



BMJ Open Behaviour change techniques that constitute effective planning interventions to improve physical activity and diet behaviour for people with chronic conditions: a systematic review

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ABSTRACT

Objectives Action planning is a brief and effective behaviour change technique (BCT) to improve physical activity (PA) and diet behaviour (DB). This study aimed to identify critical BCTs and mechanisms of action (MoAs) to interpret the effectiveness of planning interventions based on the Health Action Process Approach (HAPA) model.

Design Systematic review.

Data sources PubMed, Web of Science, CINAHL (EBSCO), PsycINFO (EBSCO), Psychology and Behavioural Sciences Collection (EBSCO), psyARTICLES and Medline were searched for studies from January 1990 to September 2021 published in English.

Eligibility criteria Experiment involving action planning intervention to improve PA or DB in community-dwelling adult patients with chronic conditions.

Data extraction and synthesis Two reviewers independently coded the planning interventions into BCT combinations and MoA assemblies. Outcome was dichotomised according to the statistical power and Cohen's d. The Cochrane risk of bias assessment tool and the Risk of Bias in Nonrandomized Studies-of Interventions assessment tool were used to assess the quality of randomised controlled trials (RCTs) and non-RCTs, respectively.

Results From the 52 included studies, 46 BCTs were identified and linked to 21 MoAs. Long-term facilitators for planning intervention included 'self-monitoring of behaviour', 'problem solving', 'instruction on how to perform the behaviour' and 'adding objects to the environments'. The three most frequently occurring MoAs were 'intention', 'behavioural regulation', 'beliefs about capabilities'. The effective intervention groups had higher MoA scores that corresponded to the HAPA model constructs than the ineffective groups.

Conclusions The findings from this review may inform scientific and effective planning intervention designs for community-dwelling people with chronic conditions in the future.

PROSPERO registration number CRD42021241227.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This review covered both randomised controlled trials (RCTs) and non-RCT research focusing on individuals with a variety of chronic diseases, resulting in a comprehensive analysis.
- ⇒ Both health outcome and behavioural outcome were taken into account to determine the effectiveness of action planning intervention.
- ⇒ The health action process approach model was used to conceptualise the key mechanisms of action.
- ⇒ Coding of interventions did not concern the intensity of each behaviour change technique.
- ⇒ Fidelity assessment failed to capture the degree of each fidelity item due to the dichotomous approach.

INTRODUCTION

It is well known that poor eating habits and physical inactivity are two major risk factors for non-communicable chronic diseases (NCDs), such as cardiovascular disease, type 2 diabetes mellitus (T2DM) and obesity,¹ and improvements in physical activity (PA) and diet behaviour (DB) can significantly benefit community-dwelling patients with NCDs.^{2–4} In this patient population, there is an urgent need for effective behavioural interventions supported by theory and evidence, as they have less pre-existing PA, a greater sense of helplessness, less social support and more perceived barriers.⁵

Complex behavioural interventions with multiple components are gaining traction as a promising and important public health approach for encouraging these people to develop healthy eating habits and actively participate in sports. Their explosion has resulted in a plethora of categorical frameworks for aggregating intervention components. The Behaviour Change Technique Taxonomy version 1 (BCTTv1) is one of the

most complete and systematic frameworks. It consists of an 'extensive, consensually agreed upon, hierarchically structured' set of 93 techniques aimed at changing health behaviours.⁶ BCTTv1 is of great value in synthesising and analysing complex behavioural interventions.

One effective behaviour change technique (BCT) popularised in PA or DB improvement is 'action planning'. It is defined as 'prompt detailed planning of behaviour performance, including context, frequency, duration and intensity'.⁶ A plan that specifies situational cues and sufficient action detail, such as 'I intend to go jogging in the park on Monday at 11:00' qualifies as an action plan. Several meta-analyses have confirmed the effectiveness of planning in improving PA⁷⁻⁹ and DB,^{7,9-11} and they identified that reinforcement,¹² barrier management⁸ and monitoring¹¹ were significant moderators. However, it is likely that some potential moderators have not yet been identified due to the absence of a theoretical and comprehensive synthesis of planning intervention components from the perspective of BCTs.

Theoretically, planning has been incorporated as one of the theoretical constructs into the Health Action Process Approach (HAPA) model. The model indicates that the process of health behaviour change involves two phases: motivational and volitional. Self-efficacy, outcome expectancy and risk perception are considered critical to promote intention formation (eg, 'I intended to do more exercise.') in the motivational phase, and planning is regarded as the watershed in intention conversion to action in the volitional phase, with self-efficacy moderating the effect.¹³ However, the contradictory results of previous studies regarding the predictability of planning suggest that there may be unspecified mechanisms in the health behaviour change process.¹⁴⁻¹⁷ For example, self-regulation^{13,18} and social support^{16,19} are frequently included as volitional constructs, and past habits were found to impair the intention-action association.^{20,21}

To improve the theoretical understanding of the planning intervention, intervention reverse coding was conducted to identify the mechanisms contributing to the planning effect. It is identifying mechanisms of action (MoAs, the theoretical approach through which behaviour change occurs) that link to the BCTs used in an intervention through the theory and technique tool.²² The tool is based on an expert consensus²² and literature review²³ that summarises existing connections between BCT and MoA. A previous study applied it to determine the most frequently used MoAs in a PA intervention programme.²⁴ However, there is no review research that synthesises MoAs that occurred in the planning of interventions, which would advance the theoretical understanding of intervention effectiveness. By deconstructing the planning interventions into BCT combinations and MoA scores, this review aimed to (1) summarise the characteristics of BCT distribution and critical BCTs in PA and DB planning interventions targeting community-dwelling patients; and (2) enhance comprehension of the theoretical mechanisms

underlying the efficacy of planning interventions based on the HAPA model.

METHOD

Patient and public involvement

No patients were involved.

Search strategy and study selection

The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines,²⁵ with the checklist available in online supplemental file 1. The protocol was registered in the International Prospective Register of Systematic Reviews (CRD42021241227). Seven electronic databases were searched, including PubMed, Web of Science, CINAHL (EBSCO), PsycINFO (EBSCO), Psychology and Behavioural Sciences Collection (EBSCO), psyARTICLES and Medline, for English-language studies published from January 1990 to September 2021. Online supplemental file 2 contains detailed information about the search strategy. Furthermore, manual searching was carried out via Google Scholar and the reference lists from previous meta-analyses.^{8,10-12}

Inclusion and exclusion criteria

This review included both randomised controlled trials (RCTs) and non-RCTs. The inclusion criteria were presented according to 'PICO'. Participants were adults who lived in the community and had at least one chronic condition (Participation). They received PA and/or DB planning intervention. Specifically, they were asked to create detailed action plans specifying when, where, and how to do things or to use an 'if-then' form to create specific behavioural plans to improve PA or DB (Intervention). There should be no planning intervention in the control group (Comparison). Physiological or behavioural outcomes (as measured by self-report questionnaires or wearable devices) were considered (Outcome). The exclusion criteria were as follows: (1) participants' plans did not qualify as action or coping plans; and (2) the intervention provider (eg, nurses, healthcare professionals, etc), rather than patients, was the research object.

