore how people with intellectual disabilities make choices in their homes and daily lives and explore the influences in achieving autonomy.	
Borthwick *et al.*[192,b]	UK	Health promotion	Qualitative study with semistructured interviews	To understand how recommended health behaviours are put into practice by caregivers accompanying an individual with Down syndrome.	
Ferguson *et al.*[193,b]	UK	Relating to autonomy and freedom of choice	Qualitative study collecting data through semistructured interviews and focus groups	Explore choice-making experiences of people with learning disabilities with different levels of regularity at appointments.	
Jahoda *et al.*[194,b]	UK	Relating to mental health and stigma from additional search	Qualitative case studies	Address experiences of stigma and how people attempted to establish their identities as young adults with learning disabilities.	
Neumeier *et al.*[122,b]	USA	Physical activity and diet	Randomised controlled trial	Examine the effectiveness of a tailored intervention on outcomes relating to weight loss for adults with learning disabilities.	Guerra *et al.* (2019)
Jingree *et al.*[195,b]	UK	Relating to autonomy and freedom of choice	Qualitative study with semistructured interviews	Explore the discourses of support staff of people with learning disabilities talking about how choices and control are promoted or denied for service users.	
Mauro *et al.*[196,b]	Germany	Physical activity	Mixed methods including online survey for caregivers, document analysis, participant observations and qualitative interviews with adults with learning disabilities	Explore individual physical activity-related knowledge, experiences and strategies, as well as individual requirements for the intervention concept.	
McDonald and Stack[164,b]	USA	Relating to social inclusion (additional search paper)	'Prospective qualitative study' with semistructured interviews	Explore experiences and feelings towards community-based participation research.	

continued

TABLE 14 Characteristics of articles included in the realist evidence synthesis (*continued*)

Author (year)	Country	Lifestyle behaviour	Study design/methods	Objectives	Linked studies included in realist evidence synthesis
Overwijk *et al.*[197,b]	Netherlands	Physical activity	Mixed-methods process evaluation	Evaluate a theory-based training and education programme for direct support professionals to learn how to support people with mild to moderate intellectual disabilities to engage in physical activity.	
Pols *et al.*[198,b]	Netherlands	Relating to autonomy and freedom of choice (additional source)	Qualitative ethnographic study	Investigate how paid caregivers understand autonomy in caring for people with learning disabilities.	
Petner-Arrey and Copeland[199,b]	USA	Relating to autonomy and freedom of choice (additional source)	Qualitative study with semistructured interviews	Investigate perceptions of persons with intellectual disabilities receiving support and persons providing support regarding the autonomy of people with intellectual disabilities.	
Umb Carlsson[155,b]	Sweden	Physical activity and diet	Qualitative study with semi structured group interviews	Explore experiences of how a health promotion intervention affected the lifestyles of adults with learning disabilities, from the perspective of residents with learning disabilities, staff members, and rehabilitation professionals.	
Whitehead *et al.*[200,b]	New Zealand	Relating to autonomy and freedom of choice (additional source)	Qualitative study with semistructured interviews	Experiences and practice of autonomy and the role of caregivers in relation to the self-management of diabetes for those with intellectual disabilities living in residential or independent living settings.	

a Indicates studies that are classified as key papers during the familiarisation stage of the realist evidence synthesis.
b Indicates studies identified during the additional searching conducted in February – this includes searches for papers not specific to lifestyle behaviours and an updated search of the literature.

TABLE 15 Context–mechanism–outcome configurations (CMOCs) and associated literature

	Support involvement CMOCs 1–7							Autonomy and freedom of choice CMOCs 8–11				Accessibility of intervention strategies and delivery CMOCs 12–23												Social connectedness and enjoyment CMOCs 24–26			Broader behavioural pathways CMOCs 27–33						
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Croot *et al.* (2018)	x	x						x	x			x			x				x		x	x	x							x			
Elinder *et al.* (2018)	x	x		x	x																x												
Harris *et al.* (2019)	x	x					x	x			x	x	x		x							x								x			
House *et al.* (2018)	x			x		x			x		x	x	x	x	x	x				x		x								x			
Kerr *et al.* (2017)	x						x	x											x			x					x	x		x			
Kouimtsidis *et al.* (2017)														x	x						x	x	x				x						
Kuijken *et al.* (2016)		x		x				x											x					x				x			x		x
Maine *et al.* (2019)								x		x	x	x		x	x		x		x	x	x	x											
Matthews *et al.* (2019)		x	x			x				x	x			x	x		x	x		x		x				x			x		x		
Mitchell *et al.* (2018)	x	x					x	x	x	x	x	x		x		x	x				x	x			x					x	x		x
O'Leary *et al.* (2018)	x	x		x	x				x																			x			x		x
Spassiani *et al.* (2019)	x	x			x		x				x										x	x		x					x	x		x	
van Schijndel-Speet *et al.* (2014a)		x						x						x				x	x		x	x			x	x		x	x				
Sundblom *et al.* (2015)		x		x	x	x	x	x											x		x	x			x	x		x	x		x	x	x
Bazzano *et al.* (2009)															x			x					x	x									
Bergstrom and Wilham (2011)									x																								
Bergström *et al.* (2013)														x																			
Bodde *et al.* (2012a)															x								x										
Bodde *et al.* (2012b)														x					x														
Burns *et al.* (2011)															x				x														

continued

TABLE 15 Context–mechanism–outcome configurations (CMOCs) and associated literature (*continued*)

	Support involvement CMOCs 1–7							Autonomy and freedom of choice CMOCs 8–11				Accessibility of intervention strategies and delivery CMOCs 12–23												Social connectedness and enjoyment CMOCs 24–26			Broader behavioural pathways CMOCs 27–33						
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Cartwright *et al.* (2015)	x					x			x		x									x								x					
Dixon-Ibarra *et al.* (2017)		x		x										x	x	x				x			x					x					
Doherty *et al.* (2019)	x					x									x	x						x									x		x
Dunkley *et al.* (2018)								x							x	x			x			x				x							
Guerra *et al.* (2019)								x						x		x	x		x	x							x			x	x	x	x
Edwards *et al.* (2014)	x			x																x		x											
Ewing *et al.* (2004)										x				x	x				x			x					x						
Harris *et al.* (2017)							x																										
Heller *et al.* (2004)																								x									
Humphries *et al.* (2009)		x		x			x	x														x											
Janson *et al.* (2021)											x		x		x		x																
Jenkins and McKenzie (2011)	x			x																													
Jones *et al.* (2015)																x			x														
Kellman *et al.* (1997)															x				x							x							
Kouimtsidis *et al.* (2017b)														x								x											
Lally *et al.* (2021)		x	x	x		x		x	x					x																			
Lindsay *et al.* (2014)																			x								x						
Mahy *et al.* (2010)							x	x	x									x		x					x	x			x		x	x	x
Mann *et al.* (2006)														x					x														
Marks *et al.* (2010)	x	x		x				x														x		x	x							x	

TABLE 15 Context–mechanism–outcome configurations (CMOCs) and associated literature (*continued*)

	Support involvement CMOCs 1–7							Autonomy and freedom of choice CMOCs 8–11				Accessibility of intervention strategies and delivery CMOCs 12–23												Social connectedness and enjoyment CMOCs 24–26			Broader behavioural pathways CMOCs 27–33						
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Marks *et al.* (2013)		x		x												x			x			x	x							x		x
Marks *et al.* (2019)				x																													
Marks *et al.* (2019b)															x									x		x							
Martínez-Zaragoza *et al.* (2016)						x																				x							
McLaughlin *et al.* (2007)						x	x																				x						
Melville *et al.* (2009)	x																																
Melville *et al.* (2011)												x	x																				
Melville *et al.* (2015)													x	x			x																
Mendel and Hipkins (2002)	x									x				x					x														
Pett *et al.* (2013)			x								x								x			x	x										
Ptomey *et al.* (2017)												x	x	x																			
Ptomey *et al.* (2017b)													x					x	x														
Rostad-Tollefsen *et al.* (2021)	x			x															x	x								x					
van Schijndel-Speet *et al.* (2014b)		x					x	x								x		x						x		x			x	x	x	x
Shields and Taylor(2015)														x																			
Singh *et al.* (2014)																x																	
Singh *et al.* (2013)									x			x				x				x				x									
Skelly *et al.* (2020)			x					x											x									x		x	x	x	x
Spanos *et al.* (2013)	x	x	x	x		x	x				x				x	x			x												x		
Spanos *et al.* (2014)															x							x											

continued

TABLE 15 Context–mechanism–outcome configurations (CMOCs) and associated literature (*continued*)

	Support involvement CMOCs 1–7							Autonomy and freedom of choice CMOCs 8–11				Accessibility of intervention strategies and delivery CMOCs 12–23												Social connectedness and enjoyment CMOCs 24–26			Broader behavioural pathways CMOCs 27–33						
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Spanos *et al.* (2016)												x		x	x	x																
Taggart *et al.* (2007)																						x					x						
Wahlstrom *et al.* (2014)	x						x	x	x											x								x					
Abbott and McConkey (2006)								x																						x		x	
Bigby *et al.* (2009)								x							x																x	
Bjornsdottir *et al.* (2015)								x																									
Borthwick *et al.* (2021)		x				x	x		x											x						x			x			x	
Ferguson *et al.* (2011)								x	x																								
Jahoda *et al.* (2010)								x																			x						
Neumeier *et al.* (2021)																				x		x											
Jingreee *et al.* (2008)								x	x																								
Mauro *et al.* (2021)	x														x				x	x	x	x		x					x	x	x		x
McDonald and Stack (2016)																							x										
Overwijk *et al.* (2022)	x	x					x												x	x													
Pols *et al.* (2017)									x																								
Petner-Arrey and Copeland (2015)									x																								
Umb Carlsson (2021)		x		x	x		x	x	x		x			x					x	x		x		x							x	
Whitehead *et al.* (2016)									x		x																						
Perez-Cruzado *et al.* (2016)																			x														

TABLE 16 Number of articles associated with lifestyle behaviours and CMOCs

Context–mechanism–outcome configurations (CMOCs)	Weight-related behaviours (*n* = 32)	Physical activity (*n* = 13)	Diet (*n* = 6)	Alcohol (*n* = 7)	Smoking (*n* = 3)	Physical activity and sedentary behaviour (*n* = 2)	Alcohol and smoking (*n* = 1)	General lifestyle behaviours (*n* = 4)
Support involvement	23	6	5	3	0	1	1	3
CMOC 1	9	3	3	1	0	0	1	2
CMOC 2	13	3	2	0	0	1	0	1
CMOC 3	4	0	0	0	0	1	0	0
CMOC 4	9	1	4	0	0	0	0	2
CMOC 5	5	0	0	0	0	0	0	0
CMOC 6	7	0	0	1	0	1	0	1
CMOC 7	8	1	1	1	0	0	1	2
Negotiating balance between autonomy and behaviour change	15	3	3	1	0	1	1	3
CMOC 8	8	3	2	0	0	0	1	1
CMOC 9	6	2	1	0	0	0	0	3
CMOC 10	1	2	0	1	0	1	0	0
CMOC 11	6	2	1	0	0	1	0	1
Accessibility of intervention strategies	23	11	3	5	3	2	1	1
CMOC 12	3	3	1	0	1	0	0	1
CMOC 13	2	1	1	0	0	1	0	1
CMOC 14	7	7	0	3	0	2	0	1
CMOC 15	9	4	2	2	1	1	0	1
CMOC 16	7	2	0	0	2	0	0	1
CMOC 17	1	2	1	0	0	1	0	0
CMOC 18	14	5	2	3	1	0	1	0
CMOC 19	1	2	0	0	0	1	0	0
Intervention delivery	17	7	4	3	1	1	1	3
CMCO 20	6	4	2	0	1	1	0	2
CMOC 21	3	4	1	1	0	0	0	0
CMOC 22	11	5	3	3	0	1	1	2
CMOC 23	4	2	1	1	0	0	0	0
Social connectedness and fun	9	6	0	0	2	1	0	1
CMOC 24	5	2	0	0	1	0	0	1
CMOC 25	1	3	0	0	0	0	0	1

continued

TABLE 16 Context–mechanism–outcome configurations (CMOCs) and associated literature (*continued*)

Context–mechanism–outcome configurations (CMOCs)	Weight-related behaviours (*n* = 32)	Physical activity (*n* = 13)	Diet (*n* = 6)	Alcohol (*n* = 7)	Smoking (*n* = 3)	Physical activity and sedentary behaviour (*n* = 2)	Alcohol and smoking (*n* = 1)	General lifestyle behaviours (*n* = 4)
CMOC 26	4	3	0	0	1	1	0	0
Broader behavioural pathways	14	5	2	4	0	1	1	3
CMOC 27	2	0	0	4	0	0	1	0
CMOC 28	4	2	1	0	0	0	1	1
CMOC 29	2	3	0	0	0	1	0	0
CMOC 30	5	2	1	0	0	0	1	1
CMOC 31 and 33	8	3	0	0	0	0	0	1
CMOC 32	6	1	0	0	0	1	0	1

achievable and self-selected goals (2/3 smoking articles; CMOC 16) was the most highly tied CMOC. Only one article reported both alcohol and smoking.

Support involvement

A partial programme theory was developed to reflect the importance of support involvement. This relates to the ability of family caregivers and paid support staff to provide social support for participation in lifestyle change programmes (see *Figure 22*). One of the core influences of social support is the underlying knowledge and motivation of family members and paid support staff (CMOC 1). However, wider contextual factors pose challenges to the ability of family and paid caregivers to facilitate participation in lifestyle change. This involves life and work pressures reducing capacity to provide support (CMOCs 2 and 3). Provision of training directly targeting caregivers' knowledge and skills, and

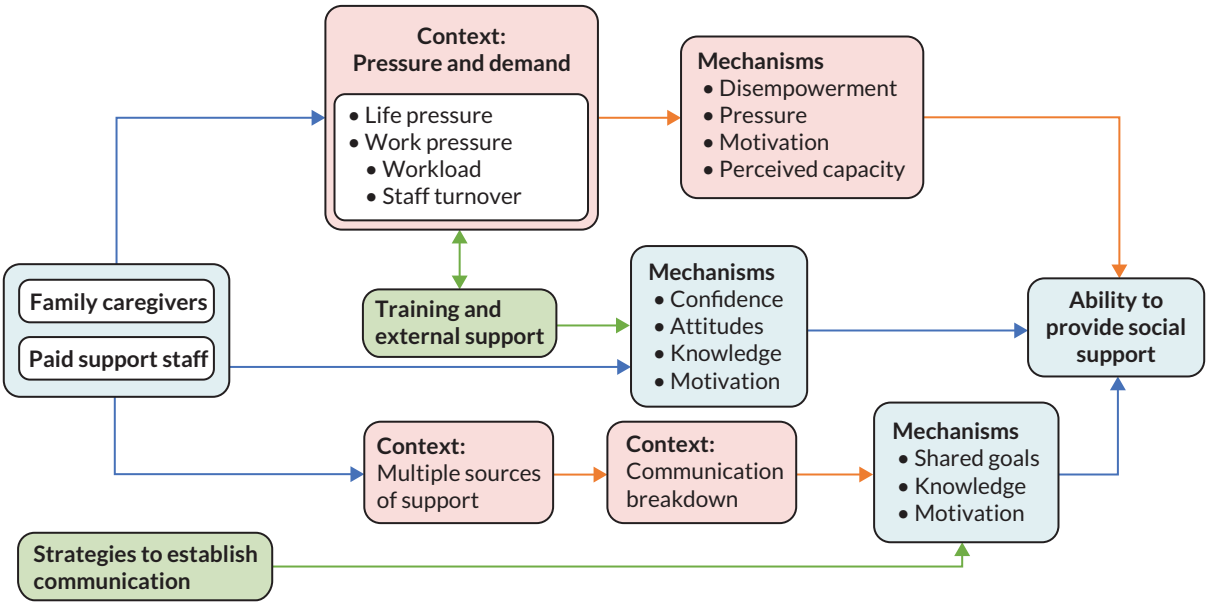

FIGURE 22 Support involvement partial programme theory (CMOCs 1–7). Green represents a positive impact; blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

wider organisational support, can negate some of the barriers experienced by sources of support (CMOCs 4 and 5). Additionally, as there are multiple caregivers involved (e.g. family members and multiple paid support staff), there can be a communication breakdown. To reduce this, it is necessary to implement communication strategies to foster shared goals (CMOCs 6 and 7).

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 1 – Caregiver knowledge and motivation. Paid support staff and family caregivers involved in lifestyle behaviour change programme (C) may not have the necessary knowledge or skills relating to healthy lifestyles (M1), which reduces confidence and motivation to provide support (M2). Additionally, caregivers may not have positive attitudes towards lifestyle behaviours and low perceived capacity towards supporting behaviour change (M3). This reduces the ability of support staff and caregivers to facilitate active engagement with the intervention and provide effective social support for behaviour change (O). (20/79 articles)

> *This inconsistent approach to health promotion was also impacted by managers and staff within the team having different knowledge, motivation and skill levels to engage in health promotion with their clients …*
>
> *O'Leary et al. 2017*[7]

Context–mechanism–outcome configuration 2 – Paid support staff pressure and demand. Paid support staff have busy work schedules, often in shift patterns and can look after multiple people (C). This causes stress (M1), which impacts on the perceived capacity, motivation and confidence to facilitate lifestyle behaviour change (M2). This results in reduced provision for social support and active engagement of adults with learning disabilities in lifestyle change programmes (O). (21/79 articles)

> *[Paid carers] are so understaffed they work all the hours and the last thing they need is someone like me going 'Ah let's see some walking'.*
>
> *Walking advisor, Matthews et al. 2019, p. 6*[154]

Context–mechanism–outcome configuration 3 – Family caregiver life pressures. Family caregivers have busy lives and own life pressures (C) which can reduce perceived capacity, confidence and motivation to promote healthy lifestyles (M), resulting in reduced provision of social support within a lifestyle modification programme (O). (5/79 articles)

> *With family carers, it is likely to be important to identify a way to deliver this information that fits in with their busy lives.*
>
> *Lally et al. 2020, p. 9*[120]

Context–mechanism–outcome configuration 4 – Provision of training for caregivers. Targeting caregivers by providing training (C) increases knowledge, motivation and confidence (M), which enhances their ability to provide support for lifestyle modification within a programme (O). (16/79 articles)

> *Several carers of participants who did not lose weight suggested the use of training for staff that would focus on the principles of a healthy balanced diet and cooking …*
>
> *Spanos et al. 2013, p. 97*[149]

Context–mechanism–outcome configuration 5 – Provision of organisational and additional support for caregivers. Organisational and managerial support for paid support staff to promote healthy lifestyles (C) can increase perceived capacity by reducing stress around workload (M1) and improve confidence and motivation (M2), resulting in better support for behaviour change and active engagement with the intervention (O). (5/79 articles)

> *A facilitator for the implementation of theory in everyday practice was that the local manager prioritised the project and considered it important. In addition, adaption of the project schedule to staffing and working hours enabled for staff to participate in intervention activities.*
>
> *Umb-Carlsson et al. 2021, p. 222*[155]

Context–mechanism–outcome configuration 6 – Communication breakdown between multiple caregivers. Adults with learning disabilities can have multiple sources of support, including multiple paid and family caregivers (C1). This can result in a communication breakdown around the health promotion and behaviour change strategies (C2). Subsequently, caregivers may not have the knowledge or skills around the person's lifestyle and how to promote behaviour change (M1). This reduces motivation and prioritisation of behaviour change goals (M2). Resulting in less support to engage in a healthy lifestyle and reduced engagement with the intervention (O). (10/79 articles)[149]

> *It was a challenge to engage carers in this study, and for those participants without a consistent carer, it was difficult to ensure information was shared between carers.*
>
> *Lally et al. 2020, p. 8*[120]

Context–mechanism–outcome configuration 7 – Communication pathways between caregivers. Developing communication strategies or having systems in place to facilitate communication between caregivers (C) fosters shared goals and skills, increasing motivation and confidence (M), resulting in better social support for behaviour change (O). (14/79 articles)

> *The health ambassadors aimed at achieving good cooperation among staff, thus leading to increased awareness and shared goals.*
>
> *Sundblom et al. 2015, p. 300*[156]

Negotiating balance between autonomy and behaviour change

A partial programme theory was developed to reflect the negotiation between autonomy, freedom of choice and promoting behaviour change (see *Figure 23*). The ability of adults with learning disabilities to make decisions and have the freedom to choose their lifestyle behaviours is impacted by the control others exert over their lives (CMOC 8). Caregivers must negotiate between balancing autonomy and promoting behaviour change as part of a lifestyle modification intervention (CMOC 9). This can contribute to adults with learning disabilities feeling nagged and pestered into taking part, with strategies needed by researchers to ensure informed consent (CMOCs 10 and 11). Overall, these contexts trigger mechanisms of perceived capacity, knowledge and confidence among adults with learning disabilities and contribute to a sense of responsibility for caregivers.