Study selection and data extraction

The title, abstract, and full text were reviewed independently and concurrently by HL and DX. Disagreements were discussed and resolved with the assistance of a third reviewer (ND). HL extracted the following data from each included study: sample size, participant health status, intervention target (either PA or DB, or both), intervention delivery, rehabilitation, key outcome indicator and measuring method, follow-up time, and statistical power of outcome difference between planning intervention group and control. In studies with multiple outcome indicators, the behavioural outcome (eg, pedometer) was selected first, followed by the physiological outcome and

finally the self-reported outcome. In the case of DB, the physiological outcome came first, followed by the self-reported behavioural outcome.

Risk of bias and fidelity assessment

RCT study quality was assessed using the Cochrane risk of bias assessment tool,²⁶ which included the following domains: (1) random sequence generation, (2) allocation bias, (3) performance bias related to participant and intervention provider blinding, (4) attrition bias due to missing data, (5) detection bias and (6) reporting bias. In the final three domains, non-RCTs were also evaluated. Additionally, they were assessed for risk of baseline confounding due to one or more prognostic variables that predicted the intervention effect, selection bias due to participant inclusion/exclusion based on their characteristics and performance bias due to deviation from intended interventions using the Risk of Bias in Nonrandomized Studies—of Interventions assessment tools.²⁷ Each item's risk level was classified as 'low risk', 'high risk' or 'uncertain'. Fidelity was assessed using modified Bellg et al.²⁸ criteria and a dichotomised assessment in terms of study design, provider training, treatment delivery and treatment receipt. Cohen's kappa was used to assess inter-rater agreement in risk of bias and fidelity assessments.

Intervention coding and reverse coding

Two reviewers (HL and DX) completed the tutorial (<http://www.bct-taxonomy.com>, accessed on 23 January 2021) to qualify them of capacity for BCT coding. In addition, prior to formal coding, DX and HL independently coded 5% of the studies to ensure consistency. Inter-rater agreement in coding was determined by Cohen's kappa value. Two coders were retrained and coded again if the kappa value was less than 80%. The remaining differences were resolved through discussion with a third reviewer (ND).

The coding result was vectorised, with '1' indicating the presence of the BCT and '0' indicating its absence. Inactive or undefined control groups were not coded. Following coding, the BCTs were mapped to MoAs using the theory and technique tool (an online interactive heatmap matrix retrieved on 23 January 2021, from <https://theoryandtechniquetool.humanbehaviourchange.org/tool>). Each MoA score was determined by the number of BCTs associated with that MoA, indicating the variety of BCTs used to modify behaviour according to this theoretical mechanism. This process was repeated for each intervention group, resulting in a matrix of MoA scores, with the row representing the score of a certain MoA for all groups and the column representing the scores of all MoAs within a certain group.

Intervention effectiveness coding

Because the outcome measurement and follow-up time were highly inconsistent, it was anticipated that quantitative estimation of planning intervention effectiveness would have low evidence power and a low reference value.

Hence, intervention effectiveness was classified as 'effective', 'ineffective' or 'inconclusive' based on the effect size (ES) and statistical significance of the key indicator. Cohen's d was used to calculate the magnitude of the ES by dividing the mean difference between the intervention and control groups by the SD.²⁹ The rules for coding intervention effectiveness were as follows: if statistical power was significant ($p > 0.05$), the ES of an 'effective' intervention should at least reach a small level ($d > 0.2$) for physiological measurement or device-based measurements, or a medium level ($d > 0.5$) for self-reported indicators, or it was coded as 'ineffective'. If there was no information on the statistical power or ES, it was classified as 'inconclusive'.

Data synthesis

Only the planning intervention groups from the included studies were included in the analysis. The occurrence rate of each BCT was calculated by dividing the number of groups that used this BCT by the total number of groups and was classified based on target behaviour, health condition and mode of delivery. The success rate of each BCT was calculated by dividing the number of effective groups that used this BCT by the total number of groups that used this BCT and was classified as long-term (ie, the follow-up period was longer than 3 months) and short-term (ie, the follow-up period was not longer than 3 months). Notably, only BCTs involved in more than 10% of studies were included in subsequent analyses.

The MoA scores for all planning intervention groups were displayed using the R software (V.3.6.1) heatmap drawing tool.³⁰ MoA with an average score greater than 1 indicates that, on average, at least one specific BCT was used to improve health behaviour change via this mechanism. These MoAs were further conceptualised with the HAPA model. Descriptive analyses were then performed on the difference in MoA score between effective intervention groups and ineffective intervention groups for PA and DB outcomes.

RESULTS

Study selection and study characteristics

A total of 52 studies were included in the analysis (figure 1). As shown in table 1, there were 45 RCTs^{31–75} and 7 quasi-experiments.^{76–82} Thirty-nine studies included PA planning interventions, and 37 included DB planning interventions. Ten trials included a rehabilitation period prior to action planning, eight of which occurred outside the hospital.^{41 47 50 51 56 58 62 78} Thirty-seven per cent of the studies targeted obese patients without metabolic syndrome (MS). The majority of studies administered the intervention via face-to-face sessions that were either individual based (58%) or individual and group based (29%). Nine studies provided merely online sessions.^{31 36 38 41 48 64 65 70 78} Three studies incorporated both individual sessions and online sessions based on computers^{37 68} or smartphone applications.⁷²

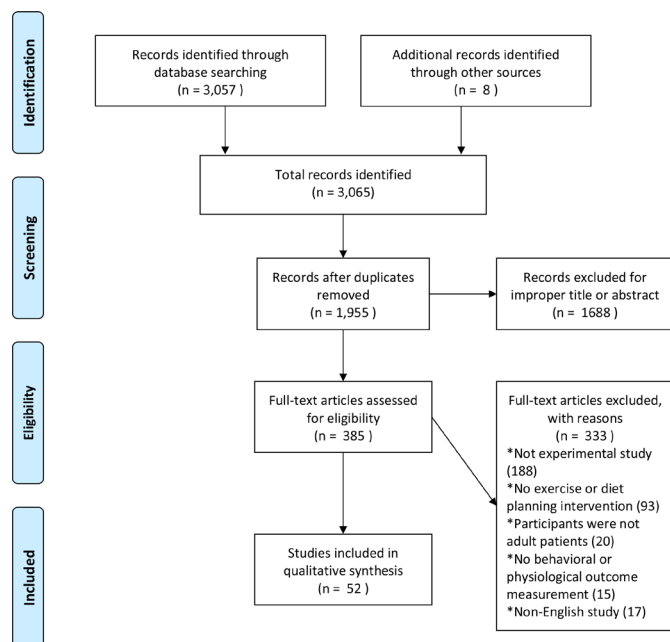


Figure 1 PRISMA flow diagram. From Moher *et al.*²⁵ PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Risk of bias and fidelity assessment

A substantial proportion of studies were evaluated with a high/unclear risk of performance bias (58%) and reporting bias (58%). Attrition bias and detection bias were high for 33% and 58% of the included studies, respectively. Seven RCTs were assessed with insufficient random sequence generation, and 18 showed insufficient concealment of allocations. Five non-RCTs had a high risk of baseline confounding, and three had significant selection bias. Only five trials were evaluated as having low risk in every domain.^{56 64 65}

According to the fidelity assessment, 81% of studies had descriptions of standardised procedures for planning intervention, and 67% provided supplementary resources to aid participants in developing action plans. Less than half (44%) measured participants' action plans. The quality of action plans was guaranteed in 54% of trials. Only 10 (19%) studies described planning intervention provider training. Online supplemental files 3 and 4 contain detailed information on the risk of bias and fidelity assessment within individual studies. The kappa values for risk of bias and fidelity were 0.87 and 0.95, respectively.

BCT coding

To improve coding consistency, a systematic review of 20 rehabilitation studies⁸³ was used to summarise the common BCTs used in rehabilitation studies. The coding consistency kappa was 0.89. A total of 46 BCTs were identified from 52 studies (see online supplemental files 5 and 6 for details). In addition to action planning, the BCTs occurring in more than 10% of all groups and their occurrence rates were: (1) information about health consequences (78%); (2) behavioural goal setting (71%); (3)

unspecified social support (69%); (4) problem solving (68%); (5) adding objects to the environment (56%); (6) instruction on how to perform the behaviour (53%); (7) self-monitoring of behaviour (52%); (8) feedback on behaviour (40%); (9) practical social support (37%); (10) self-monitoring of outcomes of behaviour (32%); (11) reduce negative emotions (31%); (12) pharmacological support (28%); (13) credible source (28%); (14) prompt/cues (28%); etc. These BCTs were referred to by serial numbers for ease of reference, for example, '(2)' refers to 'behavioural goal setting' below.

The planning interventions for patients with MS included an average of 12 BCTs, which was higher than the number of BCTs used in groups for obese patients without MS (7 BCTs on average, see [figure 2](#)). The top eight BCTs in terms of occurrence in patients with MS were (1), (2), (3), (5), (6), (4), (7) and (9). In terms of the occurrence in obese patients without MS, the top eight most popular BCTs in order were (4), (1), (2), (3), (7), (8), (5) and (6). 'Practical social support' was merely popular in patients with MS (52%), while 'feedback on behaviour' was only popular in obese patients without MS (38%).

Individual session intervention, group plus individual session intervention, and online session intervention all identified averages of 9, 12, and 11 BCTs, respectively. As shown in [figure 3](#), the top eight popular BCTs in group plus individual session interventions were (1), (2), (3), (5), (7), (4), (6) and (8) in order. The top eight common BCTs in individual session interventions were (2), (4), (1), (3), (5), (7), (6) and (11) in order. The top eight popular BCTs in order were (1), (4), (3), (2), (6), (8), (14) and (5). 'Reduce negative emotions' was simply common in individual session interventions (37%), and 'prompts/cues' was uniquely popular in online session interventions (50%).

Intervention effectiveness coding

In summary, 47 groups contained PA planning interventions, of which 42 were available for effectiveness coding, while 43 groups contained DB planning interventions. Among the 46 BCTs identified, 24 occurred in more than 10% of the PA groups, and 21 occurred in more than 10% of the DB groups. The PA intervention group had an average of 11 BCTs, whereas the DB intervention group had an average of 8 BCTs. Janssen *et al.*⁴⁷ designed an intervention involving the maximum number of BCTs (N=25).

As shown in [figure 4A](#), the top eight popular BCTs in the PA intervention groups were (1), (3), (2), (4), (6), (7), (5) and (9) in order. Except for (1), all popular BCTs had a success rate of more than 50% for long-term PA outcomes. However, only (4) and (5) had success rates above 50% for short-term PA outcomes. For the DB intervention groups, the top eight popular BCTs were (1), (2), (4), (3), (5), (7), (6) and (8). All of them had a success rate above 50% for short-term DB outcomes. However, only (4), (7), (6) and (5) had success rates