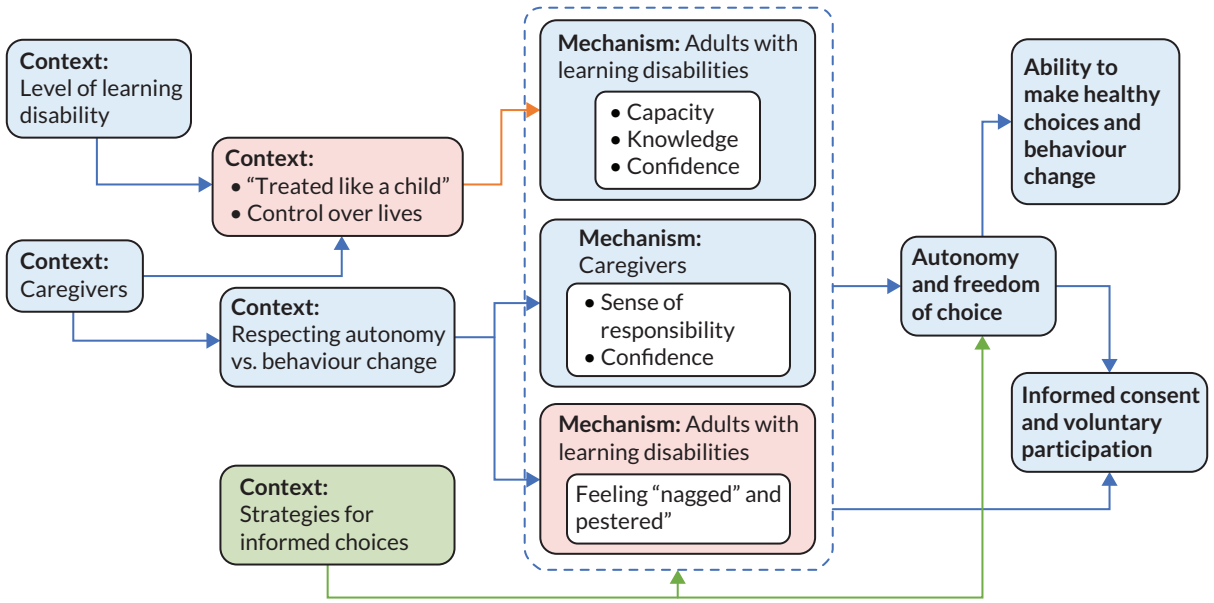

FIGURE 23 Partial programme theory: negotiating balance between autonomy and behaviour change (CMOCs 8–11). Green represents a positive impact; blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 8 – Limited autonomy experienced by some people with learning disabilities. Adults with learning disabilities can have limited control over decisions in their lives (C) with this greater number of people with more severe learning disabilities (C2). This causes adults with learning disabilities to feel disempowered and have lower perceived capacity and confidence to make healthy choices (M). Resulting in reduced active engagement with lifestyle modification programmes and healthy lifestyles (O). (22/79 articles)

> *… adults with severe and profound intellectual disabilities were found to have less autonomy over food preparation ….*
>
> *Harris et al. 2019, p. 57*[157]

Context–mechanism–outcome configuration 9 – Conflict between support autonomy and lifestyle change. Caregivers providing support feel conflict between promoting behaviour change and respecting autonomy and freedom of choice (C). There is a sense of responsibility (M) with confidence and perceived capacity to support behaviour change impacted (M). Resulting in differential support for healthy lifestyles (O). (17/79 articles)

> *… So you could force and just say, 'You're not having chips', or 'You're not having this'. We don't do that, we can't do that. All we can do is encourage them to take fewer chips and encourage them to think about the consequences …*
>
> *Cartwright et al. 2015, p. 106*[158]

Context–mechanism–outcome configuration 10 – Issues with informed consent. Adults with learning disabilities are encouraged to take part in behaviour change programmes (C). They can feel nagged and pestered to take part (M), resulting in issues with informed consent (O). (5/79 articles)

> *… one participant commented on 'pestering' or 'nagging' by day centre staff to take part.*
>
> *Matthews et al. 2016, p. 5*[154]

Context–mechanism–outcome configuration 11 – Supporting informed choice and decisions. Communicating information in an accessible way with additional time provided to read information or ask questions (C) ensures that the information is processed and that potential participants have the necessary skills to understand what is being asked (M), resulting in improved, informed decisions (O). (12/79 articles)

> *… The complex information was conveyed through easy read information sheets and meeting with the researcher to answer any questions. Extra time was also provided, and if necessary, additional appointments were scheduled …*
>
> *Harris et al. 2019, p. 55*[157]

Accessible intervention strategies

The accessibility of intervention strategies, such as the BCTs, measurement methods and materials, was covered in this partial programme theory (see *Figure 24*). Social support is sometimes required, as BCTs can rely on abstract concepts and measurement methods can be difficult to use (CMOCs 12–14). To ensure participants can engage with the necessary materials, they should reflect communication abilities of all participants (CMOC 15). When attempting to change behaviours, it is important that people should select their own achievable goals; self-monitoring should consider the suitability of measurement methods and the health promotion and learning strategies must be appropriate (CMOCs 16–19). The contexts of intervention strategy accessibility interact with mechanisms, such as knowledge, skills, perceived capacity, confidence and motivation. This plays an important role in the ability of adults with learning disabilities to actively engage with the intervention as delivered.

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 12 – Provision of support to engage with intervention strategies. Having support to participate in the intervention strategies (C) increases confidence and ensures participants have the necessary skills and knowledge (M), resulting in improved ability to actively engage with the intervention as delivered (O). (9/79 articles)[157]

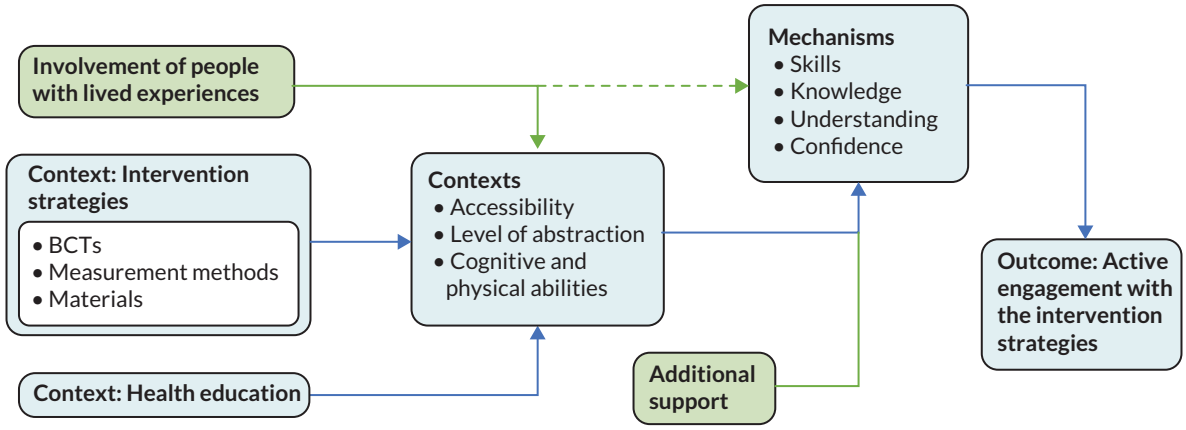

FIGURE 24 Partial programme theory: accessibility of intervention strategies (CMOCs 12–19). Green represents a positive impact; blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

> *And I didn't understand it … had I not had support [from friend], I may have felt too afraid to go back, because I felt stupid.*
>
> *Croot et al. 2018, p. 5*[108]

Context–mechanism–outcome configuration 13 – Abstract nature of BCTs. BCTs that rely on abstract concepts and do not respect the abilities of people with learning disabilities (C) may not be effective in promoting behaviour change as participants cannot actively engage with the intervention strategies (O). Participants may not have the necessary cognitive and adaptive skills to effectively process the BCTs (M1) and have reduced confidence and motivation (M2). (7/79 articles)

> *… more complex behaviour change techniques included in Walk Well, such as self monitoring or goal setting. Many participants and carers expressed difficulties using the pedometers and walking diary to self monitor daily step count against their individual goals.*
>
> *Melville et al. 2015, p. 7*[83]

Context–mechanism–outcome configuration 14 – Difficulties using measurement methods. Measurement methods can be complex and difficult for people with learning disabilities to use (C). Participants may not have necessary knowledge and skills to appropriately use the measurement methods (M1), reducing confidence, perceived capacity and motivation (M2). This potentially results in less reliable and accurate results and reduced ability to self-monitor behaviour (O). (20/79 articles)

> *Participants found the question about what they had eaten the previous day challenging (65% had difficulties with this question at baseline) with difficulties in recall and possibly defensiveness.*
>
> *House et al. 2018, p. 106*[117]

Context–mechanism–outcome configuration 15 – Importance of accessible materials. Materials produced in an easy-read and accessible format with visual aids and concrete examples (C) ensure people with learning disabilities have the necessary skills and understanding to process and interact with the materials (M1), which increases confidence (M2), resulting in improved engagement with the intervention (O)[108]. (21/79 articles)

> *Mary can't read, Mary can see pictures and work out – that means that and that means this.*
>
> *Spanos et al. 2013, p. 97*[149]

Context–mechanism–outcome configuration 16 – Prioritising achievable and self-determined goals. Goal setting should involve people with learning disabilities and relate to self-determined, concrete and observable goals (C) which increases motivation and confidence to work towards a goal (M), resulting in better engagement with the intervention as delivered (O). (13/79 articles)

> *A focus on image and appearance in weight management interventions (rather than on numerical weight loss goals) may facilitate improved motivation for weight management in people with intellectual disabilities.*
>
> *Doherty et al. 2019, p. 1073*[159]

Context–mechanism–outcome configuration 17 – Self-monitoring increases motivation. Being able to directly monitor and measure their own behaviour (C) increases motivation and fosters a sense of pride (M), resulting in better engagement with the intervention (O). (5/79 articles)

> *Most of the participants liked the concept of using a pedometer, and those who used the pedometer consistently reported that it was motivating.*
>
> *Guerra et al. 2019, p. 536*[160]

Context–mechanism–outcome configuration 18 – Incentives are motivating. Having an incentive to take part, such as a reward (C), increases motivation and fosters a sense of purpose (M), resulting in greater engagement with the intervention delivered (O). (6/79 articles)

> *… were more likely to participate in physical activity if there was a purpose to the activity or an incentive or reward at the end of the activity.*
>
> *Mahy et al. 2010, p. 799*[161]

Context–mechanism–outcome configuration 19 – Concrete information and active learning strategies in health education. Health education programmes using concrete information, active learning strategies and avoiding complex and abstract concepts (C) ensure participants have the skills to process the information provided and maintain attention while increasing confidence (M). This facilitates active engagement with the intervention and subsequent acquisition of new knowledge (O). (26/79 articles)

> *The issues which seemed to have the most impact on group members were the social effects of smoking, such as, it makes the person smell, stains their teeth and fingers, restricts where they can go and limits the amount of money they have.*
>
> *Kellman et al. 1997, p. 97*[162]

> *Active learning was also considered as being well received by the staff. Here, students were actively engaged in learning exercises such as arranging activity cards into order and identifying food packaging labels.*
>
> *Maine et al. 2019, p. 1039*[163]

Delivery of the intervention

The intervention delivery has its own CMOCs (see *Figure 25*). Researchers must respect the daily lives of people with learning disabilities and avoid further stress by respecting their routines (CMOC 20). Additionally, when administering group-based programmes, it is essential to acknowledge and cater for potential differences in support needs among participants (CMOC 21). Programmes must also be administered in a flexible way to accommodate individual needs and capabilities (CMOC 22). To facilitate both delivery and the intervention strategies in the previous sections, people with lived experiences should be included in the development, delivery and interpretation of the intervention (CMOC 23).

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 20 – Importance of respecting daily routines. Not respecting daily routines when implementing an intervention (C) can cause distress and reduce motivation (M), resulting in reduced active engagement with and adherence to the intervention delivered (O). (16/79 articles)

> *… his life is dominated by ritual and procedures and predictable behaviours … Routine is a big thing*
>
> *Mahy et al. 2019*[161]

Context–mechanism–outcome configuration 21 – Neglecting diverse abilities in a group can result in people feeling left out. Group-based activities that include people with diverse support needs (C1) can result in participants receiving differential levels of support (C2). Subsequently, some participants may not have the necessary skills or capacity to

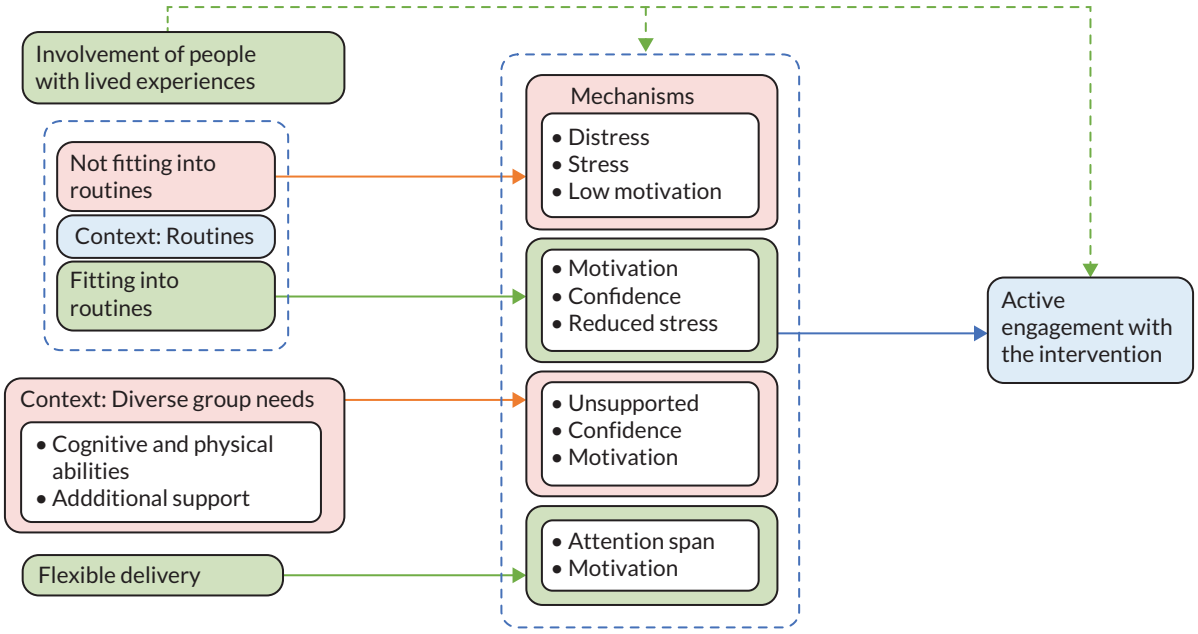

FIGURE 25 Partial programme theory: intervention delivery (CMOCs 20–23). Green represents a positive impact; blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

engage with the intervention (M1), and others may feel unsupported and unstimulated by the intervention strategies (M2). This can result in reduced active engagement with the intervention (O). (9/79)

> *… had to adapt within classes, which they described as 'very diverse'. Tailored support was required to avoid exclusion.*
> *Maine et al. 2019, p. 1041*[163]

Context–mechanism–outcome configuration 22 – Flexible delivery improves engagement. A flexible delivery reflecting the needs of people with learning disabilities (C) ensures participants have the necessary skills and capacity to participate (M), resulting in improved engagement with the intervention as delivered (O). (27/79 articles)

> *The inbuilt flexibility of the content of the intervention components facilitated adaptation to local needs …*
> *Sundblom et al. 2015, p. 300*[156]

Context–mechanism–outcome configuration 23 – Inclusion of people with lived experiences is essential. Including people with lived experiences in the intervention design and delivery (C) ensures people have the necessary skills to take part, increasing confidence and motivation (M), resulting in improved engagement with the intervention as it is suitable and relevant to the lives of adults with learning disabilities (O). (8/79 articles)

> *It is empowering to be in charge of a topic like this rather than being on the receiving end of the application of this topic.*
> *McDonald et al. 2016, p. 203*[164]

> *The group advised on the design and conduct of the study by commenting on the relevance and accessibility of the research methods and materials used throughout …*
> *Croot et al. 2018, p. 3*[108]

Social connectedness and fun

Adults with learning disabilities can experience increased enjoyment, motivation and social interaction from taking part in interventions (see *Figure 26*). Having the group-based activities and peer interaction as part of the programme can foster social connectedness and increased enjoyment (CMOCs 24 and 25). Additionally, enjoyment can be enhanced by integrating strategies, such as music and humour, that are centred around fun (CMOC 26). This can improve motivation and result in more active engagement with the intervention.

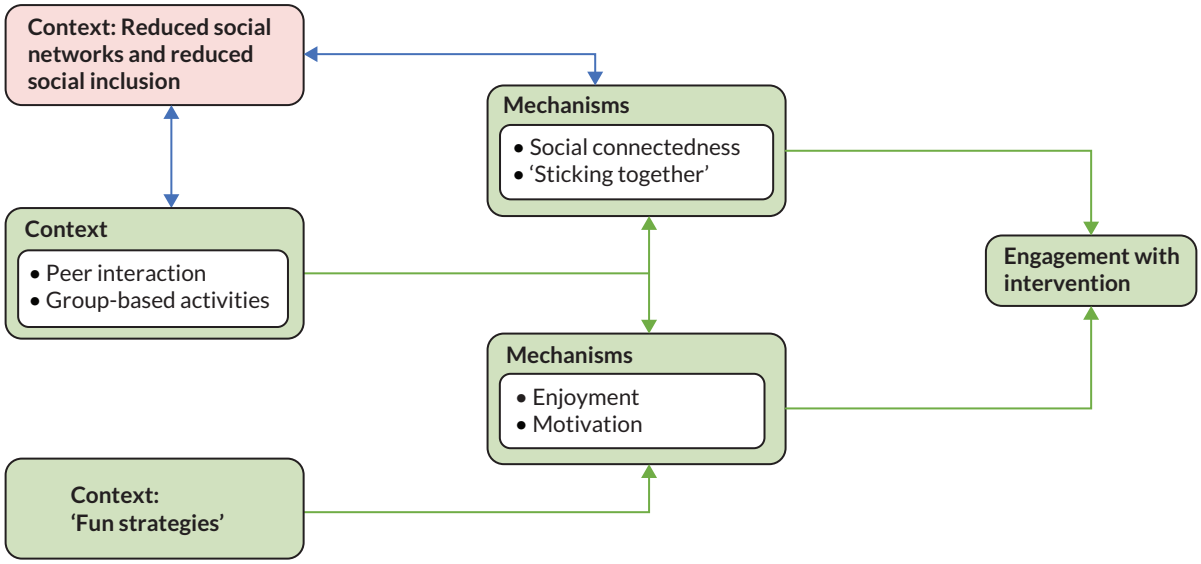

FIGURE 26 Partial programme theory: social connectedness and fun (CMOCs 24–26). Green represents a positive impact; blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 24 – Peer involvement increases confidence and enjoyment. Peer involvement in the intervention (C) can foster a sense of sticking together, increasing confidence, motivation and enjoyment through social interaction (M), resulting in better engagement with and adherence to the intervention delivered (O). (10/79 articles)

> *… having a 'buddy' system seems to be effective for athletes in that they are able to 'hold each other accountable' and have fun together.*
>
> *Marks et al. 2010, p. 127*[165]

Context–mechanism–outcome configuration 25 – Group-based activities foster social connectedness. Group-based activities with the opportunity to be social (C) foster social connectedness, motivation and enjoyment (M), improving active engagement and participation in the intervention as it provides an opportunity to expand social networks (O). (5/79 articles)

> *… My confidence wasn't so good. Since then it has grown massively … Just being more active and more social … because when I am out I have to interact with people, so it has helped me with that …*
>
> *Mitchell et al. 2016, p. 114*[166]

Context–mechanism–outcome configuration 26 – Fun and enjoyment improve active engagement. Strategies to promote fun and enjoyment, such as the inclusion of music or humour (C) increase motivation to take part (M), resulting in active engagement with the intervention (O). (10/79 articles)

> *… using humor was also motivating. For example giving a "wrong" demonstration of the activity; it provides a good atmosphere and a lot of fun.*
>
> *van Schijjndel-Speet et al. 2014, p. 404.*[167]

Broader behavioural pathways

When considering wider contexts, there are broader behavioural pathways that exert an influence on lifestyle modification (see *Figure 27*). Individual-level factors such as poor mental and physical health impact on the lifestyle behaviours engaged in and the potential effectiveness of lifestyle modification programmes (CMOCs 27 and 29). The lifestyles of others should also be considered, with lifestyle behaviours modelled from people close to an individual with learning disabilities (CMOC 28). Wider contextual factors can inhibit participation in lifestyle behaviours, such as negative attitudes from the wider community (CMOC 30), a built environment that does not support specific behaviours

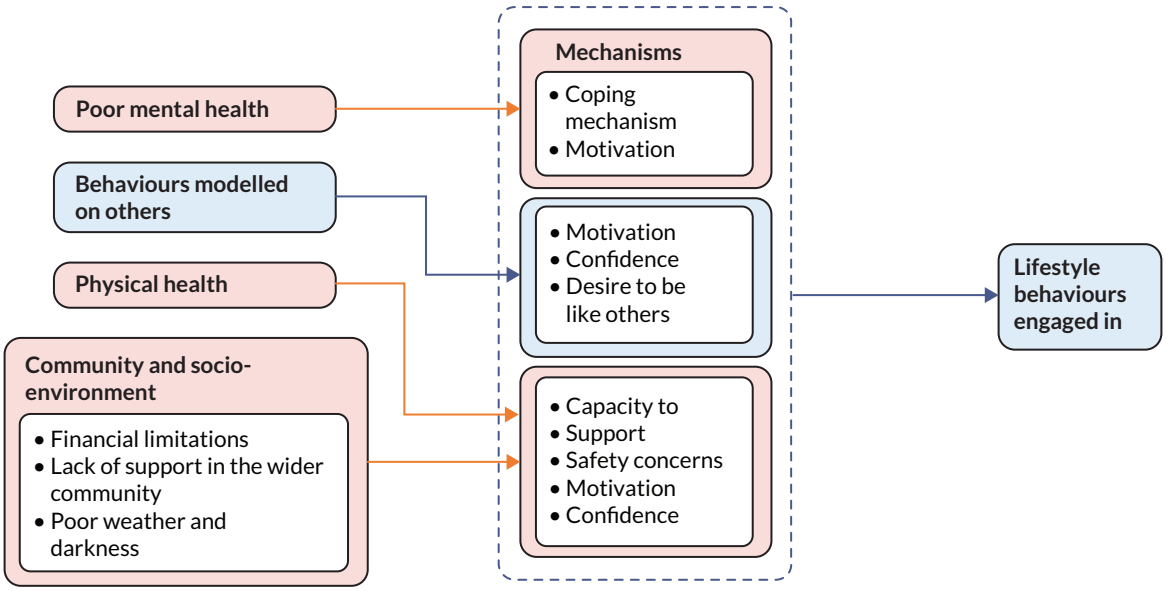

FIGURE 27 Partial programme theory: broader behavioural pathways (CMOCs 27–33). Blue represents a neutral context/mechanism; pink represents a negative context/mechanism.

(CMOC 31), financial resources (CMOC 32) and the weather (CMOC 33). These all impact on lifestyle behaviours by interacting on mechanisms such as motivation.

Context–mechanism–outcome configurations and illustrative quotes

Context–mechanism–outcome configuration 27 – Unhealthy behaviours used as coping mechanism. Poor affective states and stress (C) contribute to unhealthy lifestyles (O) as people use the hazardous behaviours as maladaptive coping mechanisms to deal with the negative emotions (M). (8/79 articles)

> *For some, smoking/drinking was associated with a mental health problem and appeared to be used as a form of self-medication ….*
>
> *Kerr et al. 2017, p. 617*[168]

Context–mechanism–outcome configuration 28 – Lifestyles are modelled on others. The lifestyle behaviours of those close to a person with learning disabilities are observed (C), resulting in the behaviours being copied and 'modelled' in order to fit in (M), contributing to the lifestyle behaviours enacted by people with learning disabilities (O). Being around people with unhealthy lifestyles (C) reduces motivation and confidence to change behaviour (M), reducing participation in healthy lifestyles (O). (9/79 articles)

> *T … They were all smokers, ma grandparents, and that … I was surrounded by people smoking so I thought … 'may as well start myself'.*
>
> *Kerr et al. 2017, p. 617*[168]

Context–mechanism–outcome configuration 29 – Health limitations reduce participation in healthy behaviours. Underlying health limitations and physical capabilities (C) reduce capacity to engage in specific lifestyle behaviours, which also reduces confidence to take part (M), resulting in reduced participation in healthy lifestyles (O). (6/79 articles)

> *People with I/DD stated getting older affected their ability to participate in the community as a result of health conditions that can come with ageing ….*
>
> *Spassiani et al. 2019, 1470*[169]

Context–mechanism–outcome configuration 30 – Concerns of safety in wider community. Lifestyle behaviours that involve being in the wider community (C) can trigger concerns over safety and feeling uncomfortable (M) which reduces confidence and motivation (M) to engage in healthy lifestyles that involve going outdoors (O). (12/79 articles)

> *P stated that he has not exercised because there is a lot of gang activity in the neighborhood where he is staying; therefore, he cannot go outside for walks.*
>
> *Guerra et al. 2019, p. 534*[160]

Context–mechanism–outcome configuration 31 – Built environment does not always support healthy lifestyles. The physical built environment may be unsupportive of healthy lifestyles due to the availability of resources or accessible walking routes (C). This reduces confidence and perceived capacity (M), resulting in greater adoption of unhealthy lifestyles (O). (13/79 articles)

> *When faced with independent food choices in the community, both groups admitted to struggling to avoid temptations in cafes or shops.*
>
> *Skelly et al. 2020, p. 10*[170]

Context–mechanism–outcome configuration 32 – Financial limitations reduce access to healthy lifestyles. Access to healthy lifestyles costs money, and people with learning disabilities may experience financial limitations (C). This reduces perceived capacity and contributes to a feeling of disempowerment (M), which results in reduced participation in healthy lifestyles (O). (12/79 articles)

> *Since healthy foods were thought of as more expensive by both groups, cost of healthy food became a noted barrier by both groups.*
>
> *Skelly et al. 2020, p. 10*[170]

Context–mechanism–outcome configuration 33 – Poor weather conditions restrict outdoor activities. Poor weather conditions (C) reduce motivation (M) to participate in outdoor physical activities (O). (13/79 articles)

> *the weather was seen as one of the main barriers to walking for most of the participants:*
> *Lindsay: 'I do try and do quite a lot of walking but with this weather you can walk but it means that you are going to get wet all the time'. (interview5)*

> *Others were put off by snow, ice and wind.*
>
> *Mitchell et al. 2016, p. 115*[166]

> *did not encourage people with intellectual disabilities to engage in exercise during the winter or in bad weather.*
>
> *O'Leary et al. 2017, p. 128*[7]

Overarching programme theory

Programme theory reflecting context, mechanism and outcome configurations

A programme theory was developed to reflect the realist synthesis of the evidence (see *Figure 28*). This was done by considering the central parts of the overarching programme theory and was developed with input from the wider research team and members of the steering committee. It emphasises that wider contextual factors (i.e. broader behavioural pathways) exert an influence on the CMOCs, such as level of learning disabilities. It also highlights that there are specific CMOCs for caregivers and that intervention strategies tie into this.