Table 1 Study characteristics

Author	Published year	Study type	Intervention target	Health status	Intervention delivery	Rehabilitation
Almeida <i>et al</i> ³¹	2015	RCT	PA & DB	CVD	Computer session	None
Armitage <i>et al</i> ³²	2014	RCT	DB	OB	Individual session	None
Armitage <i>et al</i> ³³	2017	RCT	DB	OB	Individual session	None
Ayre <i>et al</i> ³⁴	2020	RCT	DB	OB, DM	Individual session	None
Bélanger-Gravel <i>et al</i> ³⁵	2013	RCT	PA	OB	Individual session	None
Breslin <i>et al</i> ³⁶	2019	RCT	PA & DB	OB	Group session plus individual session	None
Broekhuizen <i>et al</i> ³⁷	2012	RCT	PA & DB	FH	Computer session plus individual session	None
Cheung <i>et al</i> ³⁸	2017	RCT	PA & DB	OB	Computer session	None
Christiansen <i>et al</i> ³⁹	2010	RCT	PA	CBP	Individual session	None
de Freitas Agondi <i>et al</i> ⁴⁰	2014	RCT	DB	HP	Individual session	None
Duan <i>et al</i> ⁴¹	2018	RCT	PA & DB	CVD	Computer session	Out-of-hospital
Gagnon-Girouard <i>et al</i> ⁴²	2010	RCT	DB	OB with depression or eating disorder	Group session plus individual session	None
Groeneveld <i>et al</i> ⁴³	2011	RCT	PA & DB	CVD	Individual session	None
Hayes <i>et al</i> ⁴⁴	2020	RCT	DB	OB	Individual session	None
Igelström <i>et al</i> ⁴⁵	2014	RCT	PA & DB	OB, OSAS	Individual session	None
Jackson <i>et al</i> ⁴⁶	2005	RCT	DB	CVD	Individual session	None
Janssen <i>et al</i> ⁴⁷	2014	RCT	PA & DB	CVD	Group session plus individual session	Out-of-hospital
Kim and Utz ⁴⁸	2019	RCT	PA & DB	DM	Smartphone application	None
Kwasnicka <i>et al</i> ⁴⁹	2020	RCT	PA & DB	OB	Group session plus individual session	None
Luszczynska ⁵⁰	2006	RCT	PA	Post-MI	Individual session	Out-of-hospital
Luszczynska <i>et al</i> ⁵¹	2007	RCT	DB	Post-MI	Individual session	Out-of-hospital
Luszczynska <i>et al</i> ⁵²	2007	RCT	PA & DB	OB	Individual session	None
Miller <i>et al</i> ⁵³	2016	RCT	PA & DB	DB	Group session plus individual session	None
Obara-Golebiowska and Brycz ⁵⁴	2015	RCT	DB	OB	Group session plus individual session	None
Osborn <i>et al</i> ⁵⁵	2018	RCT	PA & DB	SMI	Individual session	None
Rodgers <i>et al</i> ⁵⁶	2014	RCT	PA	CLD	Individual session	Out-of-hospital
Rodrigues <i>et al</i> ⁵⁷	2013	RCT	PA	CVD	Individual session	None
Scholz <i>et al</i> ⁵⁸	2007	RCT	PA	CVD	Individual session	Out-of-hospital
Scholz <i>et al</i> ⁵⁹	2013	RCT	DB	OB	Individual session	None
Silva <i>et al</i> ⁶⁰	2020	RCT	PA	DM	Individual session	None
Sniehotta <i>et al</i> ⁶¹	2005	RCT	PA	CVD	Individual session	Hospital
Sniehotta <i>et al</i> ⁶²	2006	RCT	PA	CVD	Individual session	Out-of-hospital
Sniehotta <i>et al</i> ⁶³	2011	RCT	PA & DB	NCD	Individual session	None
Soureti <i>et al</i> ⁶⁴	2011 a	RCT	DB	OB	Computer session	None
Soureti <i>et al</i> ⁶⁵	2011 b	RCT	DB	OB	Computer session	None
Stevens <i>et al</i> ⁶⁶	2001	RCT	PA & DB	OB	Individual session	None
Ströbl <i>et al</i> ⁶⁷	2013	RCT	PA & DB	NCD	Group session plus individual session	Hospital
Svetkey <i>et al</i> ⁶⁸	2008	RCT	PA & DB	OB, HP, DLP	Computer session or individual session	None
Thoolen <i>et al</i> ⁶⁹	2009	RCT	PA & DB	DM	Individual session	None
van Genugten <i>et al</i> ⁷⁰	2014	RCT	PA & DB	OB	Computer session	None

Continued

Table 1 Continued

Author	Published year	Study type	Intervention target	Health status	Intervention delivery	Rehabilitation
Vinkers <i>et al</i> ⁷¹	2014	RCT	PA & DB	OB	Group session plus individual session	None
Wilczynska <i>et al</i> ⁷²	2019	RCT	PA	OB, DM	Smartphone application plus individual session	None
Wooldridge <i>et al</i> ⁷³	2019	RCT	PA	DM	Group session plus individual session	None
Zakrisson <i>et al</i> ⁷⁴	2019	RCT	PA	COPD, CHF	Group session plus individual session	None
Zandstra <i>et al</i> ⁷⁵	2010	RCT	DB	OB	Individual session	None
Dombrowski <i>et al</i> ⁷⁶	2016	QE	PA & DB	OB	Individual session	None
Boekhout <i>et al</i> ⁷⁷	2018	QE	PA	NCD	Computer session	None
Fleig <i>et al</i> ⁷⁸	2011	QE	PA & DB	CVD	Computer session	Out-of-hospital
Göhner <i>et al</i> ⁷⁹	2012	QE	PA & DB	OB	Group session plus individual session	None
Kivelä <i>et al</i> ⁸⁰	2020	QE	PA & DB	NCD	Individual session	None
Leung <i>et al</i> ⁸¹	2019	QE	PA	DM, HP	Group session plus individual session	None
Richardson <i>et al</i> ⁸²	2012	QE	PA	NCD	Group session plus individual session	None

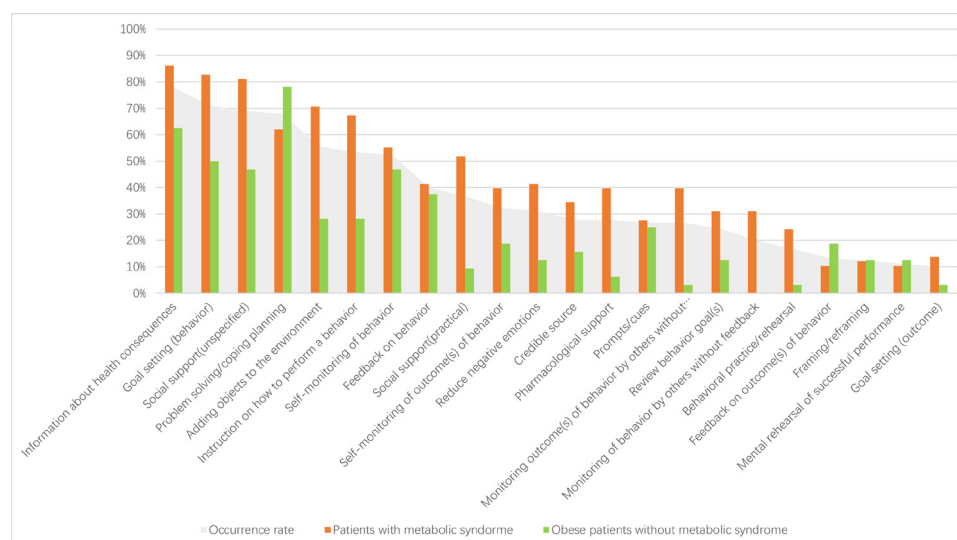
CBP, chronic back pain; CHF, chronic heart failure; CLD, chronic lung disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; DB, diet behaviour; DLP, dyslipidaemia; DM, diabetes mellitus; FH, familial hypercholesterolemia; HP, hypertension; NCD, non-communicable chronic disease; OB, obesity; OSAS, obstructive sleep apnoea syndrome; PA, physical activity; post-MI, post-myocardial infarction; QE, quasi-experiment; RCT, randomised controlled trial; SMI, severe mental illness.

above 50% for long-term DB outcomes. Overall, ‘self-monitoring of behaviour’, ‘problem solving’, ‘instruction on how to perform the behaviour’ and ‘adding objects to the environment’ were BCTs that were favoured by the planning interventions for both PA and DB long-term improvements.

Mapping BCT to MoA

BCTs in the planning intervention groups corresponded to 21 MoAs, 11 of which scored higher than 1. In addition to ‘behavioural cueing’ (which corresponded

to action planning), the top three MoAs in terms of occurrence were ‘intention’ (89%), ‘behavioural regulation’ (88%) and ‘beliefs about capabilities’ (87%). ‘Behavioural regulation’ was the highest scoring MoA, which was associated with an average of 1.6 BCTs. ‘Beliefs about capabilities’, ‘knowledge’ and ‘intention’ tied for second place, each with an average of 1.5 BCTs. A PA planning intervention involved an average of 8 MoAs, while a DB planning intervention involved an average of 11 MoAs. However, all MoAs in the PA planning

**Figure 2** Distribution of BCTs for different health conditions. BCTs, behaviour change techniques.

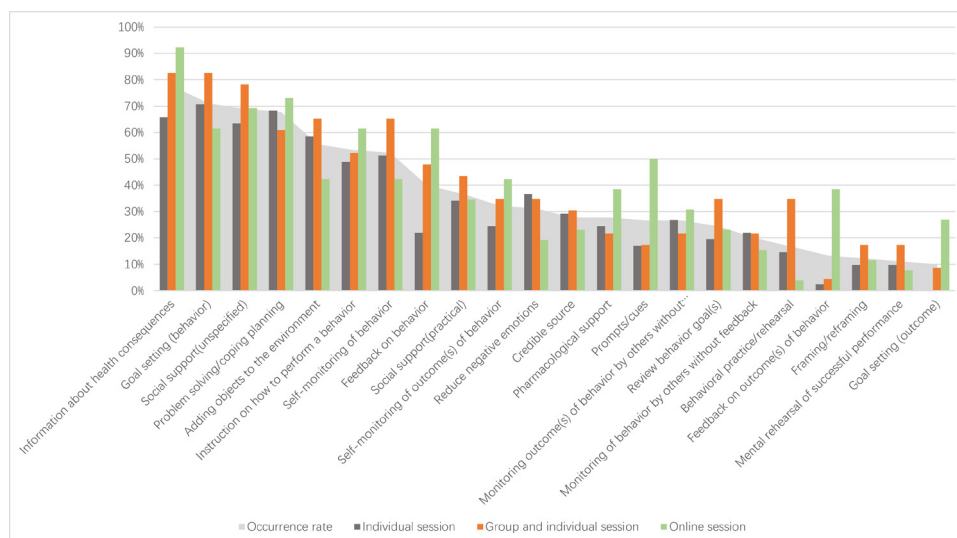


Figure 3 Distribution of BCTs for different intervention deliveries. BCTs, behaviour change techniques.

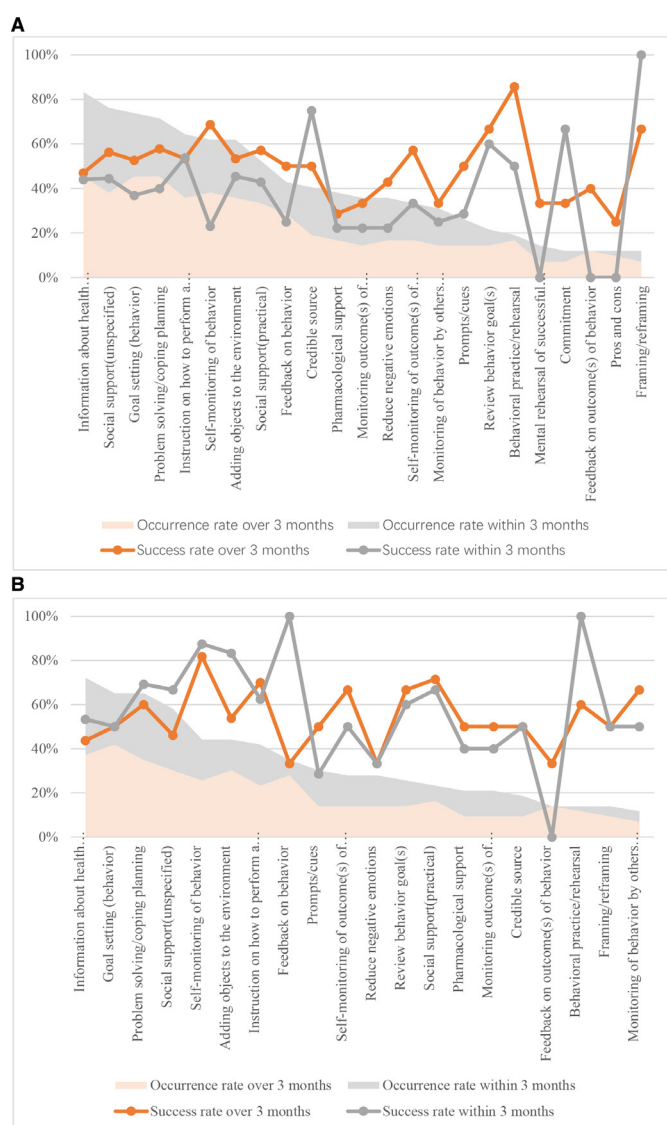


Figure 4 Occurrence and success rates of BCT in (A) physical activity and (B) diet behaviour planning intervention. BCTs, behaviour change techniques.

interventions scored higher than those in the DB planning interventions.

The results are displayed as heatmaps presenting the distribution of MoA scores (see figures 5 and 6). Table 2 displays the conceptualisation of the 11 MoAs that scored greater than 1 according to the HAPA model (columns 1 and 2), as well as their average scores for effective and ineffective planning interventions, distinguished by PA and DB outcomes (columns 4-7). Both effective and ineffective interventions covered both phases and all of the HAPA model's constructs. In the motivational phase, however, effective interventions exhibited higher scores in MoAs corresponding to self-efficacy (ie, 'beliefs about capabilities') and intention (ie, 'goals') than ineffective interventions. In the volitional phase, all effective intervention MoAs scored higher than ineffective intervention MoAs.

DISCUSSION

This study synthesised the BCT distributions and theoretical mechanisms in PA and/or DB planning interventions for community residents with chronic conditions. Overall, a total of 46 BCTs were identified from 52 included studies. There were 47PA intervention groups and 43DB intervention groups. 'Self-monitoring of behaviour', 'problem solving', 'instruction on how to perform the behaviour' and 'adding objects to the environment' were identified as critical BCTs. 'Behavioural regulation', 'beliefs about capabilities' and 'intention' were considered key MoAs. The following sections will elaborate on the results from the perspective of BCT distribution, intervention effectiveness and MoA.