The overarching programme theory developed considers the potential interaction and flow of CMOCs. For example, provision of social support from caregivers is both an outcome and a context, with social support important for participation among adults with learning disabilities. The core higher-level contexts and key mechanisms for adults with learning disabilities are also presented. These CMOCs then directly impact on the ability of adults with learning disabilities to process, interact and, ultimately, actively engage with the intervention delivered. This is required for interventions to be implemented as planned and determines the overall effectiveness of the interventions. A core aspect of this overarching programme theory is the emphasis on the need for people with lived experiences, such as adults with learning disabilities and caregivers, in all aspects of the intervention development and delivery. This ensures it reflects the needs, abilities and wants of adults with learning disabilities.

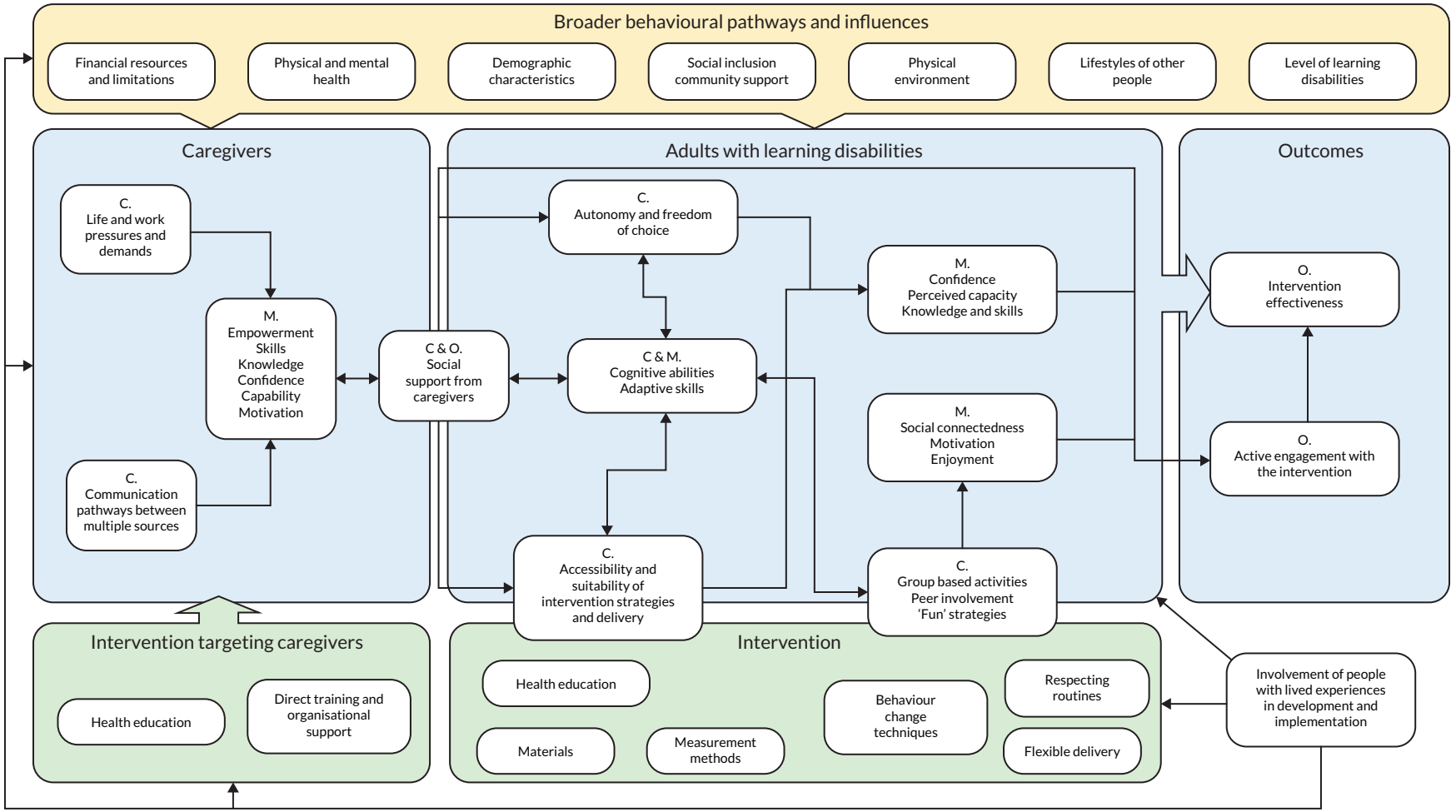

FIGURE 28 Overarching programme theory reflecting context–mechanism–outcome configurations. C = context; M = mechanism; O = outcome; green represents intervention-related aspects; blue represents CMOCs central to the programme theory; yellow represents the broader behavioural pathways that exert an influence on the intervention.

Usable overarching programme theory to highlight consideration for researchers, policy-makers and relevant stakeholders

An overarching programme theory was created that could be easily used by those interested in developing lifestyle modification programmes. This model was primarily focused on the important interacting, multilevel contexts and was less focused on CMOCs. It was designed as multilevel rings to be rotated and moved to show that different contexts and mechanisms interact with each other (see *Figure 29*). At the centre of this overarching model was active engagement, as this was identified as the core outcome of the programme theory. This is due to the specific contexts triggering mechanisms that relate most to adults with learning disabilities being able to actively engage, process and interact with the intervention as delivered. The outer ring represents the wider contextual factors that are not specific to lifestyle modification but exert an important influence on the capacity of adults with learning disabilities to actively engage with an intervention. The wider contexts also exert an influence on the next ring, which represents the programme-specific contexts that must be considered, such as accessibility of intervention strategies and support involvement. The next ring is the core mechanisms that may be triggered, which contribute to the outcome of active engagement.

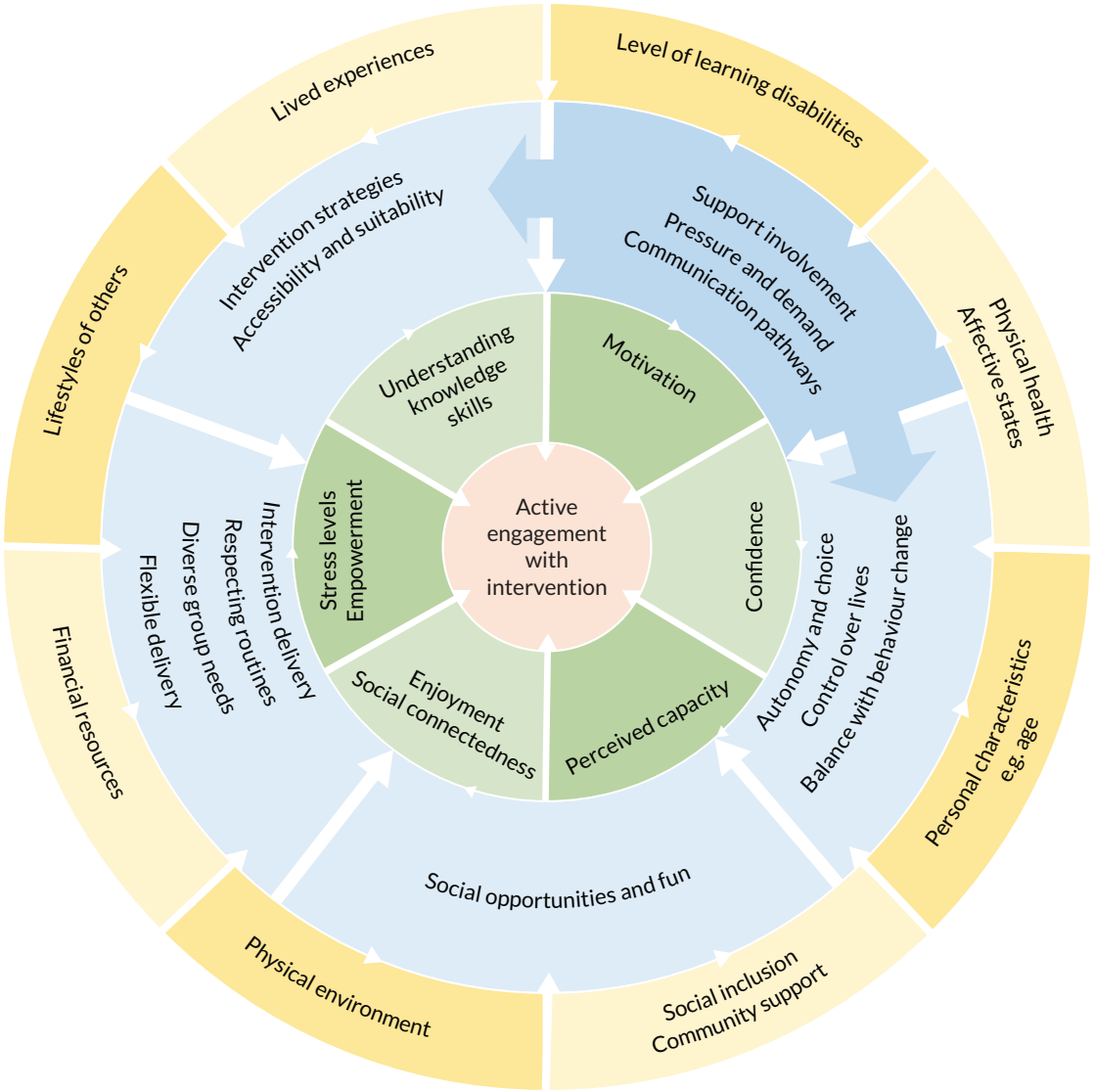

FIGURE 29 Overarching programme theory to highlight consideration for researchers, policy-makers and relevant stakeholders. Note: yellow represents the wider contexts that exert an influence on the interventions being delivered; blue represents the contexts central to the programme theory; green represents the central outcomes; red represents the core outcome.

Chapter 5 Integrating the findings: development of the logic model

Bridging the systematic review and realist synthesis

We further examined studies present in both the systematic review and realist synthesis (see *Chapters 3* and *4*), along with any associated papers (e.g. process evaluations), to explore the reasons why some studies were (in)effective using the context–mechanism–outcome configurations and associated excerpts of text.

Smoking

One study was included in both the systematic review and realist evidence synthesis.[73] The intervention successfully used mindfulness procedures to significantly reduce the number of cigarettes smoked. This intervention was coded under CMOC 16 in the realist synthesis: 'setting self-determined concrete and observable goals'. The opportunity for participants to select their own smoking reduction goals potentially contributed to the intervention's effectiveness by improved confidence and motivation, as the goals were achievable, concrete and observable.

Within the realist synthesis, Singh *et al.*[73] was an additional paper associated with this intervention. Singh *et al.*[73] further supported the benefits of having self-determined, concrete and observable goals. Additionally, it was reported that some participants received support to help track smoking in specific settings (CMOC 12: support to engage in strategies). Mornings for participants were 'hectic' which meant that it was difficult to monitor smoking, emphasising the need to be flexible and fit into routines of people with learning disabilities and caregivers (CMOC 20).

Alcohol consumption

Kouimtisidis *et al.*[70] and Mendel and Hipkins[71] were alcohol consumption interventions in both the systematic review and realist synthesis. Kouimtsidis *et al.*[70] used an extended, brief intervention and had a range of outcomes. Overall, there was a positive effect, but this was not significant for all outcomes. CMOCs were identified that may have contributed to the ability of adults with learning disabilities to actively engage with the intervention. Some participants had issues with measurement methods and had difficulties communicating with the therapist providing the intervention (CMOCs 14 and 15). Some participants would have preferred fewer sessions, and the programme was difficult to fit into their daily lives; there should be flexibility in the intervention, and it should reflect lives of participants (CMOC 20). The use of visual aids was reported to have facilitated understanding. One participant did not take part in the programme as they were reluctant to meet a new person (CMOC 21). Importantly, the authors incorporated feedback from people with learning disabilities when developing the intervention, which allowed for adaptations to be made (CMOC 23).

The intervention described by Mendel and Hipkins[71] aimed to increase motivation and confidence to change behaviour. The intervention involved working with caregivers; however, they did not always facilitate the programme, with the authors noting the need for all support staff to receive training to increase motivation (CMOC 1). Additionally, the authors also raised concerns that caregivers may have coerced participants to take part and seen an informed decision to not participate in research as refusing to receive treatment (CMOC 10). The reliance on 'retrospective memory' for the measurement methods was considered to contribute to difficulties completing drinking diaries. This information relies on potentially abstract conceptual skills, and the researchers suggested there should be consideration when these questions are asked to reduce the time between responding to questions and recalling information (CMOC 14). Reflecting this, the authors described interactive learning strategies in group settings, with visual aids using concrete and real-world examples, such as vignettes of 'popular media personalities' (CMOC 18).

Low physical activity only

Low physical activity-only interventions were included in both the realist evidence synthesis and systematic review[82,83,89,96,110] with associated mixed-methods and qualitative studies incorporated into the realist synthesis.[154,166] Systematic review of low physical activity only studies that were not included in the realist synthesis were of low

methodological rigour or had limited relevance to the programme theory as they were more structured exercise programmes with minimal reflection on behaviour change.

Across the studies, peer support was found to facilitate increases in physical activity by improving motivation (CMOC 24). The use of concrete health education and active learning strategies were also supported as accessible ways for promoting the acquisition of new knowledge and skills (CMOC 19). Challenges to behaviour change relate to the abstract nature of some BCTs, with adults with learning disabilities having difficulties using measurement methods such as pedometers (CMOCs 13 and 14). This had implications for self-monitoring and the reported outcomes of the intervention. A core barrier to behaviour change is related to engaging caregivers to provide social support, with this inhibited by life and work pressure (CMOCs 3 and 2). This reduced the ability of paid and family caregivers to provide social support and to actively engage with the intervention. To improve social support, it is important to fit into the routines of both paid and family caregivers with this facilitating participation in an intervention (CMOC 20).

Multiple behaviours (low physical activity, sedentary behaviour and poor diet)

The highest level of crossover between the systematic review and realist synthesis came for the multicomponent interventions that targeted low physical activity, sedentary behaviour and poor diet. Interventions reported positive overall effects on either anthropometric or behavioural outcomes[108,121,122,134,135,137,138,140,146] with mixed findings reported for the remaining interventions.[112,116,117,123,126,138,160] Additional associated studies in the realist synthesis provided insight into the potential CMOCs contributing to intervention outcomes.[123,126,138,156,157,172]

Across the studies, there were core CMOCs to consider that contributed to the intervention's effectiveness. Social support was important to intervention success, with this necessary for engaging with intervention strategies (CMOC 12). This is particularly important for BCTs that rely on abstract concepts and to negate difficulties with measurement methods (CMOCs 13 and 14). However, communication between multiple sources of support was variable, with effort required to ensure knowledge exchange and shared goals (CMOCs 6 and 7). The ability of caregivers to provide support was impacted by work pressures of paid support staff and life pressures of family caregivers, emphasising the need for training and support for caregivers (CMOCs 2, 3 and 4). Caregivers also feel a conflict between respecting autonomy and promoting behaviour change (CMOC 9). There is limited control over decisions in healthy lifestyles for adults with learning disabilities, especially for people with more severe learning disabilities (CMOC 8).

Accessible intervention strategies and delivery are important, such as materials that reflect communication abilities, health education that focuses on active learning and concrete health messages and respecting daily routines (CMOCs 15, 19 and 20). Involvement of peers with learning disabilities fosters a sense of sticking together and improves enjoyment and confidence (CMOC 24). To ensure the intervention strategies and delivery are accessible, relevant and suitable, it is essential to include people with learning disabilities and/or caregivers in the intervention development (CMOC 23).

Overall

Across all health risk behaviours, there are many contexts and mechanisms that contribute to the ability of adults with learning disabilities and caregivers to actively engage with the intervention. To develop interventions that address these issues, it is essential for researchers to work closely with people's lived experiences.

Logic model

A logic model is a useful medium through which underpinning the pathways and causal mechanisms of how complex interventions work can be presented.[201] It can also be used to synthesise findings of our systematic review, meta-analysis and the realist synthesis.[202] Given the broad range of our findings, we have adapted our logic model (see *Figure 30*) to show the intervention mechanisms and to provide guidance on designing an appropriate lifestyle modification intervention for a maximum and long-lasting impact on lives of adults with learning disabilities.

Core elements and resources of the intervention

The nine core elements and resources were informed from the systematic review and meta-analysis (see *Chapter 3*).

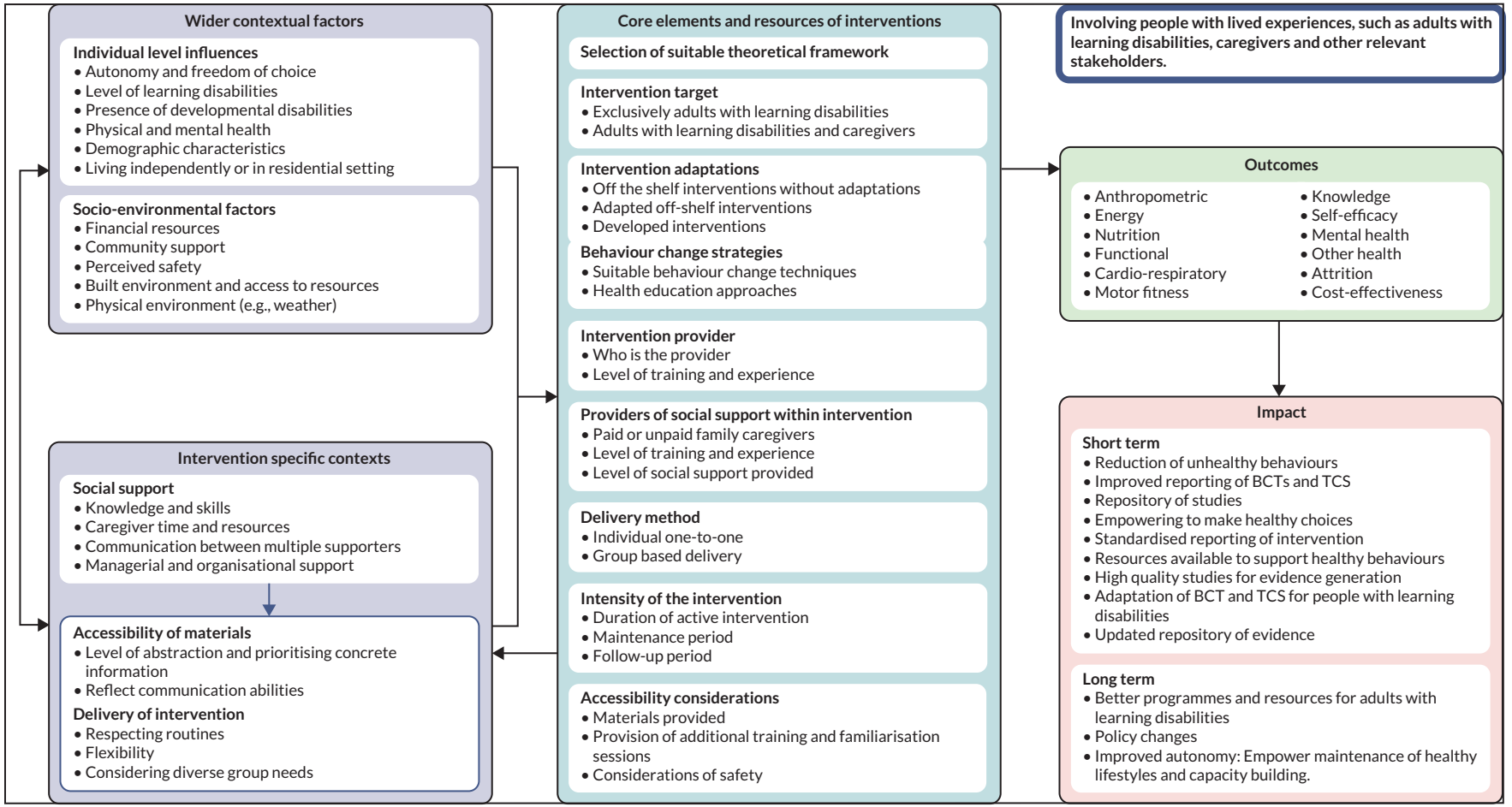

FIGURE 30 Nine core elements and resources that should be considered in designing an appropriate intervention for adults with learning disabilities.

The selection of the target population for the lifestyle modification intervention is crucial. While the intervention may focus exclusively on adults with learning disabilities, population characteristics such as age range, gender, levels of learning disabilities (including adults with severe and profound learning disabilities), comorbidities, ethnicities and socioeconomic status should be considered. Medical conditions should include any biological, physical or mental health conditions. The living arrangements of adults with learning disabilities may include living independently with or without support; living with family, carers or host in homes; living in community residences, group homes or medium-secure services; etc. The interventions can also be expanded to target anyone who closely provides support to adults with learning disabilities, including family members, caregivers, health professionals and other experts. There are various strategies to do so – for example, involving peer health ambassadors or buddies who perform activities with the target population or introducing health education content to parents.