Features of BCT distribution in planning intervention

We found that a planning intervention contains an average of eight BCTs in addition to action planning. This number is greater for PA planning interventions compared with DB planning interventions, for patients with MS versus obese patients without MS, and for group

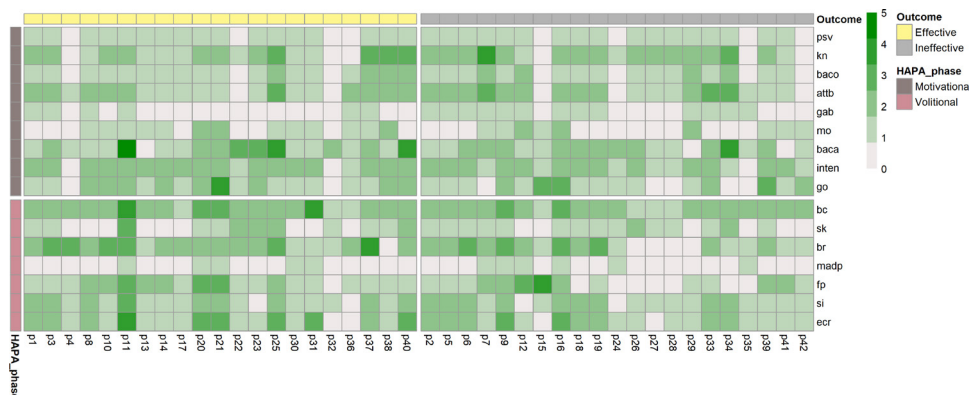


Figure 5 MoA score heatmap of physical activity planning intervention. HAPA, Health Action Process Approach; MoA, mechanism of action; psv, perceived susceptibility/vulnerability; kn, knowledge; baco, beliefs about consequences; attb, attitudes towards the behaviour; gab, general attitudes/beliefs; mo, motivations; baca, beliefs about capabilities; inten, intention; go, goals; bc, behaviour cueing; sk, skill; br, behavioural regulation; madp, memory, attention and decision processes; fp, feedback processes; si, social influences; ecr, environmental context and resources.

and individual session interventions compared with other delivery modes.

The top eight most popular BCTs in general were information about health consequences, behavioural goal setting, unspecified social support, problem solving, adding objects to the environment, instruction on how to perform the behaviour, self-monitoring of behaviour and feedback on behaviour. However, differences were detected in the most popular BCTs for different behaviours, disease populations and delivery modes. ‘Practical social support’ was only popular in PA planning interventions and interventions for patients with MS, and it was also identified as one of the key BCTs in previous reviews that synthesised the critical BCTs in PA interventions.^{84–86} ‘Feedback on behaviour’ was simply common in DB planning interventions and interventions aimed at obese patients without MS. Consistently, Cradock *et al* regarded it as one of the critical BCTs in DB interventions for patients with T2DM.⁸⁷ In addition, we found that face-to-face sessions frequently use ‘reduce negative emotions’, and online sessions often use ‘prompts/cues’. The latter was also detected in a past

review targeting mobile health application users. However, several previously identified BCTs failed to be captured in this review, for example, demonstration of behaviour,^{7 85} social comparison,⁸⁷ information about others’ approval,⁸⁵ credible source,⁸⁴ etc. This may be due to different interventions and populations of interest. However, it is insufficient to merely know what BCTs are popular because they are not always the most effective ones.

Considering intervention effectiveness, ‘self-monitoring of behaviour’, ‘problem solving’, ‘instruction on how to perform the behaviour’ and ‘adding objects to the environment’ are long-term universal facilitators for planning intervention. ‘Goal setting (behaviour)’, ‘social support (unspecified)’ and ‘social support (practical)’ are specific facilitators of PA planning. This is the first review to identify the critical BCTs based on the popularity and intervention’s efficacy by target behaviour and follow-up period, thereby enhancing the practical and reference value. Nevertheless, it is essential to comprehend the underlying mechanisms to design an effective planning intervention with a credible theoretical foundation.

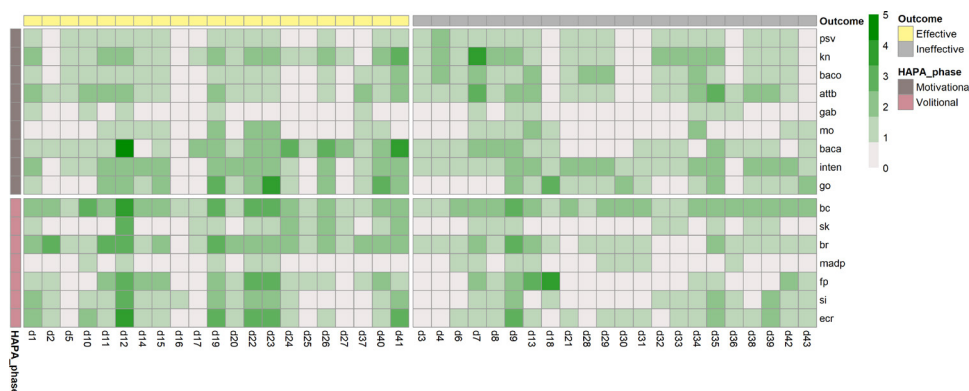


Figure 6 MoA score heatmap of diet behaviour planning intervention. HAPA, Health Action Process Approach; MoA, mechanism of action; psv, perceived susceptibility/vulnerability; kn, knowledge; baco, beliefs about consequences; attb, attitudes towards the behaviour; gab, general attitudes/beliefs; mo, motivations; baca, beliefs about capabilities; inten, intention; go, goals; bc, behaviour cueing; sk, skill; br, behavioural regulation; madp, memory, attention and decision processes; fp, feedback processes; si, social influences; ecr, environmental context and resources.

Table 2 Average mechanism of action scores for effective or ineffective planning intervention groups

HAPA framework			Mechanism of action score			
			Physical activity		Diet behaviour	
Motivation phase (goal setting)	Volitional phase (goal pursuit)	Mechanism of action	Effective (n=21)	Ineffective (n=21)	Effective (n=21)	Ineffective (n=22)
Risk perception		Knowledge	1.6	1.7	1.3	1.2
Outcome expectation		Beliefs about consequences	1.0	1.0	0.8	1.0
		Attitude towards the behaviour	1.4	1.6	1.1	1.2
Self-efficacy		Beliefs about capabilities	1.9	1.5	1.7	0.9
Intention		Intention	1.7	1.6	1.3	1.4
		Goals	1.4	1.2	1.3	0.9
	Planning	Behavioural cueing	2.1	1.9	2.0	1.8
	Action control	Behavioural regulation	2.0	1.5	1.8	1.0
	Self-efficacy	Feedback processes	1.5	1.1	1.3	0.8
	External support	Environmental context & resources	1.7	1.4	1.3	1.0
		Social influence	1.4	1.3	1.0	0.7

HAPA, Health Action Process Approach.