As described in *Chapter 3*, there is a wide range of lifestyle modification interventions available in the literature for adults with learning disabilities. It falls on the investigator to decide whether to use an 'off-shelf' intervention or to develop a new one. As there is no one-glove-fits-all solution, adapting an 'off-shelf' intervention for the target population has the potential to be more effective. Our evidence shows that almost all interventions for adults with learning disabilities were adapted using guidelines and existing literature on specific health behaviours in this population. Developing an intervention is a multifaceted process. Notably, any intervention in development must have a sound theoretical framework as a basis. This also applies to 'off-shelf' interventions that have been used multiple times in the literature. The models and theories used in existing interventions include the transtheoretical model; the biopsychosocial model; empowerment theory; control theory; person-centred theory; and social cognitive theory (see *Chapter 3*; *Appendix 7*). Simultaneously, the intervention must be built on behavioural change techniques that are appropriate for this population. Some commonly used BCTs, as identified from our systematic review, include goal and planning; feedback and monitoring; social support; shaping knowledge; natural consequences; comparison of behaviour and outcome; associations; repetition and substitutions; reward and threat; regulation; antecedents; and self-belief and identity (see *Chapter 3*; *Appendix 8*). Health education-related techniques enable adults with learning disabilities to retain knowledge in the long term. However, caveats related to Michie's TCS are presented in *Chapter 6*.

Interventions should only be provided by those who have an appropriate level of training and experience with adults with learning disabilities. This may include health professionals, support workers, families, paid carers, etc. Ideally, it is beneficial if the intervention is delivered by people familiar with the behaviours and preferences of adults with learning disabilities.

Interventions can be delivered either individually or in groups. The impact of delivery can be attuned by ensuring that groups are of small or manageable size. The ratio of intervention provider and target population must be balanced to allow personalisation in intervention delivery and assessment. The extent to which the intervention can be individualised should be considered and can include personalised recommendations or modification of activities according to individual abilities and preferences.

Social support is a major factor that influences the delivery and impact of an intervention. Social supporters include family members, friends/peers, carers and professionals such as coaches, therapists, nurses, etc. Irrespective of whether they are targeted by an intervention, they play a key role in the recruitment and logistics, communication, implementation and engagement of adults with learning disabilities (see *Figure 31*). In some cases, they can act as an intervention provider too. Investigators must ensure that social supports have an appropriate level of training and experience with adults with learning disabilities. Their level of support must be decided based on the target population's needs and comfort.

The success of an intervention lies in the extent to which this is accessible by adults with learning disabilities and their social supporters. Accessibility can be improved by introducing clear, comprehensible and entertaining materials; additional sessions and training can include opportunities for both adults with learning disabilities and their social supporters (see *Figure 32*). Moreover, conducting interventions in a convenient setting and schedule promotes accessibility and increases adherence. A major point is to ensure that all parties involved, especially adults with learning disabilities, are taught safety mechanisms and that the intervention setting follows safety regulations.

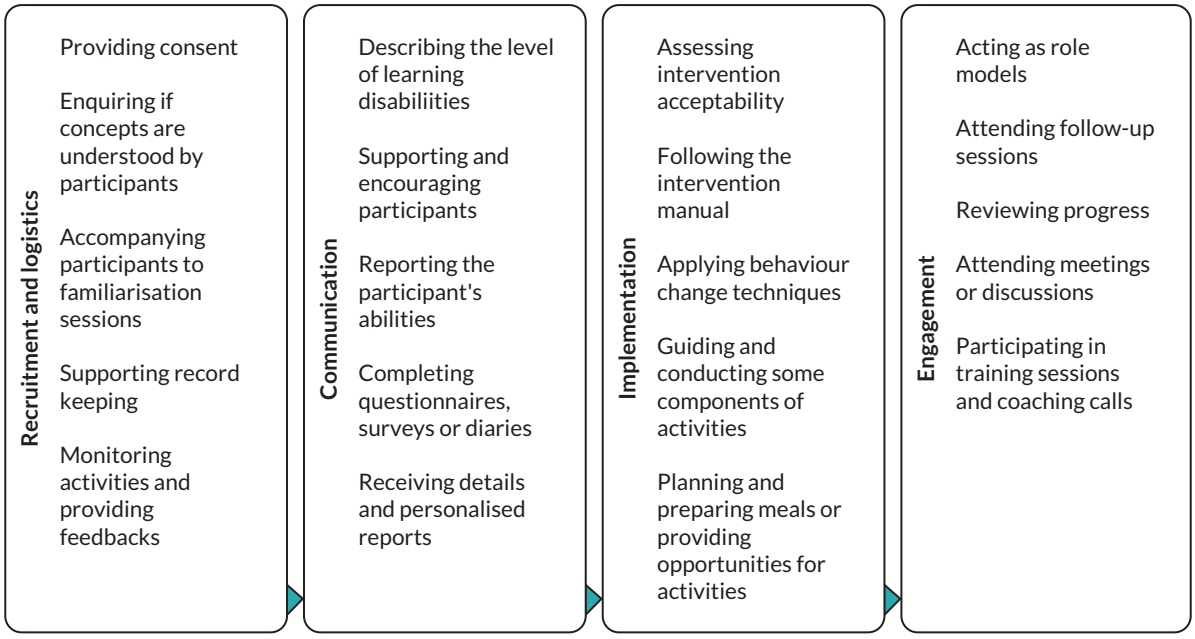

FIGURE 31 Role of social supporters in interventions.

An appropriate intervention period must be defined based on factors such as the willingness of adults with learning disabilities to participate and the availability of resources, including funding. Introducing a maintenance period, which includes strategies such as delivering interventions at a lower intensity or offering knowledge retention sessions, may help ensure that the adults with learning disabilities build sustainable habits. A suitable intervention follow-up period will also help assess the long-term impact of the intervention and identify challenges to its effectiveness.

Consideration of contextual factors

Contextual factors contribute greatly to lifestyle modification interventions for adults with learning disabilities, with this observed in both the systematic review (see *Chapter 3*) and the realist synthesis (see *Chapter 4*). Contexts must be considered to ensure adults with learning disabilities and their caregivers are able to actively engage with the intervention to achieve behaviour change.

Wider contexts

Wider contexts were split between the individual-level factors and socioenvironmental contexts and were based on both the realist synthesis and systematic review. The individual-level influences relate to contextual factors that are specific to individual people. Autonomy and freedom of choice will heavily determine the ability of participants to take part in the intervention and will also involve the potential involvement of caregivers in the intervention target. Autonomy and freedom of choice are impacted by the level of learning disabilities. The involvement of people with mild to severe or profound learning disabilities must be considered by researchers when making decisions around the core elements and resources of the interventions. Other individual-level factors include the presence of developmental disabilities, as these may require adaptations for the intervention. Reflecting this, the underlying physical and mental health of participants will impact the capacity of participants to take part. This also ties in with demographic factors, such as age, which can contribute to the increased presence of health conditions. Additionally, the residential setting is an important context. A person living independently will have different opportunities and support available compared to an individual in a residential setting.

The socioenvironmental factors relate to the wider contextual factors that impact lifestyle modification. This includes the financial resources of participants, which determine their access to healthy choices. Additionally, the wider support of the community can influence the ability of adults with learning disabilities to participate in lifestyle behaviours. This also relates to perceived safety, which can be impacted by the attitudes of people within the community and the walkability of an area. The built environment of individual participants can be both a barrier and facilitator for people, as

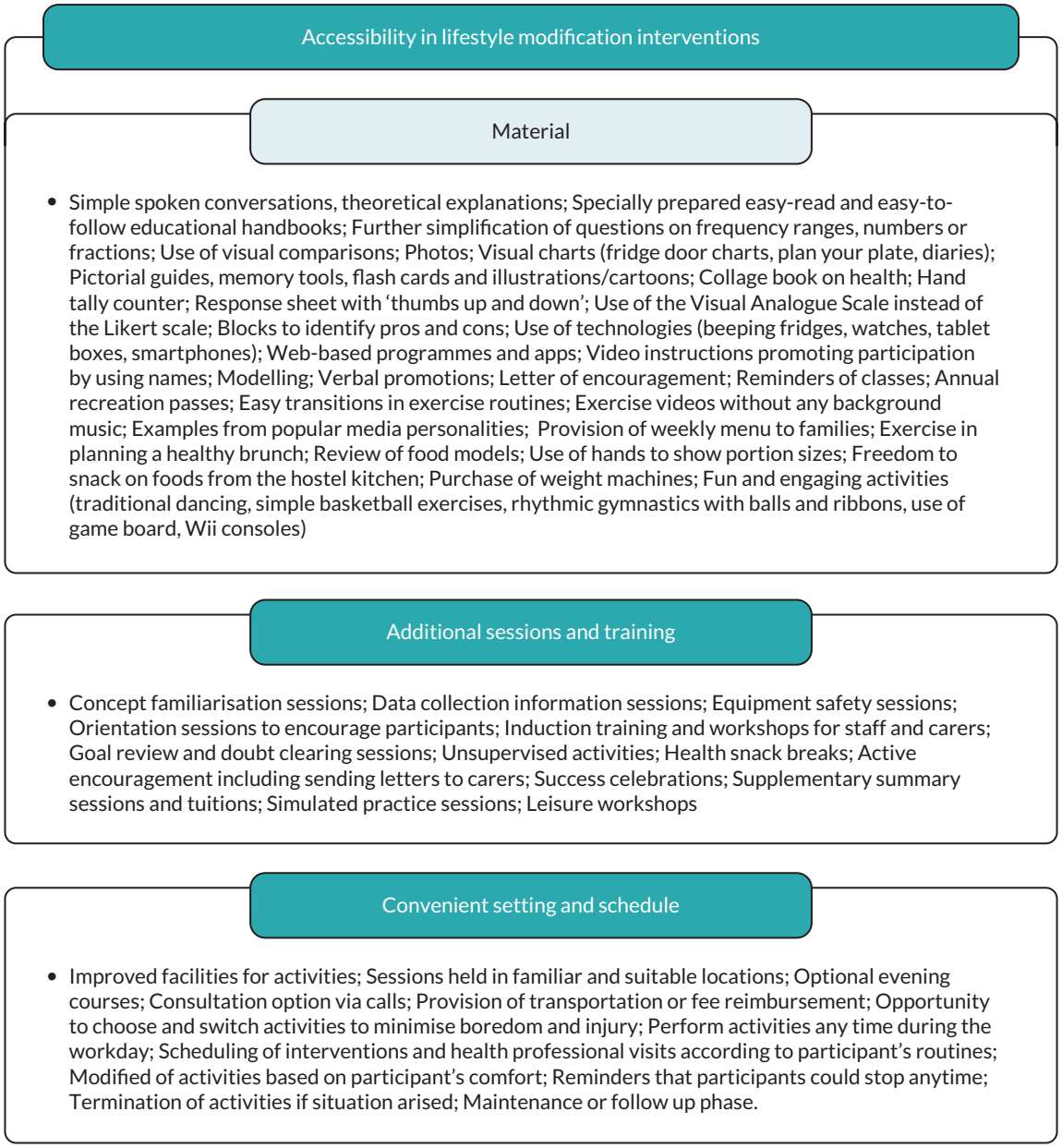

FIGURE 32 Various ways to enhance accessibility in lifestyle modification interventions.

it can determine the availability of resources for healthy lifestyles. The physical environment should be considered for interventions promoting outdoor activities, as poor weather can prevent participation.

Intervention-specific contexts

Intervention-specific contexts are more strongly based on the realist evidence synthesis and highlight core considerations. Reflecting the core elements and resources of interventions, accessible materials are essential. It is important that materials reflect the communication abilities of participants using easy read. Additionally, when developing information, concrete and observable examples should be used while avoiding a high level of abstraction which may not be clear or easily understood.

The intervention should also be delivered in a way that is suitable to the needs and lives of adults with learning disabilities and those who support them. To do this, the daily routines must be respected to facilitate participation and avoid unnecessary stress and burden. The interventions should also be delivered flexibly, with opportunities to make adaptations and to tailor them to the individual needs of participants. It is also paramount to acknowledge the diverse

group needs of participants involved in a study, for example, considerations into the support needs of each participant and the accessibility of all materials.

Delivery and accessibility of interventions are heavily influenced by the level of social support provided to participants. For example, having additional support to engage with intervention materials can facilitate understanding and confidence. However, social support is influenced by a range of contexts. The knowledge and skills of family and paid caregivers influence the capacity to provide sufficient social support. The time available to caregivers and the resources they have access to determine their ability to provide support. If a person has multiple caregivers, for example, multiple paid support staff, communication is required to share information about the intervention and foster shared goals. For paid support staff, the level of managerial and organisational support determines the time available and confidence to facilitate the active engagement of adults with learning disabilities in the intervention. Considering the caregivers and sources of support in the core elements and resources of an intervention can target these contexts, such as improving knowledge and skills and fostering communication and shared goals.

Importantly, the intervention-specific contexts and wider contextual factors interact. For example, social support also ties into the autonomy of adults with learning disabilities. The level of learning disabilities also heavily determines the accessibility of materials and the level of social support required. Additionally, the residential setting will impact the delivery of the intervention and social support. It is therefore imperative not to focus on specific contexts when developing an intervention, as this can overlook important influential factors.

Outcomes

As detailed in *Chapter 3*, the effectiveness of lifestyle modification interventions can be assessed using various measures. Any intervention targeting adults with learning disabilities must be appropriate and valid. It is important to choose relevant and standardised measures that accurately assess the specific outcomes of interest. Using measures that are not appropriate or valid can lead to incorrect conclusions and result in ineffective interventions.

Our evidence shows that the effect of interventions targeting smoking behaviour and alcohol intake was expressed using behavioural, cognitive, knowledge-related, psychosocial and quality-of-life outcomes. Similarly, the effect of interventions targeting low physical activity, sedentary behaviour and poor diet was expressed as anthropometric, behavioural, cardiorespiratory, functional, cognitive, food and nutrition, physical activity and sedentary behaviour, quality-of-life and general health outcomes. Cost-effectiveness as an outcome can be a useful tool in future reimbursement decisions. By analysing the cost-effectiveness of an intervention, decision-makers can determine whether the intervention provides a good value for the resources invested and whether it is a cost-effective solution compared to other available options. Attrition as an outcome can help understand why the target population is not fully participating or disengaging from the intervention.

Impact

An appropriate lifestyle modification intervention with the above-mentioned characteristics has the potential to create powerful short-term and long-term impacts on the health and well-being of adults with learning disabilities. In the short term, it will lead to a reduction in unhealthy behaviours and empower the adults with learning disabilities to make healthier choices. The availability of resources to support health behaviours will also gradually increase as more interventions adopt these characteristics. Research such as ours will be a repository of evidence accessible to all and highlight the importance of improved reporting and intervention adaptation, including information on the use of theories and BCTs. Additionally, it will support future studies to generate high-quality evidence and address existing gaps in the literature.

In the long term, these actions will result in better programmes and resources for adults with learning disabilities. Evidence-based, inclusive policies will be established, and adults with learning disabilities will be empowered to make autonomous decisions and build the capacity to live a healthy life. The intervention will have a lasting impact on the health and well-being of adults with learning disabilities, ultimately improving their quality of life.

The involvement of people with lived experiences

The involvement of people with lived experiences, such as adults with learning disabilities, caregivers and other relevant stakeholders, is an important aspect of this logic model. This was based on findings within the included literature and through the invaluable input of our PPI members (see *Chapter 7*) throughout this evidence synthesis project. People's lived experiences can provide unique input on what is important and what must be addressed. This can be in the form of identifying the important wider contextual factors and intervention-specific contexts. Additionally, people with lived experiences can provide input on the core elements and resources of the interventions and help to develop a programme that will fit into the lives and needs of adults with learning disabilities or their caregivers. In the longer term, people with learning disabilities can provide input on the impact of lifestyle modification interventions. It is important that researchers actively work with people with learning disabilities at all stages of the study and respect the input given. This will enrich the study and ensure the results are impactful on the health and well-being of adults with learning disabilities.

Chapter 6 Discussion

This mixed-methods evidence synthesis investigated the effectiveness and underlying mechanisms of lifestyle modification interventions in adults with learning disabilities to establish what works, for whom, why and in what context (see *Chapters 3* and *4*). The findings of systematic review, meta-analysis and realist evidence synthesis were integrated into a logic model that features evidence-based account of intervention mechanisms and provides a guidance on designing an appropriate lifestyle modification intervention in this population (see *Chapter 5*). Following the discussions below, we will outline future research priorities and suggestions to develop lifestyle modification interventions for the NHS and social care services.

Effectiveness of lifestyle modification intervention and its core components

Summary of findings

Our review of evidence on effectiveness of interventions targeting alcohol consumption and smoking behaviour was based on 6 studies with 288 participants who received interventions were based on core components of mindfulness, BCTs and a combination of both. We found that interventions were based on BCT and mindfulness components and targeted behavioural, cognitive, knowledge-related, psychosocial and quality-of-life outcomes. The RCT-based intervention for alcohol consumption had mixed effectiveness results, improving behavioural outcomes but worsening quality of life outcomes. The RCT-based smoking intervention also improved behavioural outcomes. Among the non-RCTs, the strengths of improvement in outcomes varied, an improvement was observed on knowledge-related outcomes. However, these results were based on limited evidence and had a varying level of statistical significance.

The evidence on the effectiveness of interventions targeting low physical activity only behaviour was based on 33 studies with 1413 participants who received interventions primarily consisting of aerobic exercise only or a combination of aerobic exercise, resistance exercise, behaviour change technique and mindfulness core components. These interventions targeted anthropometric, cardiorespiratory, functional and general health outcomes, including mental health, qualitify of life and life satisfaction. In RCTs, intervention effectiveness was mixed, leading to improvements in outcomes as well as instances of no change or worsened outcomes. Non-RCTs also exhibited a similar range of effects on outcomes across different studies. No change or worsened outcomes could be attributed the presence of a single core-component or a combination of similar core-components. For example, interventions with similar core components of aerobic exercise, resistance exercise, mindfulness and BCT did not show improvement or even lead to worsening of some cardio-respiratory and functional outcomes. However, the interventions had a varying level of statistical significance.

The evidence on effectiveness of interventions targeting multiple behaviours (low physical activity only, sedentary behaviour and poor diet) was based on 41 studies with 3164 participants who received primarily a combination of energy-deficit diet (EDD), aerobic exercise and behaviour change technique. Other component combinations included diet advice and resistance exercise. These interventions targeted anthropometric, behavioural, cardiorespiratory, functional, cognitive, food and nutrition, physical activity and sedentary behaviour-related, psychosocial, quality of life and general health outcomes. Similar to the low physical activity-only interventions, multiple behaviour interventions reported results of mixed effectiveness. RCT-based interventions resulted in improvements across a range of outcomes, although the strength of these effects varied or, in some instances, led to no change or adverse outcomes which could be attributed to the presence of a single core-component or a combination of similar core-components. Similar results were observed in non-RCTs. Compared to interventions targeting low physical activity only, fewer studies with interventions targeting multiple behaviours reported no change or worsened outcomes. However, the interventions had a varying level of statistical significance.

We extended our systematic review to conduct intervention-level and component-level meta-analyses of weight management outcomes (anthropometric) present in lifestyle modification interventions targeting physical activity-only or multiple behaviours. The pairwise meta-analysis lumped all interventions together and compared them with TAU. It found that lifestyle modification interventions did not lead to a significant change in the outcomes related to weight management when compared to treatment as usual. The NMA compared the effectiveness of interventions directly

and indirectly with each other and TAU. The NMA, which allows direct and indirect comparison of interventions with each other and TAU, showed that there is no difference in effect between the interventions and TAU in terms of weight management outcomes. Despite the NMA's results, we also conducted a component NMA using the core components and additional components, mode of delivery of interventions, availability of support mechanisms, and residence status, on weight management outcomes with maximum information (BMI). It confirmed the findings of NMA and revealed no significant differences between individual components and TAU.

Limitations in included studies

The limitations identified in our included studies are in line with existing literature reviews.[32–46] We found that the evidence base for the effectiveness of lifestyle modification interventions in adults with learning disabilities is emerging but imbalanced in terms of the health behaviours targeted by the interventions. This is especially in the case of alcohol consumption and smoking interventions.[39,40,168] Newer studies distinguish between physical activity and sedentary behaviour.[116,134,140]

There is a lack of high-quality, appropriately powered studies in this field.[36,39,41,46] Studies with alcohol and smoking behaviour[71,72,74,75] interventions mostly followed controlled and uncontrolled pre–post study designs. Majority of studies on physical activity-only and multiple behaviours were RCTs. Few were case-control studies, which included controls without learning disabilities.[106,107,143–146] Studies lacked methodological rigour, particularly non-RCTs.[34,38,39] Randomised controlled trials featured 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. Non-RCTs featured 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.

Another major limitation is the small, inadequately justified sample size in studies. Problems were faced in recruiting participants, especially those with profound learning disabilities.[70] Participants were from high-income countries and were recruited from a variety of sources. It is important to consider sample size in alcohol consumption and smoking studies, as there is limited literature on the prevalence of such behaviours in adults with learning disabilities. Also, it leads to the question of whether these behaviours are difficult to diagnose in this population.[70]

The intervention, its intensity and follow-up period varied across studies: intervention period in studies on alcohol consumption and smoking; physical activity-only and multiple behaviours ranged between 2 weeks to 6 months; 8 weeks to 9 months and 6 weeks to 16 months, respectively. These studies also had short follow-ups[32,36,46] with the longest follow-ups ranging from 12 to 18 months. Maintenance periods were either defined to be a period where interventions were offered at a lower intensity with classes aimed at knowledge retention or as the phase when participants maintained their modified behaviour.

Studies also faced issues related to outcome measures. Primary and secondary outcomes were not always clearly defined in studies. In the case of interventions targeting physical activity-only or multiple behaviours, the focus was on weight management outcomes.[32,34–38,44,45] Variety of outcomes also contributed to studies neglecting the correlation between multiple outcomes, and the same outcome measures at multiple time points. There was a lack of standardised measures used in studies to assess similar outcomes. Psychological measures were used limitedly.[41] Studies did not expand on the reliability of self-report measures and methods to monitor adherence[84,185] Studies also lack a formal investigation into participants' experiences and their acceptability of the interventions. Many studies did not report adverse effects and reasons for dropping out. The cost-effectiveness of study interventions was not explored in studies.

Additionally, there are number of important elements that are not covered or under-reported by the studies.[32,36,45,46,140] Our review also showed that studies under-represent certain segments of the population, that is, adults from ethnicities other than Caucasian who are older than 65 years and who have severe to a profound level of learning disabilities. Adults with long-term medical conditions and those who are on medications were frequently listed under exclusion criteria. Limited information is available on whether learning disabilities are specific to other conditions such as Prader–Willi syndrome, comorbidities, socioeconomic status and living arrangements of adults with learning disabilities. Few studies included adults with severe and profound learning disabilities.[41] Simultaneously, the

heterogenous characteristics of participants across studies also limited generalisability of the findings.[42,140] Moreover, insufficient reporting was observed in the intervention description[152] and if it followed valid clinical guidelines;[32] usual care definitions according to the setting; intervention adaptation/development process and involvement of wider stakeholder group, which also includes people with lived experiences and participants; involvement of social supporters and various ways used to increase intervention accessibility and personalisation. There is also an insufficient description of the extent of theory use and BCTs, which contributes to difficulties in the application of behavioural taxonomies.[23,58] Therefore, our review reports that the current lifestyle change interventions are also not optimally tailored to meet the needs of people with intellectual disabilities.[32,37,44,45,134,152]

The findings from meta-analysis are in line with the previously conducted systematic reviews, which included the studies comparing only multicomponent interventions with TAU.[23,203] These multicomponent interventions were defined only on the basis of intervention components: physical activity, diet advice and BCT. The stricter inclusion criteria[203] of only studies with all three components narrowed the scope of the interventions to be studied, and the heterogeneity barred any meta-analysis. Similar to our review, interventions did not reduce weight significantly when compared to the TAU.[23]

How lifestyle interventions work, for whom they work and why they work in some cases but not others

Our main finding from the realist evidence synthesis is that there is no single context or mechanism that can be targeted by lifestyle modification programmes for adults with learning disabilities. There are a wide range of complex and interacting CMOCs. Additionally, due to the availability of the extant literature, it was not possible to draw clear conclusions about what relates to explicit outcomes. Instead, the findings outline the processes that contribute to active engagement within an intervention and subsequent lifestyle outcomes. An intervention that fails to be developed and implemented in a way for adults with learning disabilities, or their caregivers, to actively take part, to process and engage with the intervention, will not be effective.

A core contributor to how interventions work and why they work sometimes and not others relates to the level of support received. Level and quality of social support both directly and indirectly contribute to lifestyle outcomes and active engagement with the intervention. It is essential to facilitate social support from caregivers. Caregivers include both family members and paid support staff who experience their own barriers and facilitators to promoting healthy lifestyles. Researchers must work with caregivers to develop an intervention that does not contribute to the pressure and demand that may already exist when supporting daily activities. It is important to promote the acquisition of knowledge and skills around healthy lifestyles to promote social support and to acknowledge that a person may have multiple sources of support. Provision of social support may therefore contribute to the accessibility of intervention strategies and the level of autonomy adults with learning disabilities have.

Although researchers can develop an intervention that effectively improves motivation of adults with learning disabilities, people may have limited control over their lives to change their lifestyle choices. It is important to empower adults with learning disabilities to make informed choices around healthy lifestyles; however, it is equally imperative to ensure caregivers can support these choices. It is essential for materials and information around healthy lifestyles to be shared in accessible and easy-read formats to facilitate informed decision-making for adults with learning disabilities.

In addition to the accessibility and suitability of intervention materials, strategies used to achieve behaviour change require attention. The realist synthesis highlighted the need to avoid abstract concepts in BCT techniques, with BCTs primarily based on techniques used for the general population without a learning disability. Research has discussed the suitability of BCTs for adults with mild learning disabilities, with multiple of those used for the general population considered unsuitable.[204] However, there is a need for the suitability of BCTs to be investigated for all levels of learning disabilities.

The realist synthesis also identified measurement issues which have implications for both the intervention outcomes and BCTs, such as self-monitoring. Issues have been raised by other researchers for subjective self-report measurements[19,205] and objective measurements used with adults with learning disabilities.[206] Therefore, an implication from these CMOCs relating to accessibility of intervention strategies is the need for the development of population-specific measurement methods and BCTs.

A context within the intervention that may contribute to the motivation of adults with learning disabilities to engage is peer involvement, group-based activities and opportunities for social interaction and fun. Adults with learning disabilities can have restricted social networks and may experience reduced opportunities for social inclusion.[206] Promoting healthy lifestyles through programmes that also facilitate social connectedness may have more far-reaching benefits for well-being and quality of life.

Although there are numerous contexts and mechanisms to consider, the most essential aspect is the involvement of people with lived experience in the design of interventions. In addition to being based on the literature, this was observed by the research team throughout this project. People with learning disabilities worked as part of the research team and were involved through a PPI group. The PPI group included adults with learning disabilities through the organisation People First. The feedback given helped to highlight the important issues that impact the daily lives and lifestyles of people with learning disabilities. The feedback given challenged assumptions made by the researchers and ensured the results were reflective of the experiences of people with learning disabilities. Involvement of people with learning disabilities in the development of interventions will ensure that intervention strategies are suitable, the delivery of the programme is appropriate and that there are no wider contextual factors that may inhibit adults with learning disabilities from actively engaging with the intervention. This should include the consultation and involvement at all stages in the project and acknowledgement that people with lived experience will have substantial understanding on what is important and what works in the context of their own lives.

Integrating the findings

The logic model developed from the integration of the study findings emphasises the complexity of lifestyle modification for adults with learning disabilities (see *Chapter 5*). Each aspect of the logic model highlights important considerations that should be made by those wanting to develop appropriate lifestyle modification programmes. This goes beyond only considering the intervention being developed and highlights the need to reflect upon the wider contextual factors that may contribute to the lifestyles of adults with learning disabilities. An essential emphasis is on the involvement of adults with learning disabilities, caregivers and other relevant stakeholders when developing an intervention and interpreting the implications of the findings.

Strengths and limitations of our project

This is the first evidence synthesis to integrate the findings of systematic review, meta-analysis and realist synthesis into a logic model to understand lifestyle modification interventions for adults with learning disabilities. The study was coproduced with people with learning disabilities and ensured the findings reflected their needs and experiences. The findings of this novel review can be directly used by individuals wanting to develop lifestyle modification programmes for adults with learning disabilities.

The systematic review is comprehensive and conducted alongside the realist synthesis, which ensured that maximum studies were included. We searched for relevant studies in major databases, clinical trial registries, Grey literature sources and other additional sources. We used a robust and validated search strategy to identify both RCTs and non-RCTs on interventions targeting five health behaviours (alcohol consumption, smoking, physical activity, sedentary behaviour and diet) in adults with learning disabilities. We identified and defined a range of core components present in complex lifestyle modification interventions. We also coded interventions for their extent of theory use and BCT using appropriate tools.[57] Our quantitative synthesis employed meta-analysis methods which have not been used in this field. Additionally, the identification of core components allowed us to pool together studies which had not been considered by previous reviews. Our CNMA goes beyond including core components based on intervention description and adds attributes that were highlighted to be important by our PPI members.

The realist synthesis was developed closely following the recommendations and quality standards.[62] Additionally, a member of the steering committee had expertise in conducting realist evidence syntheses and ensured the methods were conducted to a high standard. A mix of intervention effectiveness studies (e.g. RCTs), and qualitative and mixed-methods research were integrated into the synthesis, with this based on thorough searches of the literature. The development of the programme theory was an iterative process that involved feedback from the wider research team and the PPI team.

However, there are some limitations to our evidence synthesis. We were unable to follow few actions we had set out in the protocol, including the assessment of cumulative evidence using GRADE. Explanation for this is available in *Chapter 2*, section *Changes to the protocol*. We used filtering options in clinical trial registries according to adult participants. Inconsistent and insufficient reporting in included studies made identification of core components and coding of theory use and behaviour change taxonomy difficult. These coding frameworks and taxonomies were developed primarily for the general population and focused on motivational influences. Thus, it made the process difficult and subjective. Caution must be observed when interpreting and generalising findings from non-RCTs, especially case-control studies which included the general population without learning disabilities. Moreover, only limited number of RCTs with weight management outcomes could be pooled in our analysis. The pairwise meta-analysis, which assumed homogeneity and lumped all interventions, and TAU may have introduced heterogeneity, but it was done to maximise the limited data for meta-analysis. The reporting inconsistency also impacted our ability to include individual BCTs as a component in CNMA. The CNMA was unable to identify the optimum combination of components which enhanced effectiveness in interventions. However, it provides us with the foundation to explore its application in this field.

Consequently, the limited available literature may have inhibited meaningful conclusions to be made for specific lifestyle behaviours. Nevertheless, the overarching findings of the study focus on considerations for people developing lifestyle interventions for adults with learning disabilities and can be applied to multiple lifestyle behaviours. Although efforts were made to expand the searches in the realist synthesis, most of the studies were focused on people with mild to moderate learning disabilities. This may have resulted in some unique barriers for people with severe or profound learning disabilities being missed. However, the logic model and overarching programme theory emphasised the importance of considering the level of learning disabilities when developing interventions.

Due to COVID-19, the PPI meetings were restricted to Zoom meetings. Although this can make it more accessible for people living further away, it can restrict accessibility for people with learning disabilities. Research has indicated that some people with learning disabilities may have limited access to the internet or computers, which may have prevented some people from being involved.[207] Moreover, our PPI group did not include family and paid caregivers.

Future priorities and recommendations

Key research recommendations:

1. Codevelop new research studies with people living with learning disabilities. There needs to be greater reflection on how to make methods more accessible to improve the inclusion of adults with severe and profound learning disabilities in research.
2. Undertake research to codevelop population-specific materials, including new frameworks for assessing extent of theory and behaviour change taxonomies used in development of interventions.
3. Undertake research to address variability in methodologies used in assessing effectiveness of interventions in research studies. This includes designing high-quality studies with appropriate outcomes.
4. Undertake more qualitative and mixed-method research to improve understanding of what works, for whom and why.

Key recommendations for policy and practice:

5. New lifestyle interventions need to be co-designed with people living with intellectual disabilities and their caregivers.
6. There is unlikely to be a one-size-fits-all approach; instead, a more holistic, person-centred approach is required that addresses root causes, is tailored to individual contexts and codeveloped with the individual and their carers.
7. Communications should be clear, simple, precise and codeveloped with the target audience.
8. Future interventions should include peer support, fun, group-based activities and opportunities for social interaction. All of which can offer important, far-reaching benefits such as improved well-being and quality of life, which should be considered as part of a person-centred, compassionate approach to long-term care and measured accordingly.

Patient and public involvement

All involvement of people with learning disabilities was through the non-profit organisation, People First Scotland. People First is an organisation that helps give people with learning disabilities a voice, advocates for their rights and is controlled by people with learning disabilities. Our PPI group consisted of four members (two males and two females) with mild learning disabilities: the PPI co-applicant (male) and a staff member (female) who supported the group during the course of the project.

We hosted regular meetings with the PPI group. A total of four PPI meetings were held. Due to the COVID-19 pandemic, all meetings were conducted online. Easy-read presentations were developed using photo symbols as visual aids to facilitate discussions. The PPI group was involved in giving feedback on preliminary and main findings, including contributing to the development of an initial programme theory that was used for the realist synthesis. This was particularly important for the realist synthesis to determine what was relevant and important to adults with learning disabilities. The PPI group also ensured that the interpretation of the findings accurately reflected the lived experiences of adults with learning disabilities. Additionally, both the research team and the steering group included members with learning disabilities, who provided invaluable feedback on all aspects of the synthesis. Anonymised meeting minutes which show a broad range of topics discussed are available in *Appendix 10*.

Following are some comments from our PPI group members who coproduced this piece of research:

> *'It is good to have the opportunity to talk about my experiences and also talk about the experiences some of the other members we represent have had. Some people have had no opportunities to talk about or get involved in issues to do with their health. This is particularly true of people who live in institutions'.*
>
> *'Some people have lost the support workers they used to have and that stops them having the opportunities to do health related activities'.*
>
> *'During Covid, lots of people have not been able to get out and exercise or attend health programmes, so this project couldn't have come at a better time'.*
>
> *'It is good that the researchers are asking people with lived experience what we think'.*
>
> *'The researchers were good at explaining things which can be complicated to understand'.*
>
> *'Presentations from the researchers helped to explain the project and its progress. Slides were easy to understand, and we could ask questions and comment on the issues raised'.*
>
> *'Questions asked by the researchers helped those there to think about feedback to give on. We were asked, for instance, about suggested ways to get the findings out in various ways once published'.*

Equality, diversity and inclusion

Our project is on people with learning disabilities. Our evidence has endeavoured to specifically look for characteristics that assess equality, diversity and inclusion in the existing literature. In the reviewed studies, participants who belonged to ethnicities other than Caucasian, who were older than 65 years, who had long-term medical conditions and who have severe to a profound levels of learning disabilities were under-represented. Codevelopment of interventions with people with lived experiences and consideration of participant characteristics by study investigators might have prevented this. In collaboration with organisations that support people with learning disabilities (People First Scotland), we have taken active steps in involving our PPI group during the research process. This includes production of easy-to-read materials. The PPI group was balanced in terms of representation. Similarly, our research group includes our PPI representative and researchers with wide range of experience and expertise, including those who are in the early career stage. Our research group has good representation in terms of age, gender and ethnicity.

Additional information

Contributions of authors

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Patient data statement

This research does not use any patient data.

Data-sharing statement

All data requests should be submitted to the corresponding author for consideration. Access to available anonymised data may be granted following review.

Ethics statement

This research did not require any ethical approval.

Information governance statement

This study was a systematic review of published studies. All synthesis was performed at study level. No individual participant data or personal information were sourced for this study.

Disclosure of interests

Full disclosure of interests: Completed ICMJE forms for all authors, including all related interests, are available in the toolkit on the NIHR Journals Library report publication page at https://doi.org/10.3310/BSTG4556.

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Appendix 1 Search strategies

Applied Social Sciences Index and Abstracts (ASSIA) via ProQuest

MAINSUBJECT.EXACT.EXPLODE("Intellectual functioning") OR MAINSUBJECT.EXACT.EXPLODE("Developmental disorders") OR MAINSUBJECT.EXACT.EXPLODE("Learning disabilities") OR ab(((Learn* OR development* OR mental* OR intellect* OR cognitv*) NEAR/2 (disab* OR disorder* OR deficien* OR difficult* OR impair* OR handicap* OR retard* OR sub*normal* OR challenge*)) OR (cretin* OR "feeble minded*" OR imbecil* OR moron*))AND MAINSUBJECT.EXACT.EXPLODE("Smoking") OR MAINSUBJECT.EXACT.EXPLODE("Alcohol consumption") OR MAINSUBJECT.EXACT.EXPLODE("Diet") OR MAINSUBJECT.EXACT.EXPLODE("Sedentary") OR MAINSUBJECT.EXACT.EXPLODE("Obesity") OR ab((smok* OR tobacco* OR cigarette*) OR (alcohol* OR drink* OR ethanol*) OR (unhealth* NEAR/2 (food* OR diet*)) OR (sedentar* OR inactiv*) OR ((sit OR sedentar*) NEAR/2 time) OR (weight NEAR/2 (over OR excess*)) OR (obes*)) AND ab((interven* or program* or therap* or counsel* or educat*) or ((life*style* or behavio*r*) near/2 (modif* or interven* or change*)) or (health near/2 (education* or promotion*)) or ((smok* or tobacco) near/2 (cessation* or prevent* or reduc*)) or ((diet* or nutrition*) near/2 (educat* or guide* or habit* or health*)) or (calori* near/2 (control* or reduc* or restrict*)) or ((nutri* or food or carb* or protein* or fat*) near/2 intake) or (time restrict* feed*) or (energy balance*) or (exercise*) or (physical* activ*) or (Weight near/2 (loss or reduc* or manage*)) or (health* weight*)) OR MAINSUBJECT.EXACT.EXPLODE("Health promotion") OR MAINSUBJECT.EXACT.EXPLODE("Health education") OR MAINSUBJECT.EXACT.EXPLODE("Cognitive behavioural counselling") OR MAINSUBJECT.EXACT.EXPLODE("Counselling") OR (MAINSUBJECT.EXACT.EXPLODE("Low calorie diet") OR MAINSUBJECT.EXACT.EXPLODE("Low fat diet")) OR MAINSUBJECT.EXACT.EXPLODE("Physical activity") OR MAINSUBJECT.EXACT.EXPLODE("Weight loss")

Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO Host

S42	S39 AND S40 AND S41
S41	S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38
S40	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16
S39	S1 OR S2 OR S3 OR S4
S38	TX "weight* loss*" or "weight reduc*" or "weight manage*" or "health* weight*" or "obes* manage*"
S37	(MH "Weight Loss+")
S36	TX(gym* or circuit* or aqua* or walk* or jog* or run* or swim* or weight* lift* or (strength or resist* or circuit* or aerobic*)) AND train*
S35	TX (Moderat* or vigo#r*) AND TX ("physical activ*" or exercis* or train*)
S34	TX "physical* activ*" or "exercise*" or "aerobic* exercise*" or "exercise* train*" or "exercise fit*" or "exercise activ*" or "exercis* endur*"
S33	(MH "Sports+")
S32	(MH "Exercise+")
S31	(MH "Physical Activity")
S30	TX "nutrition* intake" or "food* intake" or "carb* intake" or "protein* intake" or "fat* intake" or "nutrition* educat*" or "nutrition* guide*" or "nutrition* habit*"
S29	TX "diet* educat*" or "diet* guide*" or "diet* habit*"
S28	TX "health* diet*" or "weight* diet*" or "health* diet*" or "weight* diet*" or "calori* control*" or "calori* reduc*" or "calori* restrict*" or "portion* size*" or "serving* size*"

S27	(MH "Diet+")
S26	TX "tobacco cessat*" or "tobacco stop" or "tobacco reduc*" or "tobacco prevent*" or "nicotine replace* therap*"
S25	TX "smok* cessation" or "smok* reduc*" or "smok* prevent*" or "relapse prevention"
S24	(MH "Smoking Cessation") OR (MH "Smoking Cessation Programs")
S23	TX "health* promotion*" or "health* education*" or "psycho#education*" or "counseling session*"
S22	TX "behavio#r therap*" or "behavio#r* technique*" or "psychotherapy session*"
S21	TX (life#style or behavio#r) AND TX (chang* or modif* or interven*)
S20	TX interven* or program*
S19	(MH "Preventive Health Care+") OR (MH "Health Promotion+") OR (MH "Health Education+")
S18	(MH "Cognitive Therapy+") OR (MH "Psychotherapy+") OR (MH "Counseling+")
S17	(MH "Life Style Changes")OR (MH "Behavioral Changes")
S16	TX "over weight" or "excess weight"
S15	(MH "Obesity+")
S14	TX "sedentar*" or "sedentar* life#style*" or "sedentar* behavio#r*" or "passive life#style*" or "passive behavio#r*" or "passive life#style*" or "passive behavio#r*" or "inactiv*" or "inactiv* life#style*" or "inactiv* behavio#r*" or "physical* inactiv*" or "sit* time" or "sedentar* time"
S13	(MH "Life Style, Sedentary+")
S12	TX unhealth* food* or diet*
S11	TX ("unhealth* food*" or "unhealth* diet*") AND TX (habit or consum*)
S10	TX (Alcohol or ethanol) AND TX (us* or consum* or drink* or misuse*)
S9	TX "problem* drink*" or "harm* drink*" or "hazard* drink*" or "depend* drink*" or "binge drink*" or "drink* behavio#r*" or "drink* habit*"
S8	TX alcohol*
S7	(MH "Alcohol Drinking+")
S6	TX "smok* behavio#r*" or "smok* habit*" or "smok* us*" or "smok* consum*" or "tobacco* smok*" or "smok* cigarette*"
S5	(MH "Tobacco+") OR (MH "Smoking+')
S4	TX cretin* or "feeble minded*" or imebecil* or moron*
S3	TX "intellectual* disab*" or "intellectual* disorder*" or "intellectual* deficien*" or "intellectual* difficult*" or "intellectual* impair" or "intellectual* handicap*" or "intellectual* retard*" or "intellectual* sub#normal*" or "intellectual* challenge*"
S2	TX "learning disab*" or "learning disorder*" or "learning deficien*" or "Learning difficult*" or "learning impair*" or "learning handicap*" or "learning retard*" or "sub#normal* learning" or "learning challenge*"
S1	(MH "Intellectual Disability+") OR (MH "Developmental Disabilities") OR (MH "Learning Disorders+") OR (MH "Learning Disabilities+")

Ovid EMBASE 1947 to Present, updated daily

1	exp developmental disorder/or exp learning disorder/
2	exp intellectual impairment/or exp intellectual disability/
3	((learn* or development* or mental* or intellect* or cognitv*) adj2 (deficien* or disab*or disorder* or deficien* or difficult* or impair* or handicap* or retard* or sub?normal* or challenge*)).tw.
4	(cretin* or feeble minded* or imbecil* or moron*).tw.
5	exp smoking/or exp cigarette smoking/

6	((smok* adj2 (behavio?r or habit* or us* or consum*)) or (tobacco or cigarette)).tw.
7	exp binge drinking/or exp alcohol consumption/
8	((alcohol or ethanol or drink*) adj2 (problem* or harm* or hazard* or depend* or binge or us* or consum* or misuse* or behavio?r or habit*)).tw.
9	exp unhealthy diet/
10	(unhealth* adj2 (food or diet*) adj2 (habit* or consum*)).tw.
11	exp sedentary time/or exp sedentary lifestyle/
12	((sedentary or passive or inactive or physical*) adj2 (life?style* or behavio?r* or liv* or li?e or time)).tw.
13	exp obesity/
14	((over or excess) adj2 weight).tw.
15	exp behavior change/or exp lifestyle modification/
16	exp behavior therapy/or exp cognitive behavioral therapy/or exp psychotherapy/or exp family therapy/or exp counseling/
17	((life?style* or behavio?r*) adj2 (modif* or interven* or change* or program*)).tw.
18	((behavio?r* or cogniti* or CBT or psycho?therap* or psycho?educat or psycho?social or counsel*) adj2 (session* or therap* or technique* or modif* or interven* or change*)).tw.
19	(health* adj2 (promot* or educat* or life?style*)).tw.
20	exp health promotion/or exp health education/
21	exp smoking cessation/
22	((tobacco or smok* or nicotine or replace* or relapse) adj2 (cessat* or stop or reduc* or prevent* or therap*)).tw.
23	exp diet therapy/or exp caloric restriction/or exp low fat diet/or exp low carbohydrate diet/or exp portion size/or exp nutritional support/
24	(health* adj2 (diet* or weight)).tw.
25	((calorie* or portion* or serv* or size*) adj2 (control* or reduc* or restrict*)).tw.
26	((diet* or nutri* or food or carb* or protein* or fat*) adj2 (educat* or guide* or habit* or intake)).tw.
27	exp physical activity/or exp exercise/
28	(interven* adj2 (physic* or exercise*)).tw.
29	((moderat* or vigo?r*) adj2 (activit* or exercise* or train*)).tw.
30	((exercise* or physic*) adj2 (aerobic* or train* or fit* or active* or endur*)).tw.
31	((gym* or circuit* or aqua* or walk* or jog* or run* or swim* or weight* lift* or (strength or resist* or circuit* or aerobic*)) adj2 train*).tw.
32	exp body weight loss/
33	((health or weight or obes*) adj2 (loss or reduc* or manage*)).tw.
34	or/1-4
35	or/5-14
36	or/15-33
37	34 and 35 and 36