Interpretation of MoAs in planning intervention based on the HAPA model

The BCTs identified through planning interventions were primarily associated with 11 MoAs. They were conceptualised based on the HAPA model. We discovered that PA planning interventions are more diverse in BCT selection but less complex in potential theoretical mechanisms than DB planning interventions. The three mechanisms with the highest scores were 'intention', 'behavioural regulation' and 'beliefs about capabilities', which were also the three most prevalent. This indicates that they are the most frequently considered factors when designing PA or DB interventions for community-dwelling patients. A prior study also found that 'beliefs about capabilities' was the most frequently targeted theoretical domain in a PA intervention programme for patients with diabetes.²⁴ Furthermore, effective intervention groups had higher MoA scores for action self-efficacy, maintenance self-efficacy and all other volitional constructs, which appear to be able to account for intervention effectiveness. This finding is also consistent with the connotation of the HAPA model. Schwarzer proposed that the integrity and interpretability of the HAPA model with regard to varying situations of behaviour change remain to be perfected.⁸⁸ The findings of this review would be useful for enhancing the theoretical understanding and development of HAPA research, as well as for planning interventions to improve PA and DB in community-dwelling patients with chronic conditions.

Strengths and limitations

To the best of our knowledge, this is the first review identifying BCTs and MoAs in planning interventions aimed at improving PA and DB for community-dwelling patients

with chronic conditions. The summary of the characteristics of BCTs in terms of various target behaviours, chronic conditions and intervention deliveries has practical significance. The conceptualisation of identified MoAs according to the HAPA model further improves the theoretical understanding of the intervention of interest.

Several limitations exist in this review. First, the MoA score was unable to reflect the actual impact of the interventions, and data on social cognitive indicators were not collected. Second, population and language restrictions in the inclusion criteria limit the generalisability of the findings. Third, the validity of intergroup comparisons of intervention components was compromised by the fact that the coding of intervention content only accounted for the variety, but not the intensity, of each BCT. Fourth, the inclusion of non-RCT studies and dichotomous coding of intervention effectiveness diminished the evidence power. Fifth, both the overall quality of the included studies and fidelity of the planning interventions were inadequate. Due to the dichotomous approach, the fidelity assessment failed to capture the degree of each fidelity item.

Implications for future research

To design an effective PA or DB planning intervention, intervention designers should apply the prevalent BCTs identified with long-term effects in this review and consider the target population and intervention delivery. In addition, we also encourage future intervention studies on phase-based planning interventions, structuring as BCTs, and elaborating processes in a structured form (eg, intensity, frequency and delivery), as well as measuring implementation fidelity. When analysing complex behavioural interventions in the future, it is advised that implementation factors be considered. In addition, it was

suggested that data be collected on social cognitive indicators to determine the actual impact of BCTs on them.

CONCLUSIONS

In conclusion, the prevalent BCTs for planning interventions vary by target behaviour, chronic condition and intervention delivery. However, the most widely used BCTs are not always the most effective. To increase the success rate of exercise or diet planning interventions, it is best to employ BCTs that promote self-efficacy and volitional constructs of the HAPA model. The findings of this review may serve as an important reference for future research aimed at developing a rational and effective PA or DB intervention for individuals living in the community with chronic conditions.

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Behaviour changes techniques that constitute effective planning intervention to improve physical activity and diet behaviour for people with chronic conditions: a systematic review	1
ABSTRACT			
Structured summary	2	<p>Objectives: Action planning is a brief and effective behaviour change technique (BCT) to improve physical activity (PA) and diet behaviour (DB). This study aimed to identify critical BCTs and mechanisms of action (MoA) to interpret the effectiveness of planning interventions based on the health action process approach (HAPA) model.</p> <p>Design: Systematic review</p> <p>Data Sources: PubMed, Web of Science, CIHNAL (EBSCO), PsycInfo (EBSCO), Psychology and Behavioural Sciences Collection (EBSCO), psyARTICLES, and Medline were searched for studies from January 1990 to September 2021 published in English.</p> <p>Eligibility Criteria: Experiment involving action planning intervention to improve PA or DB in community-dwelling adult patients with chronic conditions.</p> <p>Data extraction and synthesis: Two reviewers independently coded the planning interventions into BCT combinations and MoA assemblies. Outcome was dichotomized according to the statistical power and Cohen's d. The Cochrane risk of bias assessment tool and the Risk of Bias in Nonrandomized Studies of Intervention assessment tool were used to assess the quality of RCTs and non-RCTs, respectively.</p> <p>Results: From the 52 included studies, 46 BCTs were identified and linked to 21 MoAs. Long-term facilitators for planning intervention included 'self-monitoring of behaviour', 'problem solving', 'instruction on how to perform the behaviour', and 'goal setting (behaviour)'. The most frequently occurring MoA was "beliefs about capabilities". The effective intervention groups had higher MoA scores that corresponded to the HAPA model constructs than the ineffective groups.</p> <p>Conclusions: The findings from this review may inform scientific and effective planning intervention designs for community-dwelling people with chronic conditions in the future.</p>	2
INTRODUCTION			
Rationale	3	One effective BCT popularized in PA or DB improvement is "action planning". It is defined as "prompt detailed planning of behaviour performance, including context, frequency, duration, and intensity". [6] A plan that specifies situational cues and sufficient action detail, such as, "I intend to go jogging in the park on Monday at 11:00 a.m." qualifies as an action plan. Several meta-analyses have confirmed the effectiveness of planning in improving PA [7-9] and DB, [7, 9-11] and they identified that reinforcement, [12] barrier management [8], and monitoring [11] were significant moderators. However, it is likely that some potential moderators have not yet been identified due to the absence of a theoretical and comprehensive synthesis of planning intervention components from the perspective of BCTs.	4
Objectives	4	By deconstructing the planning interventions into BCT combinations and MoA scores, this review aimed to (1) summarize the characteristics of BCT distribution and critical BCTs in PA and DB planning interventions targeting community-dwelling patients and (2) enhance comprehension of the theoretical mechanisms underlying the efficacy	5