Ovid MEDLINE (R) 1946 to January 2021

1	((development* or learn*) adj2 disorder*).tw.
2	exp intellectual disability/
3	((learn* or development* or mental* or intellect* or cognitv*) adj2 (deficien* or disab*or disorder* or deficien* or difficult* or impair* or handicap* or retard* or sub?normal* or challenge*)).tw.
4	(cretin* or feeble minded* or imbecil* or moron*).tw.
5	exp smoking/or exp cigarette smoking/
6	((smok* adj2 (behavio?r or habit* or us* or consum*)) or (tobacco or cigarette)).tw.
7	exp binge drinking/or exp alcohol consumption/
8	((alcohol or ethanol or drink*) adj2 (problem* or harm* or hazard* or depend* or binge or us* or consum* or misuse* or behavio?r or habit*)).tw.
9	(unhealth* adj2 (food or diet*) adj2 (habit* or consum*)).tw.
10	exp sedentary time/or exp sedentary lifestyle/
11	((sedentary or passive or inactive or physical*) adj2 (life?style* or behavio?r* or liv* or li?e or time)).tw.
12	exp obesity/
13	((over or excess) adj2 weight).tw.
14	exp behavior therapy/or exp cognitive behavioral therapy/or exp psychotherapy/or exp family therapy/or exp counseling/
15	((life?style* or behavio?r*) adj2 (modif* or interven* or change* or program*)).tw.
16	((behavio?r* or cogniti* or CBT or psycho?therap* or psycho?educat or psycho?social or counsel*) adj2 (session* or therap* or technique* or modif* or interven* or change*)).tw.
17	(health* adj2 (promot* or educat* or life?style*)).tw.
18	exp health promotion/or exp health education/
19	exp smoking cessation/
20	((tobacco or smok* or nicotine or replace* or relapse) adj2 (cessat* or stop or reduc* or prevent* or therap*)).tw.
21	exp diet therapy/or exp caloric restriction/or exp low fat diet/or exp low carbohydrate diet/or exp portion size/or exp nutritional support/
22	(health* adj2 (diet* or weight)).tw.
23	((calorie* or portion* or serv* or size*) adj2 (control* or reduc* or restrict*)).tw.
24	((diet* or nutri* or food or carb* or protein* or fat*) adj2 (educat* or guide* or habit* or intake)).tw.
25	exp physical activity/or exp exercise/
26	(interven* adj2 (physic* or exercise*)).tw.
27	((moderat* or vigo?r*) adj2 (activit* or exercise* or train*)).tw.
28	((exercise* or physic*) adj2 (aerobic* or train* or fit* or active* or endur*)).tw.
29	((gym* or circuit* or aqua* or walk* or jog* or run* or swim* or weight* lift* or (strength or resist* or circuit* or aerobic*)) adj2 train*).tw.
30	((fat or body or weight) adj2 loss).tw.
31	((health or weight or obes*) adj2 (loss or reduc* or manage*)).tw.
32	or/1-4
33	or/5-13
34	or/14-31
35	32 and 33 and 34

APA PsycINFO via EBSCO Host

S44	S41 AND S42 AND S43
S43	S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40
S42	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17
S41	S1 OR S2 OR S3 OR S4
S40	TX "weight* loss*" or "weight reduc*" or "weight manage*" or "health* weight*" or "obes* manage*"
S39	DE "Weight Loss"
S38	TX(gym* or circuit* or aqua* or walk* or jog* or run* or swim* or weight* lift* or (strength or resist* or circuit* or aerobic*)) AND train*
S37	TX (Moderat* or vigo#r*) AND TX ("physical activ*" or exercis* or train*)
S36	TX "physical* activ*" or "exercise*" or "aerobic* exercise*" or "exercise* train*" or "exercise fit*" or "exercise activ*" or "exercis* endur*"
S35	DE "Sports" OR DE "Physical Activity" OR DE "Exercise"
S34	TX "nutrition* intake" or "food* intake" or "carb* intake" or "protein* intake" or "fat* intake" or "nutrition* educat*" or "nutrition* guide*" or "nutrition* habit*"
S33	TX "diet* educat*" or "diet* guide*" or "diet* habit*"
S32	TX "health* diet*" or "weight* diet*" or "health* diet*" or "weight* diet*" or "calori* control*" or "calori* reduc*" or "calori* restrict*" or "portion* size*" or "serving* size*"
S31	DE "Weight Control"
S30	TX "tobacco cessat*" or "tobacco stop" or "tobacco reduc*" or "tobacco prevent*" or "nicotine replace* therap*"
S29	TX "smok* cessation" or "smok* reduc*" or "smok* prevent*" or "relapse prevention"
S28	DE "Smoking Cessation"
S27	DE "Health Education" OR DE "Drug Education" OR DE "Public Health Campaigns"
S26	TX "health* promotion*" or "health* education*" or "psycho#education*" or "counseling session*"
S25	TX "behavio#r therap*" or "behavio#r* technique*" or "psychotherapy session*"
S24	TX (life#style or behavio#r) AND TX (chang* or modif* or interven*)
S23	TX interven* or program*
S22	DE "Counseling" OR DE "Community Counseling" OR DE "Cross Cultural Counseling" OR DE "Educational Counseling" OR DE "Genetic Counseling" OR DE "Group Counseling" OR DE "Peer Counseling"OR DE "Psychotherapeutic Counseling" OR DE "Rehabilitation Counseling"
S21	DE "Group Psychotherapy" OR DE "Guided Imagery" OR DE "Gestalt Therapy" OR DE "Psychodynamic Psychotherapy" OR DE "Psychotherapeutic Counseling" OR DE "Psychotherapeutic Techniques" OR DE "Psychotherapy" OR DE "CBT" OR DE "Cognitive Behaviour Therapy" OR DE "Behaviour therapy"
S20	DE "Cognitive Behavior Therapy" OR DE "Acceptance and Commitment Therapy" OR DE "Cognitive Processing Therapy" OR DE "Prolonged Exposure Therapy"
S19	DE "Behavior Change" OR DE "Readiness to Change" OR DE "Stages of Change"
S18	DE "Lifestyle Changes"
S17	TX "over weight" or "excess weight"
S16	DE "Overweight" OR DE "Obesity"
S15	TX "sedentar*" or "sedentar* life#style*" or "sedentar* behavio#r*" or "passive life#style*" or "passive behavio#r*" or "passive life#style*" or "passive behavio#r*" or "inactiv*" or "inactiv* life#style*" or "inactiv* behavio#r*" or "physical* inactiv*" or "sit* time" or "sedentar* time"

S14	DE “Sedentary Behavior”
S13	TX “unhealth* food*” or diet*
S12	TX (“unhealth* food*” or “unhealth* diet*”) AND TX (habit or consum*)
S11	DE “Diets” OR DE “Weight Control”
S10	TX (Alcohol or ethanol) AND TX (us* or consum* or drink* or misuse*)
S9	TX “problem* drink*” or “harm* drink*” or “hazard* drink*” or “depend* drink*” or “binge drink*” or “drink* behavio#r*” or “drink* habit*”
S8	TX alcohol*
S7	DE “Alcohol Drinking Patterns” OR DE “Binge Drinking” OR DE “Social Drinking” OR DE “Underage Drinking”
S6	TX “smok* behavio#r*” or “smok* habit*” or “smok* us*” or “smok* consum*” or “tobacco* smok*” or “smok* cigarette*”
S5	DE “Tobacco Smoking” OR DE “Electronic Cigarettes” OR DE “Passive Smoking” OR DE “Smokeless Tobacco”
S4	TX cretin* or “feeble minded*” or imebecil* or moron*
S3	TX “intellectual* disab*” or “intellectual* disorder*” or “intellectual* deficien*” or “intellectual* difficult*” or “intellectual* impair” or “intellectual* handicap*” or “intellectual* retard*” or “intellectual* sub#normal*” or “intellectual* challenge*”
S2	TX “learning disab*” or “learning disorder*” or “learning deficien*” or “learning difficult*” or “learning impair*” or “learning handicap*” or “learning retard*” or “sub#normal* learning” or “learning challenge*”
S1	DE “Intellectual Development Disorder” OR DE “Developmental Disabilities” OR DE “Learning Disorders” OR DE “Learning Disabilities” OR DE “Reading Disabilities”

Cochrane Central Register of Controlled Trials (CENTRAL)

– https://www.cochranelibrary.com/central

1	((learn* or development* or mental* or intellect* or cognitv*) NEAR/2 (deficien* or disab* or disorder* or deficien* or difficult* or impair* or handicap* or retard* or sub?normal* or challenge*)):ti,ab,kw
2	((development* or learn*) NEAR/2 disorder*):ti,ab,kw
3	(cretin* or feeble minded* or imbecil* or moron*):ti,ab,kw
4	MeSH descriptor: [Intellectual Disability] explode all trees
5	#1 or #2 or #3
6	MeSH descriptor: [Smoking] explode all trees
7	(smok* NEAR/2 (behavio?r or habit* or us* or consum*)):ti,ab,kw
8	(smok* NEAR/2 (tobacco or cigarette)):ti,ab,kw
9	MeSH descriptor: [Alcohol Drinking] explode all trees
10	((alcohol or ethanol or drink*) NEAR/2 (problem* or harm* or hazard* or depend* or binge or us* or consum* or misuse* or behavio?r or habit*)):ti,ab,kw
11	MeSH descriptor: [Diet] explode all trees
12	(unhealth* NEAR/2 (food or diet*)):ti,ab,kw
13	MeSH descriptor: [Sedentary Behavior] explode all trees
14	((sedentary or passive or inactive or physical*) NEAR/2 (life?style* or behavio?r* or liv* or li?e or time or activ*)):ti,ab,kw
15	MeSH descriptor: [Obesity Management] explode all trees
16	((over or excess) NEAR/2 weight):ti,ab,kw

17	#6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16
18	(adult*):ti,ab,kw
19	#5 and #17 and #18743

U.S. National Library of Medicine ClinicalTrials.gov

https://clinicaltrials.gov/

Filters: Adult, Older Adult

Learning disabilities OR learning difficulty OR developmental disabilities OR developmental disorder OR mental retardation OR cognitive impairment OR intellectual disability | Lifestyle OR behavioral OR behaviour OR health OR physical activity OR exercise OR sport OR sedentary OR nutrition OR diet OR smoking OR cigarette OR tobacco OR alcohol OR weight OR obesity

International Standard Randomised Controlled Trials Number (ISRCTN)

https://www.isrctn.com/

Filters: Participant age range, Adult

("Intellectual disability") OR ("intellectual disabilities") OR ("learning disability") OR ("learning disabilities") OR ("learning difficulty") OR ("developmental disability") OR ("developmental disorder") OR ("mentally retarded") OR ("mental retardation") OR ("cognitive impairment")

Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre)

https://eppi.ioe.ac.uk/cms/

"intellectual disabilities" OR "learning disabilities" OR "mental retardation" OR "developmental disabilities" OR "developmental disorder" OR "cognitive impairment" OR "learning difficulties"

Google Scholar

https://scholar.google.com/

("Learning disabilities" OR "learning difficulty" OR "developmental disabilities" OR "developmental disorder" OR "mental retardation" OR "cognitive impairment") AND ("Intellectual Disability") AND ("Lifestyle" OR "behavioural" OR "behaviour" OR "health" OR "physical activity" OR "exercise" OR "sport" OR "sedentary" OR "nutrition" OR "diet" OR "smoking" OR "cigarette" OR "tobacco" OR "alcohol" OR "weight" OR "obesity")

Appendix 2 WINBUGS code for component network meta-analysis using the additive model

```
model{
for(i in 1:Ntrials){                    #   LOOP THROUGH STUDIES
   w[i,1] <- 0                                          # adjustment for multi-arm trials is zero for control arm
   delta[i,1] <- 0                                      # treatment effect is zero for control arm
   mu[i] ~ dnorm(0,.0001)                               # vague priors for all trial baselines

   for (k in 1:na[i]) {                                 #  LOOP THROUGH ARMS
      prec[i,k] <- n[i,k]/pow(sd[i,k],2)                # set precisions
      y[i,k] ~ dnorm(theta[i,k],prec[i,k])              # normal likelihood
      theta[i,k] <- mu[i] + delta[i,k]                  # model for linear predictor

#Deviance contribution
            dev[i,k] <- (y[i,k]-theta[i,k])*(y[i,k]-theta[i,k])*prec[i,k]
 }
#  summed residual deviance contribution for this trial
            resdev[i] <- sum(dev[i,1:na[i]])
# LOOP THROUGH ARMS
            for (k in 2:na[i]) {
                  # trial-specific treatment effect distributions
            delta[i,k] ~ dnorm(md[i,k],taud[i,k])
                  # mean of treatment effect distributions, with multi-arm trial correction
            md[i,k] <-  d[2]*E[i, k] + d[3]*B[i, k] + d[4]*DA[i, k] + d[5]*EDD[i, k] + d[6]*ID[i, k] + d[7]*S[i, k] + sw[i,k]
                  # precision of treatment effect distributions (with multi-arm trial correction)
            taud[i,k] <- tau *2*(k-1)/k
                  # adjustment, multi-arm RCT
            w[i,k] <- delta[i,k] - (d[2]*E[i, k] + d[3]*B[i, k] + d[4]*DA[i, k] + d[5]*EDD[i, k] + d[6]*ID[i, k] + d[7]*S[i, k]) + d[1]
# cumulative adjustment for multi-arm trials
            sw[i,k] <- sum(w[i,1:k-1])/(k-1)
            }
            }
 #total residual deviance
            totresdev <- sum(resdev[])
# treatment effect is zero for control arm
            d[1]<-0
# vague priors for treatment effects - loop through treatments
            for (k in 2:nt){
                  d[k] ~ dnorm(0,.0001)
            }
# vague prior for between-trial SD
            sdbt ~ dunif(0,9)

# between-trial precision = (1/between-trial variance)
            tau <- pow(sdbt,-2)

# Linear combinations of d for the additve effects of interventions
            dall[2] <- d[2]
            dall[3] <- d[3]
            dall[4] <- d[4]
            dall[5] <- d[5]
            dall[6] <- d[6]
            dall[7] <- d[2] + d[3]
            dall[8] <- d[2] + d[4]
            dall[9] <- d[3] + d[4]
            dall[10] <- d[4] + d[5]
            dall[11] <- d[4] + d[6]
            dall[12] <- d[2] + d[3] + d[4]
          dall[13] <- d[2] + d[3] + d[5]
            dall[14] <- d[2] + d[3] + d[6]
            dall[15] <- d[2] + d[4] + d[7]
            dall[16] <- d[2] + d[5] + d[6]
            dall[17] <- d[3] + d[4] + d[7]
            dall[18] <- d[2] + d[3] + d[4] + d[7]
            dall[19] <- d[3] + d[4] + d[5] + d[6]
}
```

Appendix 3 More detailed summary of the process of developing a draft programme theory

Detailed notes on the methods.

Phase 1 – September to November 2020 (finished December 2020)

A rough programme theory was developed by quickly searching the literature and identifying relevant articles that could inform the programme theory. Articles included lifestyle (physical activity, sedentary behaviour, diet, alcohol and smoking) modification interventions for adults with learning disabilities, process evaluations, feasibility studies and broader qualitative/mixed-methods studies.

Throughout these stages, papers were saved to referencing software based on relevance to programme theory after quickly reading the title or abstract. There were no systematic eligibility criteria and included a range of methodologies and topic areas. Papers that were most relevant based on title were prioritised, and any relevant papers had citation searches. A data extraction Excel spreadsheet was used to organise the data.

As this was a time-sensitive process, after data extraction from 52 relevant papers relating to lifestyle behaviours of adults with learning disabilities including interventions, process evaluations, qualitative and mixed-methods studies had been conducted, the findings were quickly summarised. Broad themes were identified to develop draft context–mechanism–outcome configurations and an initial programme theory.

Following this, the draft programme theory was presented in an easy-read format to the PPI group of adults with intellectual disabilities for feedback and to identify other important issues to include. It was presented to three experts (research in relevant areas), and questions were asked relating to processes leading to poor health/unhealthy lifestyles, and facilitators of behaviour change that may also be of importance.

Throughout this process, there were bi-weekly discussions with an overseeing/more experienced researcher to guide the search process. After a draft programme theory was developed, a PPI group and researchers in the broader research team were consulted.

Summary of the search process:

1. Forward citation searching and related article searches were conducted on Google Scholar for interventions already known to the research team conducting this study to identify potentially relevant process evaluations, follow-up qualitative papers or related articles. This included studies identified when conducting initial scoping searches while developing the NIHR protocol.
2. A scoping title-abstract-key terms search was conducted on Scopus in September 2020. Scopus was searched as it was a large database covering science, medicine and social sciences. Title and abstracts were quickly read through on the database, and articles were downloaded and saved if potentially relevant. The search identified *n* = 2431 and *n* = 81 were saved.

(TITLE-ABS-KEY (“intellectual* disab*” OR “learning* disab*” OR “mental* retard*” OR “development* disab*”)) AND (TITLE-ABS-KEY (“lifestyle behav*” OR “health behav*” OR “lifestyle modification” OR inactiv* OR sedentar* OR alcohol* OR diet* OR smok* OR “physical* activ*”)) AND (LIMIT-TO (EXACTKEYWORD, “Adult”))

3. It was observed that most studies related to physical activity or diet, so a search was conducted on Google Scholar for papers that had the terms alcohol/smoking and intellectual disabilities in their title.
4. Papers identified from a previous scoping search of lifestyle modification interventions (provided by Leanne) were included if they were relevant data to the programme theory.

5. To get a good understanding of contexts and mechanisms, the search was broadened to consider qualitative or mixed-methods research area in the topic area – not restricted to intervention studies. Papers citing learning or intellectual disabilities were searched in the journals of Sociology of health and illness, and social science and medicine.
6. Papers were also searched through qualitative researchers in the field of disability, including Prof Sara Ryan and Prof Andrew Jahoda.
7. This was then followed by searches in PsycINFO for papers with the terms of intellectual disabilities and social cognitive theory and transtheoretical model in the abstract (as social cognitive theory was the core theory reported in the interventions identified). This was followed by a search including terms for intellectual disabilities, health promotion and qualitative research terms within the abstract.
8. Reference lists of relevant systematic reviews (e.g. Willems *et al.* 2018) were hand-searched.

Appendix 4 Draft programme theory

CMOC	Summary	CMOC colour key
Processes leading to ill health and unhealthy lifestyles		Original draft
CMOC 1: Neighbourhood effects	Living in a neighbourhood with increased availability of, exposure to, and options for unhealthy lifestyle choices (context), and reduced availability of accessible resources/facilities (context) contributes to decreased motivation and perceived ability to engage in a healthy lifestyle (mechanism) resulting in unhealthy lifestyle choices and increased health risks (outcome)	Expert input
CMOC 2: Financial restrictions	People with learning disabilities may experience deprivation and financial restrictions (context)and be unable to afford healthy foods or activities (context) reducing their perceived ability to participate in a healthy lifestyle (mechanism) and increasing participation in unhealthy behaviours (outcome)	PPI input
CMOC 3: Perceived safety	Walking and some physical activities require going outside (context) people with learning disabilities may feel unsafe, vulnerable or anxious being outside (mechanism), especially at night (context). This results in less engagement in physical activity and increased health risks (outcome)	Reported both PPI and experts
CMOC 4: Social capital	People with learning disabilities have restricted social networks (Context) and experience reduced social capital (mechanism), and reduced opportunities to be supported to engage in healthy behaviours (mechanism) resulting in increased risk of unhealthy lifestyles and health risks (outcome)	
CMOC 5: Social norms	The lifestyle behaviours of peers and caregivers are observed (context) and copied/modelled (outcome) as the people with learning disabilities desire to fit in with the social norms and engage in the same behaviours (mechanism)	
CMOC 6: Caregiver/support person choices	People with learning disabilities may require support from (family and/or paid) caregivers (context 1). The caregivers may make unhealthy choices regarding food purchased and activities engaged in (context 2) reducing a person's opportunity to exercise autonomy and their perceived ability to engage in a healthy lifestyle (mechanism) resulting in engagement in unhealthy lifestyle behaviour and increased health risks (outcome)	
CMOC 7: exclusion from specific activities	People with learning disabilities may experience exclusion from certain physical activities (context) due to low baseline fitness levels, and not having the fundamental movement or motor skills (mechanism) also contributing to reduced perceived ability or self-efficacy to participate (mechanism), resulting in unhealthy lifestyles and greater risk of health outcomes (outcome)	
CMOC 8: Abstract nature of the relationship between behaviours and health	Concept of a healthy lifestyle and how this contributes to health outcomes is abstract (context). People with learning disabilities may not have the knowledge and skills to understand or process this information (mechanism) resulting in reduced understanding of the negative effects and consequences of a person's behaviours (outcome)	
CMOC 9: Enjoyment and personal preference	People have personal preferences for lifestyle choices based on enjoyment (context) resulting in increased motivation (mechanism) and participation in a lifestyle behaviour (outcome)	
Facilitating lifestyle behaviour change		
Importance of the social environment		
CMOC 10: Social connectedness	Interventions that include a social or group component (context) can foster a sense of belonging in participants with learning and their paid caregivers (mechanism 1). This can increase enjoyment (mechanism) and promote engagement with the intervention (outcome).	
CMOC 11: Social norms in a group-based activity	Interventions that include a social or group component targeting behaviours of all members of the group (context), can increase behaviour change among participants (outcome), as participants will observe the behaviour change in others and model their own behaviours to reflect the social norm (mechanism)	

CMOC	Summary	CMOC colour key
CMOC 12: Modelling behaviours and targeting others' behaviours	Interventions that target the lifestyle behaviours of promote healthier choices of peers and caregivers (context) result in the healthier lifestyle behaviours being copied/modelled (outcome) as the people with learning disabilities desire to fit in with the social norms and engage in the same behaviours (mechanism)	
CMOC 13: Interventions including social support from caregivers	Interventions that rely on social support from caregivers (context) can result in varying levels of success (outcome) as caregivers may not have the skills, knowledge or confidence in their ability to promote a lifestyle behaviour/ behaviour change (mechanism)	
CMOC 14: Targeting caregiver knowledge	Caregivers or supports with increased knowledge of healthy lifestyles and behaviour change skills (context) will be more motivated to support people with learning disabilities to engage in a healthy lifestyle (outcome) due to their increased confidence and self-efficacy to promote a healthy lifestyle (mechanism).	
CMOC 15: Working schedules of paid caregivers	Paid caregivers may have limited time and busy schedules with less opportunity to support people with learning disabilities during an intervention (context 1). Interventions that are flexible, and work with managers to integrate it within the schedule of caregivers (context 2) could increase provision of support for a person with learning disabilities to engage with the intervention (outcome), due to a perception of reduce burden/stress and increased perceived ability to promote the lifestyle intervention (mechanism).	
CMOC 16: Work within the socioeconomic status of participants	Interventions that consider the socioeconomic background of participants and ensure the lifestyle activities promoted are financially accessible (context) may increase perceived ability to engage in the activities (mechanism) promoting adoption of healthier lifestyle activities (outcome)	
CMOC 17: Social environment within an accommodation setting	Interventions with multipoint recruitment strategies including people from diverse residential settings (context) and will include participants with different sources of social support (context 2). The varying levels of autonomy influences and perceived social support (mechanism) result in differential engagement with/ successfulness of the intervention (outcome).	
CMOC 18: Support in a group home setting	Interventions that include participants or are based in a group home setting (context) will rely on social support from support staff that are responsible for looking after multiple residents (context), support staff may not have the perceived ability, opportunities or capacity to support participants to engage in a lifestyle programme (mechanism) resulting in reduced social support and less successful engagement with the intervention content (outcome)	
CMOC 19: The cultural background of household	The ethnicity and wider culture of participant and their household should be considered (context) as social/cultural norms regarding activities and food (mechanism) will influence participation in lifestyle activities and engagement with an intervention (outcome)	
Essential to consider the abilities of people with learning disabilities		
CMOC 20: Accessible information and suitable methods	Interventions that provide concrete information and examples, with materials in an easy-read format and limited reliance on abstract concepts (context), participants can engage with and internalise the information (mechanism) and may have greater confidence using the materials (mechanism) resulting in more successful participation with the intervention content and more successful delivery of the programme (outcome).	
CMOC 21: Suitability of behaviour change techniques must be considered	Interventions that consider the cognitive abilities of people with learning disabilities (context) and use appropriate BCTs that do not use abstract concepts, such as rewards (context 2), ensure that people with learning disabilities have the knowledge, skills or capacity to understand, process and internalise the techniques (mechanism) resulting in the techniques being implemented correctly and more successful engagement with an intervention (outcome).	
CMOC 22: Validated measures	Interventions that do not use outcome measurements that have been validated for use with people with learning disabilities (context) may not accurately measure the outcome (outcome), as people with learning disabilities may not have the knowledge or skills to process and understand questions or instructions associated with the measure (mechanism)	

CMOC	Summary	CMOC colour key
CMOC 23: Must consider the abilities of all participants when using group-based methods	Group-based intervention activities including participants with diverse cognitive abilities (context 1), can have difficulties effectively administering the content (outcome). Some participants may require additional support (context 2), resulting in other participants feeling unsupported (mechanism 1). Additionally, material may be suitable and accessible for some participants, but not others (context 3). This may hinder the ability to effectively engage with the intervention (outcome 2) as participants do not have the necessary skills, knowledge or capacity to process the information.	
CMOC 24: Not considering physical abilities	Interventions that promote physical activities without considering the physical capabilities of participants with learning disabilities (context) may not be successful in achieving behaviour change (outcome) as participants may not have the necessary baseline fitness or motor skills to engage with the intervention content (mechanism)	
CMOC 25: Consider the physical abilities of participants when developing interventions	Interventions that promote accessible activities taking into consideration the physical capabilities of people with learning disabilities (context) can increase mastery of an activity, reduce the perceived difficulty and encourage positive experiences (mechanism 1). This increases self-efficacy and motivation to perform an activity (mechanism 2) resulting in increased participation in an intervention/successful behaviour change (outcome).	
Need to take into consideration the individual preferences of people with learning disabilities		
CMOC 26: Personal preferences to increase adherence	Interventions that take into consideration the personal preferences of people with learning disabilities when designing the intervention (contexts), can increase enjoyment and motivation to participate (mechanisms) resulting in better adherence to the intervention content (outcome).	
CMOC 27: Work within the routines	Failure of researchers to work with people with learning disabilities and their supports to fit the intervention within the daily established routines (context), can be stressful for the participant with learning disabilities and reduce their motivation to participate in an activity (mechanism), resulting in unsuccessful behaviour change (outcome).	
CMOC 28: Fun activities	Interventions that promote fun activities (context) will be more enjoyable and increase motivation to take part (mechanism) resulting in better engagement with an intervention.	
Work directly with people with learning disabilities		
CMOC 29: Include people with lived experiences in the design	Interventions that are designed using input from adults with learning disabilities and their supports (context) may be more feasible and successfully delivered (outcome), as people with learning disabilities and their supports have the lived experiences of people targeted by the intervention and will understand the needs, abilities, motivations and unique influences on participation (mechanism).	
CMOC 30: Tailored interventions	Interventions should be tailored to the individual needs of people with learning disabilities and the barriers they experience (context) to increase motivation, perceived ability and self-efficacy to take part (mechanism) and facilitate engagement/success of the intervention (outcome).	

Appendix 5 Final coding framework

Final coding framework	Files	References
Programme theory coding	79	767
Accessibility of intervention strategies	51	209
Having support to engage with strategies	9	14
Abstract nature of BCTs and the need for additional support	7	11
Measurement issues with people with learning disabilities	20	36
Abstract nature of measurement methods for outcome variables	13	18
Difficulties and discomfort using objective measurement devices	11	17
Ensuring delivery and materials are accessible and reflect communication abilities	21	48
Setting self-identified concrete and observable goals	13	17
Having people with learning disabilities set their own goals	7	8
Setting realistic goals	7	9
Self-monitoring can increase motivation but there are issues with measurement methods	5	8
Self-monitoring provides motivation and awareness	5	6
Rewards give a sense of pride and source of motivation	6	9
Concrete health education messages and active learning strategies for people with learning disabilities	26	66
Concrete information and active learning facilitate learning and add meaning	16	32
Difficulties processing abstract health promotion messages reduce motivation and cause confusion	14	26
New skills and knowledge improve motivation, self-efficacy and quality of life	6	7
Broader behavioural pathways	34	93
Unhealthy behaviours and mental health	8	14
Importance of a therapeutic rapport and ability to talk about issues	2	2
Unhealthy behaviour as maladaptive coping mechanism	7	12
Lifestyle behaviours modelled on others	9	13
Physical capabilities and health limitations	6	9
Safety concerns in the wider community	12	16
The wider environment is not supportive of lifestyle change	12	19
Financial limitations impacting resources and capacity to support	12	22
Intervention delivery	39	98
Fitting into routines of people with learning disabilities and caregivers	16	24
Incorporating strategies into daily routine	12	15
Negative affect over changing routines	4	8
Groups with different support needs and preferences can cause exclusion	9	21
Flexible intervention design that is tailored to individual needs	27	40

Final coding framework	Files	References
Including people with learning disabilities or care staff in intervention development	8	13
Negotiating balance between autonomy and behaviour change	37	109
Developing strategies to support healthy choice	7	11
Reduced autonomy and freedom of choice	22	47
Supports feel conflict between supporting freedom of choice and autonomy vs. promoting behaviour change	17	38
Respecting informed decisions and consent	8	13
Reliance on supports who encourage participation leading participants to feel pestered	5	5
Using additional strategies to ensure informed consent	6	8
Social connectedness and fun	22	49
Enjoyment and sticking together with peers – builds confidence and improves health behaviours	10	18
Group-based activities fostering enjoyment, motivation and improved confidence doing activities with others	5	7
Strategies to promote fun and enjoyment increase motivation and aid learning	10	15
Need for social inclusion and interaction	3	9
Support involvement	44	209
Knowledge, motivation and attitudes of caregivers influence ability to provide support	20	46
Low knowledge and limited opportunities for training	14	31
Support staff motivation and attitudes impacts health promotion	9	13
Paid support staff work pressures and burden	21	46
Staff burden, morale and disempowerment	4	5
Workload pressures and high staff turnover	21	41
Family caregivers can provide support out with paid support, but life pressures are a barrier to lifestyle change	5	5
Need for support and training for supporters	16	30
Need for external support and training to help paid staff promote behaviour change	14	26
Training increases collaboration and improves confidence	4	4
The importance of organisational and managerial support	5	11
Active social support necessary for positive outcome	18	32
Establishing communication pathways	20	39
Communication breakdown between multiple supporters	10	16
Develops increased awareness, support and shared goals	14	23

Appendix 6 Studies included in the systematic review

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Appendix 7 Coding for extent of theory use in the interventions

TABLE 17 Application of Michie's theory coding scheme on alcohol consumption and smoking studies

		Mendel *et al.*, 2002[71]	Forbat, 1999[72]
		Transtheoretical model	*Biopsychosocial model*
1	Theory/model of behaviour mentioned	✓	✓
2	Target construct mentioned as predictor of behaviour	✓	?
3	Intervention based on single theory	✓	✓
4	Theory/predictors used to select recipients of intervention	✓	x
5	Theory/predictors used to select/develop intervention techniques	✓	✓
6	Theory/predictors used to tailor intervention techniques to recipients	✓	✓
7	All intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	✓	?
8	At least one, but not all, of the intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	x	?
9	Group of techniques are linked to a group of constructs or predictors	x	?
10	All theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	✓	?
11	At least one, but not all of the theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	x	?
12	Theory-relevant construct mention in relation to the intervention measured		
a.	*Pre intervention*	✓	
b.	*Post intervention*	✓	
13	Quality of measures		
a.	*All theory-relevant measures had evidence of reliability*	?	-
b.	*At least one theory-relevant, but not all, evidence of reliability*	?	-
c.	*All measures of theory relevance previously validated*	?	-
d.	*At least one relevant previously validated*	?	-
e.	*Behaviour measure evidence of reliability*	?	-
f.	*Behaviour measure previously validated*	?	-
14	Randomisation		
a.	*Randomisation claimed*	x	x
b.	*Method of randomisation described*	-	-
c.	*Success tested*	-	-
d.	*Randomisation successful*	-	-
15	Changes in measures theory relevant	✓	-

TABLE 17 Application of Michie's theory coding scheme on alcohol consumption and smoking studies (*continued*)

		Mendel *et al.*, 2002[71]	Forbat, 1999[72]
16	Mediational analysis of constructs/predictors		
a.	*Mediator predicts DV*	-	-
b.	*Mediator predicts DV when controlling for IV*	-	-
c.	*Intervention does not predict DV*	-	-
d.	*Mediated effect statistically significant*	-	-
17	Results are discussed in terms of theoretical basis of intervention	✓	x
18	Appropriate support for the theory	✓	?
19	Results used to refine theory		
a.	*Constructs added or removed from theory*	x	x
b.	*Inter-relationships between theoretical constructs to be changed*	x	x

'✓' = Yes; 'x' = No; '?' = Don't know; '-' = Not applicable.

TABLE 18 Application of Michie's theory coding scheme on low physical activity only studies

		Heller *et al.*, 2004[82]	Melville *et al.*, 2015[83]	Van Schijndel-Speet *et al.*, 2017[91]	Yan *et al.*, 2015[104]
		Social cognitive theory; trans-theoretical model	*Trans-theoretical model*	*Social cognitive theory; theory of planned behaviour*	*Social cognitive theory*
1	Theory/model of behaviour mentioned	✓	✓	✓	?
2	Target construct mentioned as predictor of behaviour	✓	✓	✓	x
3	Intervention based on single theory	x	x	x	?
4	Theory/predictors used to select recipients of intervention	x	x	x	?
5	Theory/predictors used to select/develop intervention techniques	✓	✓	✓	?
6	Theory/predictors used to tailor intervention techniques to recipients	✓	✓	✓	?
7	All intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	✓	✓	✓	?
8	At least one, but not all, of the intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	✓	x	x	?
9	Group of techniques are linked to a group of constructs or predictors	?	x	x	?
10	All theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	?	x	?	?
11	At least one, but not all of the theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	✓	x	?	?

continued

TABLE 18 Application of Michie's theory coding scheme on physical activities only studies (*continued*)

		Heller *et al.*, 2004[82]	Melville *et al.*, 2015[83]	Van Schijndel-Speet *et al.*, 2017[91]	Yan *et al.*, 2015[104]
12	Theory-relevant construct mention in relation to the intervention measured				
a.	*Pre intervention*	✓	✓	✓	?
b.	*Post intervention*	✓	✓	x	?
13	Quality of measures				
a.	*All theory-relevant measures had evidence of reliability*	?	✓	-	-
b.	*At least one theory-relevant, but not all, evidence of reliability*	✓	✓	-	-
c.	*All measures of theory relevance previously validated*	?	✓	-	-
d.	*At least one relevant previously validated*	?	✓	-	-
e.	*Behaviour measure evidence of reliability*	-	✓	✓	✓
f.	*Behaviour measure previously validated*	-	✓	✓	✓
14	Randomisation				
a.	*Randomisation claimed*	✓	✓	✓	x
b.	*Method of randomisation described*	x	✓	✓	-
c.	*Success tested*	x	x	?	-
d.	*Randomisation successful*	?	✓	✓	-
15	Changes in measures theory relevant	?	✓	?	?
16	Mediational analysis of constructs/predictors				
a.	*Mediator predicts DV*	?	-	-	-
b.	*Mediator predicts DV when controlling for IV*	?	-	-	-
c.	*Intervention does not predict DV*	?	-	-	-
d.	*Mediated effect statistically significant*	?	-	-	-
17	Results are discussed in terms of theoretical basis of intervention	✓	x	x	x
18	Appropriate support for the theory	✓	?	?	?
19	Results used to refine theory				
a.	*Constructs added or removed from theory*	?	x	?	?
b.	*Inter-relationships between theoretical constructs to be changed*	?	x	?	?

'✓' = Yes; 'x' = No; '?' = Don't know; '-' = Not applicable.

TABLE 19 Application of Michie's theory coding scheme on multiple behaviour studies

		Bazzano *et al.*, 2009	**Lally-Beeken *et al.*, 2021**	**McDermott *et al.*, 2012**	**Marks *et al.*, 2013**	**Neumeier *et al.*, 2021**	**Pett *et al.*, 2013**	**Ptomey *et al.*, 2018, 2020**	**Marks *et al.*, 2019**	**Geller *et al.*, 2009**
		Social cognitive theory	*Social cognitive theory; control theory*	*Social cognitive theory*	*Social cognitive theory; transtheo-retical model*	*Stages of change model; person-centred theory; socioeco-logical model*	*Social cognitive theory*	*Social cognitive theory*	*Social cognitive theory; transthe-oretical model*	*Empowerment theory*
1	Theory/model of behaviour mentioned	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Target construct men-tioned as predictor of behaviour	✓	?	?	✓	x	✓	✓	✓	?
3	Intervention based on single theory	✓	x	✓	x	x	x	✓	x	✓
4	Theory/predictors used to select recipients of intervention	x	?	x	x	x	✓	✓	x	x
5	Theory/predictors used to select/develop interven-tion techniques	-	?	✓	✓	?	✓	✓	✓	✓
6	Theory/predictors used to tailor intervention techniques to recipients	x	?	?	✓	?	✓	✓	✓	?
7	All intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	✓	?	x	✓	?	✓	?	✓	?
8	At least one, but not all, of the intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	✓	?	x		?	x	?	x	✓
9	Group of techniques are linked to a group of constructs or predictors	x	?	x	?	?	x	?	x	✓

continued

TABLE 19 Application of Michie's theory coding scheme on multiple behaviour studies (*continued*)

		Bazzano *et al.*, 2009	Lally-Beeken *et al.*, 2021	McDermott *et al.*, 2012	Marks *et al.*, 2013	Neumeier *et al.*, 2021	Pett *et al.*, 2013	Ptomey *et al.*, 2018, 2020	Marks *et al.*, 2019	Geller *et al.*, 2009
10	All theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	?	?	?	✓	?	✓	?	✓	?
11	At least one, but not all of the theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	?	?	?	x	?	x	?	x	?
12	Theory-relevant construct mention in relation to the intervention measured									
a.	Pre intervention	✓	?	?	✓	?	✓	✓	✓	x
b.	Post intervention	✓	?	x	✓	?	✓	x	✓	x
13	Quality of measures									
a.	All theory-relevant measures had evidence of reliability	x	?	x	?	-	✓	-	?	-
b.	At least one theory-relevant, but not all, evidence of reliability	x	?	x	✓	-	x	-	✓	-
c.	All measures of theory relevance previously validated	x	?	x	?	-	✓	-	?	-
d.	At least one relevant previously validated	✓	?	x	✓	-	x	-	✓	-
e.	Behaviour measure evidence of reliability	x	x	?	?	-	-	✓	?	-
f.	Behaviour measure previously validated	✓	x	?	?	-	-	✓	?	-

TABLE 19 Application of Michie's theory coding scheme on multiple behaviour studies (*continued*)

		Bazzano *et al.*, 2009	Lally-Beeken *et al.*, 2021	McDermott *et al.*, 2012	Marks *et al.*, 2013	Neumeier *et al.*, 2021	Pett *et al.*, 2013	Ptomey *et al.*, 2018, 2020	Marks *et al.*, 2019	Geller *et al.*, 2009
14	Randomisation									
a.	Randomisation claimed	x	✓	✓	✓	✓	✓	✓	x	x
b.	Method of randomisation described	-	✓	✓	✓	✓	x	✓	-	-
c.	Success tested	-	?	x	x	?	x	?	-	-
d.	Randomisation successful	-	?	✓	✓	✓	✓	✓	-	-
15	Changes in measures theory relevant	✓	?	?	✓	?	✓	✓	✓	?
16	Mediational analysis of constructs/predictors									
a.	Mediator predicts DV	?	?	-	-	-	-	-	-	-
b.	Mediator predicts DV when controlling for IV	?	?	-	-	-	-	-	-	-
c.	Intervention does not predict DV	✓	?	-	-	-	-	-	-	-
d.	Mediated effect statistically significant	?	?	-	-	-	-	-	-	-
17	Results are discussed in terms of theoretical basis of intervention	x	✓	x	✓	x	x	x	?	x
18	Appropriate support for the theory	x	?	?	✓	?	✓	✓	✓	?
19	Results used to refine theory									
a.	Constructs added or removed from theory	x	?	x	x	?	x	x	x	x
b.	Inter-relationships between theoretical constructs to be changed	x	?	x	x	?	x	x	x	x

'✓' = Yes; 'x' = No; '?' = Don't know; '-' = Not applicable.

Appendix 8 Coding for behaviour change taxonomy used in the interventions

TABLE 20 Application of Michie's behaviour change taxonomy on alcohol consumption and smoking studies

Author, year	Behaviour change taxonomy
RCT	
Alcohol	
Kouimtsidis *et al.*, 2017	1.1, 1.2,1.6; 2.2,2.3; 3.1; 12.2
Smoking	
Singh *et al.*, 2014	1.1,1.5*; 4.9; 8.6; 11.2*; 12.6;13.4
Controlled pre–post	
Smoking and alcohol	
Lindsay *et al.*, 1998	2.7; 4.1; 5.1, 5.3*; 6.1,6.3
Uncontrolled pre–post	
Alcohol	
Mendel *et al.*, 2002	1.1; 2.2;3.3; 9.2; 15.1*
Forbat, 1999	4.1; 5.1, 5.2*, 5.6; 6.1
Smoking	
Tracy *et al.*, 1997	1.3*; 2.2*; 5.1,5.3*; 6.1; 10.1,10.2

Notes
Goals and planning [1.1 = Goal setting (behaviour); 1.2 = Problem solving; 1.5 = Review behaviour goals 1.6 = Discrepancy between current behaviour and goal]
Feedback and monitoring [2.1 = Monitoring of behaviour by others without feedback; 2.2 = Feedback on behaviour; 2.3 = Self-monitoring of behaviour; 2.7 = Feedback on outcome(s) of behaviour]
Social support [3.1 = Social support (unspecified); 3.3 = Social support (emotional)]
Shaping knowledge [4.1 = Instruction on how to perform the behaviour]
Natural consequences [5.1 = Information about health consequences; 5.2 = Salience of consequences; 5.3 = Information about social and environmental consequences; 5.6 = Information about emotional consequences]
Comparison of behaviour [6.1 = Demonstration of the behaviour; 6.3 = Information about others' approval]
Repetition and substitution [8.6 = Generalisation of target behaviour]
Comparison of outcomes [9.2 = Pros and cons; 10.1 = Material incentive (behaviour)]
Reward and threat [10.2 = Material reward (behaviour)]
Regulation [11.2 = Reduce negative emotions]
Antecedents [12.2 = Restructuring the social environment;12.6 = Body changes]
Identity [13.2 = Framing/reframing, 13.4 = Valued self-identify]
Self-belief [15.1 = Verbal persuasion about capability]

TABLE 21 Application of Michie's behaviour change taxonomy on low physical activity only studies

Author, year	Behaviour change taxonomy
RCT	
Boer *et al.*, 2016	4.1*; 6.1*; 8.1*
Boer *et al.*, 2018	4.1*; 6.1*; 8.1*

TABLE 21 Application of Michie's behaviour change taxonomy on low physical activity only studies (*continued*)

Author, year	Behaviour change taxonomy
Bossink *et al.*, 2017	3.2*; 4.1*; 6.1*
Calders *et al.*, 2011	4.1*; 6.1*; 8.1*
Carmeli *et al.*, 2009	1.1; 3.2*; 6.1; 8.1; 12.6
Carraro *et al.*, 2012	1.5*; 4.1*;12.6
Heller *et al.*, 2004	1.1,1.4; 3.1; 4.1; 5.1*; 6.1; 8.1*; 15.1*;16.3*
Melville *et al.*, 2015	1.1,1.2,1.5; 2.2,2.3; 3.1,3.3; 5.1; 12.5
Ordonez *et al.*, 2014	4.1; 6.1; 8.1
Pérez-Cruzado *et al.*, 2017	4.1; 5.1; 12.5*
Rimmer *et al.*, 2004	4.1; 6.1; 8.1
Rosety-Rodriguez *et al.*, 2013	1.1, 1.4; 2.5*; 4.1; 12.6*
Shields *et al.*, 2008	1.1, 1.4; 4.1; 5.1; 12.6*
Shields *et al.*, 2015	1.1, 1.5*; 2.3; 3.1*; 12.5*
Silva *et al.*, 2017	4.1; 6.1; 8.1
Van Schijndel-Speet *et al.*, 2017	1.2; 2.2; 3.1,3.2*; 4.1; 5.1; 6.1; 8.1; 8.6*; 10.1*,10.2*
Controlled pre–post	
Carmeli *et al.*, 2004	4.1*; 8.1*
Oviedo *et al.*, 2014	4.1; 6.1; 8.1
Uncontrolled pre–post	
Jones *et al.*, 2007	3.1*; 4.1; 6.1; 8.1
Messent *et al.*, 1998	1.3*,1.4
Moss, 2009	1.1; 2.1; 4.1; 6.1
Pérez-Cruzado *et al.*, 2016	1.3*, 1.4; 3.2; 4.1;5.1; 8.2*
Pitetti *et al.*, 1991	1.1; 2.1*; 4.1; 6.1
Podgorski *et al.*, 2004	1.1, 1.4; 2.5; 4.1; 12.6*
Pommering *et al.*, 1994	1.3, 1.4; 4.1; 12.6*
Przysucha *et al.*, 2020	1.1, 1.4; 2.5; 4.1; 12.6*
Stanish *et al.*, 2001	4.1; 5.1; 6.1; 8.1; 10.1*
Wu *et al.*, 2010	3.1*; 4.1; 6.1; 8.1*
Yen *et al.*, 2012	3.1*; 4.1; 6.1; 8.1*
Yan *et al.*, 2015	1.1; 1.2; 3.1; 5.1; 12.1
Zurita-Ortega *et al.*, 2020	1.4; 5.1; 6.1;8.1, 8.3*

continued

TABLE 21 Application of Michie's behaviour change taxonomy on low physical activity only studies (*continued*)

Author, year	Behaviour change taxonomy
Case control	
Giagkoudaki *et al.*, 2010	4.1; 6.1*; 8.1
Mendonca *et al.*, 2011	1.1; 4.1; 6.1

Notes
Goal and planning [1.1 = Goal setting (behaviour); 1.2 = Problem solving; 1.3 = Goal setting (outcome); 1.4 = Action planning; 1.5 = Review behaviour goal(s)]
Feedback and monitoring [2.1 = Monitoring of behaviour by others without feedback; 2.2 = Feedback on behaviour; 2.3 = Self-monitoring of behaviour; 2.5 = Monitoring of outcome(s) of behaviour without feedback]
Social support [3.1 = Social support (unspecified); 3.2 = Social support (practical)]
Shaping knowledge [4.1 = Instruction on how to perform the behaviour]
Natural consequences [5.1 = Information about health consequences]
Comparison of behaviour [6.1 = Demonstration of the behaviour]
Repetition and substitution [8.1 = Behavioural practice/rehearsal; 8.2 = Behaviour substitution; 8.3 = Habit formation; 8.6 = Generalisation of target behaviour]
Reward and threat [10.1 = Material incentive (behaviour); 10.2 = Material reward (behaviour)]
Antecedents [12.1 = Restructuring the physical environment; 12.5 = Adding objects to the environment; 12.6 = Body changes]
Self-belief [15.1 = Verbal persuasion about capability]
Covert learning [16.3 = Vicarious consequences]

TABLE 22 Application of Michie's behaviour change taxonomy on multiple behaviour studies

Author, year	Behaviour change techniques
RCT	
Bergström *et al.*, 2013	6.1; 8.1; 12.1,12.2; 15.1*
Curtin *et al.*, 2013	1.1; 2.3; 4.1; 6.1; 8.1; 10.4*; 12.3*
Fisher, 1986	2.3; 4.1*; 6.1*; 8.1; 8.7*; 10.6*
Fox *et al.*, 1984	2.3; 3.1,3.2; 4.1; 6.1; 8.1*; 10.1; 12.4*
House *et al.*, 2018	1.1,1.2,1.4,1.5;2.1,2.3;3.1; 4.1;15.1
Jackson *et al.*, 1982	1.1,1.2,1.4; 2.2; 3.1,3.2;4.1; 5.1;6.1;8.2,8.3;9.2; 10.1; 15.1
Kovacic *et al.*, 2020	1.1*; 4.1; 6.1; 5.1;12.6
Lally and Wilson *et al.*, 2021	1.1,1.2,1.5; 2.2,2.3; 3.1;4.1; 5.1,5.3; 8.7; 10.7,10.9
McDermott *et al.*, 2012	4.1*; 5.1*; 11.2
Marks *et al.*, 2013	1.1,1.5,1.7*; 2.2,2.7; 3.1; 4.1, 4.3
Harris *et al.*, 2017	1.1,1.2,1.3; 2.2,2.3,2.4; 3.1; 5.1; 12.5
Neumeier *et al.*, 2021	1.2,1.3,1.4; 2.2; 3.2
Pett *et al.*, 2013	3.1; 4.1; 6.1; 8.1; 11.2; 12.1,12.2
Ptomey *et al.*, 2018	1.1,1.2; 2.2,2.3,2.7; 4.1; 10.1, 10.8; 12.5
Ptomey *et al.*, 2018	1.1,1.2; 2.2,2.3,2.7; 4.1; 10.1, 10.8; 12.5
Rotatori *et al.*, 1980	6.1; 7.3*; 10.8
Rotatori *et al.*, 1986	1.1,1.4*,1.7*; 3.1*;6.1; 7.1*,7.3*; 9.1;10.2*,10.8; 12.2

TABLE 22 Application of Michie's behaviour change taxonomy on multiple behaviour studies (*continued*)

Author, year	Behaviour change techniques
Controlled pre–post	
Bodde *et al.*, 2012	3.1; 4.1; 5.6*; 6.1
Chapman *et al.*, 2005	1.2; 3.1*; 4.1; 9.1
Chapman *et al.*, 2008	1.2; 3.1*; 4.1; 9.1
Fox *et al.*, 1985	2.3; 3.1,3.2*; 4.1; 6.1; 8.1*; 10.1; 12.4
Mauro-Martín *et al.*, 2016	5.1; 8.1,8.3*
Niemeier *et al.*, 2021	1.1,1.4*; 2.2,2.3; 3.2; 4.1; 8.1;9.1*;15.1
Norvell *et al.*, 1987	2.2,2.3,2.5; 3.1; 4.1
Steele McCarran *et al.*, 1990	1.1; 2.3;7.2;10.1*
Uncontrolled pre–post	
Bazzano *et al.*, 2009	3.1; 4.1,4.2*;5.1,5.2*;6.1; 10.1
Croot *et al.*, 2018	3.1*;5.1*
Geller *et al.*, 2009	1.4; 2.1*; 3.1*; 4.1; 5.1;6.1; 8.1
Harris *et al.*, 1984	1.1;2.3;5.1; 7.1
Mann *et al.*, 2006	1.1; 1.5*; 2.3; 3.1; 4.1;5.1;6.1; 8.1;11.1*
Marks *et al.*, 2019	1.1,1.5; 2.2; 3.1; 4.1
Marshall *et al.*, 2002	3.1;5.1
Melville *et al.*, 2011	1.1,1.2,1.3; 2.2,2.3,2.4; 3.1; 5.1; 12.5
Spanos *et al.*, 2016	1.2,1.3;5.1; 7.5*
Saunders *et al.*, 2011	1.1,1.2; 2.2,2.3,2.7; 4.1; 10.1, 10.8; 12.5
Wilson *et al.*, 1993	1.1, 1.5; 3.1;5.1; 6.1; 8.1,8.2;15.1
Yilmaz *et al.*, 2014	1.1; 5.1; 6.1; 8.1
Case control	
Ewing *et al.*, 2004	1.2;5.3;11.2;13.1*
Martínez-Zaragoza *et al.*, 2016	1.1,1.3,1.7*; 2.2; 3.1; 4.1; 5.1; 6.1; 8.1; 12.1*
Spanos *et al.*, 2014	1.2;2.3;3.1;5.1; 6.1*
Ptomey *et al.*, 2020	1.1,1.2; 2.2,2.3,2.7; 4.1; 10.1, 10.8; 12.5

Notes
Goal and planning [1.1. Goal setting (behaviour); 1.2. Problem solving; 1.3. Goal setting (outcome); 1.4. Action planning; 1.5. Review behaviour goal(s); 1.7. Review outcome goal(s)]
Feedback and monitoring [2.1. Monitoring of behaviour by others without feedback; 2.2. Feedback on behaviour; 2.3. Self-monitoring of behaviour; 2.5. Monitoring of outcome(s) of behaviour without feedback; 2.7. Feedback on outcome(s) of behaviour]
Social support [3.1. Social support (unspecified); 3.2. Social support (practical); 3.3. Social support (emotional)]
Shaping knowledge [4.1. Instruction on how to perform the behaviour; 4.3. Re-attribution]
Natural consequences [5.1. Information about health consequences; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences]
Comparison of behaviour [6.1. Demonstration of the behaviour]
Associations [7.1. Prompts/cues; 7.2. Cue signalling reward; 7.3. Reduce prompts/cues]
Repetition and substitution [8.1. Behavioural practice/rehearsal; 8.2. Behaviour substitution; 8.3. Habit formation; 8.7. Graded tasks]
Comparison of outcomes [9.1. Credible source; 9.2. Pros and cons]
Reward and threat [10.1. Material incentive (behaviour); 10.2. Material reward (behaviour); 10.4. Social reward; 10.6. Non-specific incentive; 10.7. Self-incentive; 10.8. Incentive (outcome); 10.9. Self-reward]
Regulation [11.1. Pharmacological support; 11.2. Reduce negative emotions]
Antecedents [12.1. Restructuring the physical environment; 12.2. Restructuring the social environment; 12.3. Avoidance/reducing exposure to cues for the behaviour; 12.4. Distraction; 12.5. Adding objects to the environment; 12.6. Body changes]
Identity [13.1. Identification of self as role model]
Self-belief [15.1. Verbal persuasion about capability]

Appendix 9 Additional analysis for the network meta-analysis

Sensitivity Analysis

Change in BMI

We did the sensitivity analysis by excluding the study by Bergström *et al.* The study was included in the analysis for change in BMI. This was the only study about the resistance training exercises only. It was excluded as the resistance training was provided by the automated machine and did not involve participant efforts. Excluding the study from the analysis did not change the relative effects of the interventions.

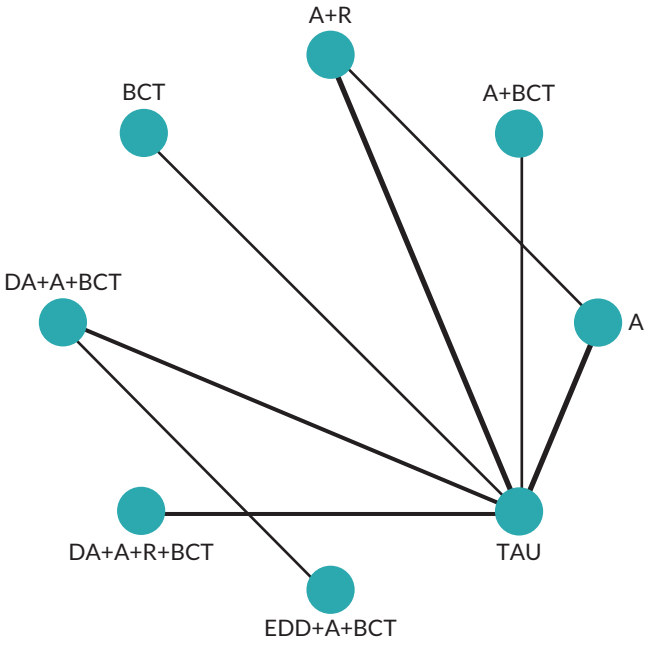

FIGURE 33 Network plot for change in BMI excluding study by Bergström *et al.*

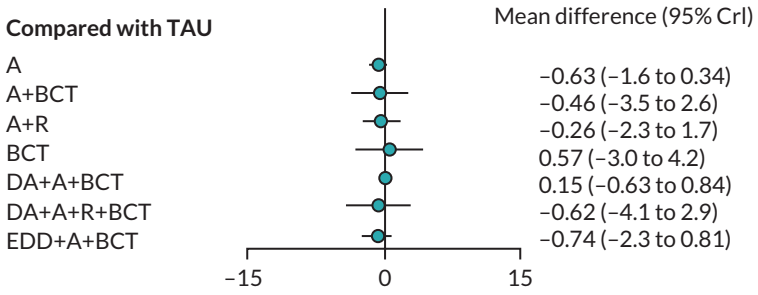

FIGURE 34 Forest plot – change in BMI excluding study by Bergström *et al.*

TABLE 23 Sensitivity analysis

Interventions	All studies	Excluding the Bergström study
A	−0.62 (−1.59, 0.33)	−0.63 (−1.6, 0.34)
A + BCt	−0.49 (−3.51, 2.53)	−0.46 (−3.5, 2.6)
A + R	−0.29 (−2.29, 1.73)	−0.26 (−2.3, 1.7)
BCT	0.59 (−3.02,4.19)	0.57 (−3.0, 4.2)
DA + A + BCT	0.15 (−0.62, 0.83)	0.15 (−0.63, 0.84)
DA + A + R + BCT	−0.72 (−6.28,4.76)	−0.62 (−4.1, 2.9)
EDD + A + BCT	−0.75 (−2.31, 0.78)	−0.74 (−2.3, 0.81)
R	0.37 (−1.38, 2.14)	NA

Note
All studies: analysis based on all the studies that reported the outcome, excluding the Bergström study_ analysis based on excluding one study.

Assessments

Assessment of transitivity

Transitivity assumption means that any participants would have received any of the interventions in the network. In our network, the proportion of participants with mild to moderate learning disabilities were balanced across the comparisons. However, only few studies included participants with severe or profound levels of learning disabilities so we assume that any imbalance could be a chance error. Thus, the assumption of transitivity is balanced.

Assessment of model fit and consistency

Both fixed- and random-effects model had satisfactory convergence after 20,000 iterations. We also compared the models using the results based further 50,000 iterations. In all NMAs, the random-effects model provided a better fit over the fixed-effects model and fit the data well.

For the outcome of change in BMI, we compared the posterior means and DIC and constructed the leverage plots (see *Figure 35*) and found no significant difference in the models. We used change in BMI outcome as it has maximum information (number of studies and participants).

Similarly, we compared DICs for both the consistency and inconsistency random-effects model for change in BMI. No evidence of inconsistency was found through comparison of the consistency and inconsistency random-effects models (see *Figure 36*). The consistency versus inconsistency plot comparing the posterior mean deviance of both the models also revealed the same (see *Figure 37*).

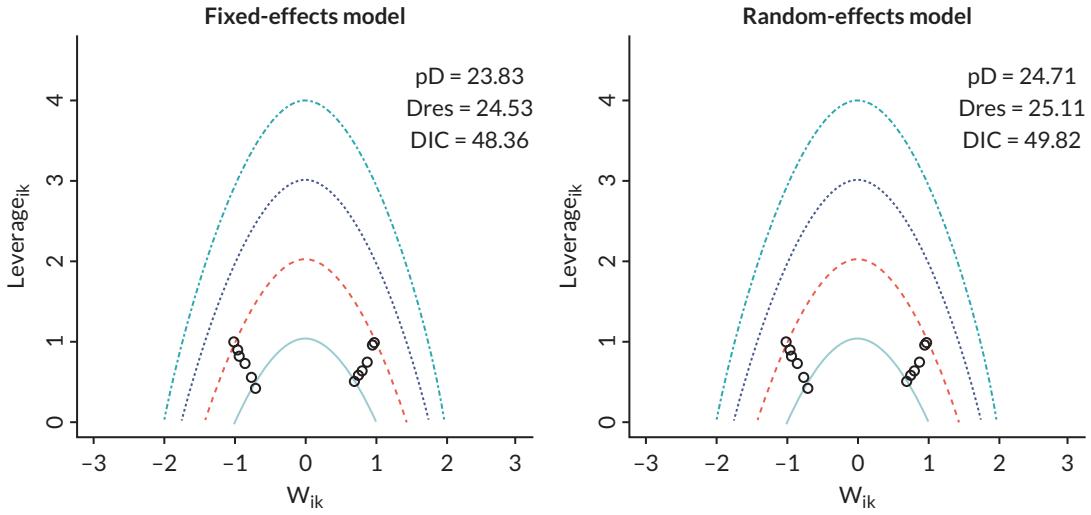

FIGURE 35 Leverage plot with DIC Dres and pD for fixed- and random-effects model.

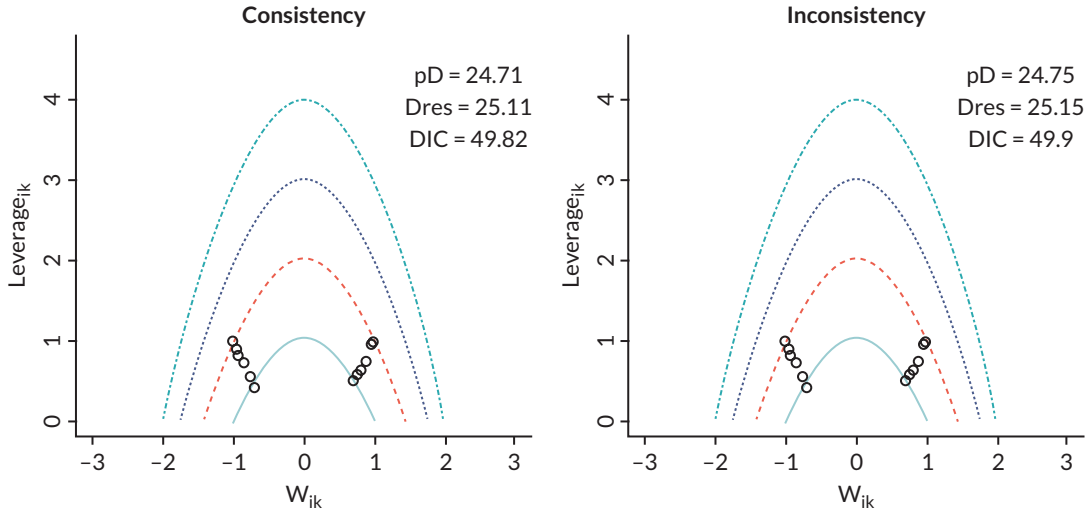

FIGURE 36 Leverage plots comparing the consistency and inconsistency models.

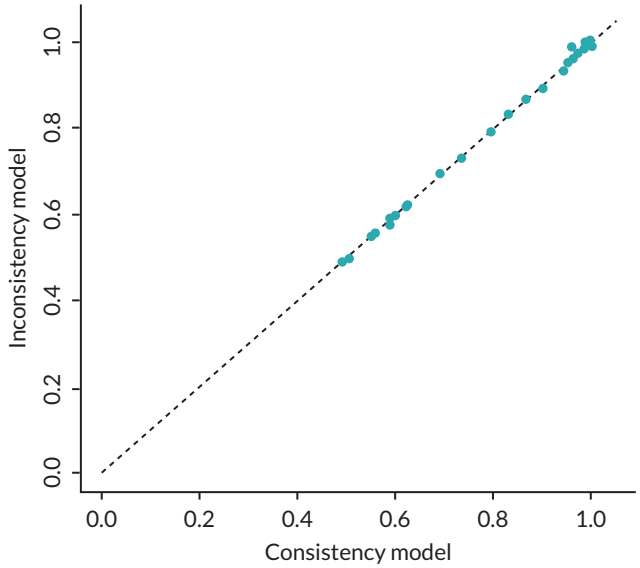

FIGURE 37 Consistency vs. inconsistency plot.

Appendix 10 Meetings with the patient and public involvement group

Agenda items and actions (1)

1

Welcome and introductions
Researchers welcomed participants to the meeting and a round of introductions was undertaken.

2

Project presentation
Researchers presented to the group what the project is about and what the role of the group will consist of.

3

Group discussion
Attendees discussed about lifestyle change programmes and agreed on the following:

- Tackling poor lifestyle behaviours among adults with learning disabilities is very important.
- Research should be designed with and specifically for people with learning disabilities and their needs.
- Programmes need to be fun to help engage people.
- Social support is particularly important in various ways (e.g. to help introduce people into new programmes and to reduce safety concerns associated with physical activity, such as walking when dark).
- Information should be disseminated widely and in various ways (e.g. easy-read leaflets, videos, presentations).
- Programmes should be financially accessible and financial concerns should be accounted for (e.g. as unhealthy foods are cheaper than healthy foods, some people have no choice but to buy unhealthy foods).

4

Any other business
Researchers thanked everyone for taking the time to participate in the meeting and advised that the next meeting will be held some 6 months from now, with the exact date to be confirmed in due course.

Agenda items and actions (2)

1

Welcome and introductions
Researchers welcomed participants to the meeting.

Agenda items and actions (1)

2

Project presentation
Researchers presented the progress of the work since the last meeting and what the planned next steps are.

3

Group discussion
Attendees discussed about possible dissemination activities and agreed on the following:

- Group were very positive about the ideas of roadshows and drama performances.
- Online materials, such as a project website, could be useful. However, not everyone with learning disabilities has access to the internet, so this will not be accessible to everyone.
- Leaflets are a good way to disseminate findings. These should be in an easy-read format and could include quotes from people with learning disabilities about the study findings.
- Could use PPI members' links with the BBC to get press coverage for the project findings to help with dissemination.
- Additional points were discussed about barriers and facilitators to healthy lifestyles:
- Opportunities that people have for healthy lifestyles are different in different settings. For example, institutional of hospital settings may be less supportive for healthy lifestyles, as staff do not always have time to support this.
- If people had the opportunity to grow their own food, such as allotments, could help people eat healthier foods.
- The lower rates of smoking and drinking in people with learning disabilities could be due to safety concerns relating to environments where these behaviours happen. For example, people with learning disabilities may feel unsafe in pubs and going to shops. They may also be denied access to pubs they may appear drunk when not, for example due to balance problems associated with cerebral palsy. Interestingly, the barriers (e.g. safety concerns) that limit healthy behaviours, such as physical activity, are very similar to the barriers that limit unhealthy behaviours, such as smoking and drinking.

4

Any other business
Researchers thanked everyone for taking the time to participate in the meeting and advised that the next meeting will be held some 6 months from now, with the exact date to be confirmed in due course.

Agenda items and actions (3)

1

Welcome and introductions
Researchers welcomed participants to the meeting and introduced another researcher to the group.

2

Project presentation
Researchers presented main findings under four domains: (a) social support from caregivers; (b) freedom of choice and informed decisions; (c) design and delivery of interventions; and (d) additional influences on behaviour change and healthy lifestyles.

Agenda items and actions (1)

3

Group discussion
Attendees were asked to give their feedback on key findings and agreed on the following:
Social support from caregivers

- Yes, very important. Gives people with learning disabilities encouragement and independence.
- Some people are too unsure to do things on their own and social support can help the to 'come out of their shell'.
- Social support can also be a good way to get and share important information.
- Freedom of choice and informed decisions
- Yes, people should have the choice to take part in lifestyle change programmes.
- Stopping taking part if no longer enjoying is important too.
- Design and delivery of lifestyle change programmes:
- Important to include people with learning disabilities when designing programmes.
- Involvement can make people with learning disabilities feel proud to have had an impact.
- Sometimes people with learning disabilities can feel overlooked when involved in groups designing programmes and they therefore need to be able to 'hold their own'.
- Agree with accessible materials (easy-read) and flexible delivery.
- Peer support is important.
- Programmes should be fun. Social aspects and learning new things are good ways to have fun.
- Researchers need to be willing to take onboard the views of people with learning disabilities and their suggested changes.
- Researchers should be good listeners and communicators with people with learning disabilities. Researchers should be able to let people speak without interrupting and take others' views on board.
- People with learning disabilities should be included in the delivery of programmes, not just the design.
- Additional influences on behaviour change and healthy lifestyles.
- Agree with all points listed.
- COVID could impact programmes. For example, people may not feel comfortable using public transport to go to activities.
- Other people's attitudes (e.g. bus drivers) can have a negative impact. This can make people feel unsafe. People can also misunderstand disabilities and how it effects people in their lives.
- Bad weather can have an impact. But this can be reduced if there are other motivating factors. For example, people might not want to walk alone in the rain but will be more likely to walk with friends in the rain.

4

Any other business
The next meeting will focus on dissemination of findings. Researchers thanked everyone for taking the time to participate in the meeting and advised that the next meeting will be held about 6 months from now, with the exact date to be decided.

Agenda items and actions (4)

1

Welcome and introductions
Researchers welcomed participants to the meeting.

Agenda items and actions (1)		
2		**Project presentation** Researchers presented the progress of the work since the last meeting. The aim of this meeting was to plan dissemination online event.
3		**Summary of discussion on dissemination** • Researchers updated on current plans for online event. Will be on 27 July, 1–2:30 p.m. We will have four presentations, a drama performance and discussion time. • PPI members made point that people might like to attend in groups in person. Group discussed that people could meet in person and participate in online event together. • Task: PPI representative to look into arranging for people to meet in same location for event. • Researchers discussed that we would like People First members to lead the presentations on the following topics: Background to project Results (two presentations) Experiences of PPI group • Researchers will support people to develop and practice presentations. • Researchers discussed that presentations can be done by individuals or in pairs. Presentations can be done live or pre-recorded. However, if people meet in groups, this might prevent people from presenting live. • Group were keen to do doing presentations and opinions varied on whether people would prefer live or recorded delivery. Task: PPI representative to talk to group individually to see who would like to do presentation and what delivery they would prefer. • Researchers discussed that we need to advertise event, for example on Twitter. To help with this, it would be good if people can send the researchers a photo of themselves and quote saying why people should attend event. Task: PPI representative to talk to group about getting quotes and photos. • Group had a lot of ideas of organisations that we could invite to event. Task: Group are going to make a list of groups for the researchers to e-mail and tell about event.
4		**Any other business** This was the last PPI group meeting. Researchers thanked the group for all their time and value inputs into the project.

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