PRISMA 2009 Checklist

		of planning interventions based on the HAPA model.	
METHODS			
Protocol and registration	5	The review was reported in accordance with PRISMA guidelines,[25] with the checklist available in Additional file 1. The protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42021241227).	5
Eligibility criteria	6	This review included both randomized controlled trials (RCTs) and non-RCTs. The inclusion criteria were presented according to "PICO." Participants were adults who lived in the community and had at least one chronic condition (participation). They received PA and/or DB planning intervention. Specifically, they were asked to create detailed action plans specifying when, where, and how to do things or to use an "if-then" form to create specific behavioural plans to improve PA or DB (Intervention). There should be no planning intervention in the control group (Comparison). Physiological or behavioural outcomes (as measured by self-report questionnaires or wearable devices) were considered (outcome). The exclusion criteria were as follows: (1) participants' plans did not qualify as action or coping plans; and (2) the intervention provider (e.g., nurses, health care professionals, etc.), rather than patients, was the research object.	6
Information sources	7	Seven electronic databases were searched, including PubMed, Web of Science, CIHNAI (EBSCO), PsycINFO (EBSCO), Psychology and Behavioural Sciences Collection (EBSCO), psyARTICLES, and Medline, for English language studies published from January 1990 to September 2021.	5-6
Search	8	Additional file 2 contains detailed information about the search strategy. Furthermore, manual searching was carried out via Google Scholar and the reference lists from previous meta-analyses. [8, 10-12]	6
Study selection	9	The title, abstract, and full text were reviewed independently and concurrently by HL and DX. Disagreements were discussed and resolved with the assistance of a third reviewer (ND).	6
Data collection process	10	HL extracted the following data from each included study...	7
Data items	11	...sample size, participant health status, intervention target (either PA or DB, or both), intervention delivery, rehabilitation, key outcome indicator and measuring method, follow-up time, and statistical power of outcome difference between planning intervention group and control. In studies with multiple outcome indicators, the behavioural outcome (e.g., pedometer) was selected first, followed by the physiological outcome and finally the self-reported outcome. In the case of DB, the physiological outcome came first, followed by the self-reported behavioural outcome.	7-8
Risk of bias in individual studies	12	RCT study quality was assessed using the Cochrane risk of bias assessment tool,[26] which included the following domains: (1) random sequence generation, (2) allocation bias, (3) performance bias related to participant and intervention provider blinding, (4) attrition bias due to missing data, (5) detection bias, and (6) reporting bias. In the final three domains, non-RCTs were also evaluated. Additionally, they were assessed for risk of baseline confounding due to one or more prognostic variables that predicted the intervention effect, selection bias due to participant inclusion/exclusion based on their characteristics, and performance bias due to deviation from intended interventions using the Risk of Bias in Nonrandomized Studies – of Interventions (ROBINS-I) assessment tools. [27] Each item's risk level was classified as "low risk," "high risk," or "uncertain."	7
Summary measures	13	intervention effectiveness was classified as "effective", "ineffective", or "inconclusive" based on the effect size (ES)	8



PRISMA 2009 Checklist

		and statistical significance of the key indicator. Cohen's d was used to calculate the magnitude of the ES by dividing the mean difference between the intervention and control groups by the standard deviation. [29] The rules for coding intervention effectiveness were as follows: if statistical power was significant ($p > 0.05$), the ES of an "effective" intervention should at least reach a small level ($d > 0.2$) for physiological measurement or device-based measurements, or a medium level ($d > 0.5$) for self-reported indicators, or it was coded as "ineffective." If there was no information on the statistical power or ES, it was classified as "inconclusive".	
Synthesis of results	14	<p>The occurrence rate of each BCT was calculated by dividing the number of groups that used this BCT by the total number of groups and was classified based on target behaviour, health condition, and mode of delivery. The success rate of each BCT was calculated by dividing the number of effective groups that used this BCT by the total number of groups that used this BCT and was classified as long-term (i.e., the follow-up period was longer than three months) and short-term (i.e., the follow-up period was not longer than three months). Notably, only BCTs involved in more than 10% of studies were included in subsequent analyses.</p> <p>The MoA scores for all planning intervention groups were displayed using the R software (version 3.6.1) heatmap drawing tool. [30] MoA with an average score greater than one indicates that, on average, at least one specific BCT was used to improve health behaviour change via this mechanism. These MoAs were further conceptualized with the HAPA model. Descriptive analyses were then performed on the difference in MoA score between effective intervention groups and ineffective intervention groups for PA and DB outcomes.</p>	8-9

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Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	No meta-analysis.	
Additional analyses	16	No meta-analysis.	
RESULTS			
Study selection	17	A total of 52 studies were included in the analysis (Figure 1).	9
Study characteristics	18	As shown in Table 1, there were 45 RCTs and 7 quasi-experiments. Thirty-nine studies included PA planning interventions, and 35 included DB planning interventions. Eleven trials included a rehabilitation period prior to action planning, nine of which occurred outside the hospital. Thirty-seven percent of the studies targeted obese patients without metabolic syndromes. The majority of studies administered the intervention via face-to-face sessions that were either individual-based (58%) or individual-and-group-based (25%). Nine studies provided merely online sessions. Three studies incorporated both individual sessions and online sessions based on computers [38, 75] or smartphone applications. [79]	9-10
Risk of bias within studies	19	A substantial proportion of studies were evaluated with a high/unclear risk of performance bias (58%) and reporting bias (58%). Attrition bias and detection bias were high for 33% and 58% of the included studies, respectively. Seven RCTs were assessed with insufficient random sequence generation, and 18 showed insufficient concealment of allocations. Five non-RCTs had a high risk of baseline confounding, and three had significant selection bias. Only five trials were evaluated as having low risk in every domain. [63, 71, 72]	10



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Results of individual studies	20	In summary, 47 groups contained PA planning interventions, of which 42 were available for effectiveness coding, while 43 groups contained DB planning interventions. Among the 46 BCTs identified, 24 occurred in more than 10% of the PA groups, and 21 occurred in more than 10% of the DB groups. The PA intervention group had an average of 11 BCTs, whereas the DB intervention group had an average of 8 BCTs. Janssen et al. [51] designed an intervention involving the maximum number of BCTs (N = 25).	12
Synthesis of results	21	No meta-analysis	
Risk of bias across studies	22	No meta-analysis	
Additional analysis	23	No meta-analysis	
DISCUSSION			
Summary of evidence	24	This study synthesized the BCT distributions and theoretical mechanisms in PA and/or DB planning interventions for community residents with chronic conditions. Overall, a total of 46 BCTs were identified from 52 included studies. There were 47 PA intervention groups and 43 DB intervention groups. "Self-monitoring of behaviour", "problem solving", "instruction on how to perform the behaviour", and "adding objects to the environment" were identified as critical BCTs. "Behavioural regulation", "beliefs about capabilities", and "intention" were considered key MoAs. The following sections will elaborate on the results from the perspective of BCT distribution, intervention effectiveness, and MoA.	13
Limitations	25	Several limitations exist in this review. First, the MoA score was unable to reflect the actual impact of the interventions, and data on social cognitive indicators were not collected. Second, population and language restrictions in the inclusion criteria limit the generalizability of the findings. Third, the validity of intergroup comparisons of intervention components were compromised by the fact that the coding of intervention content only accounted for the variety, but not the intensity, of each BCT. Fourth, the inclusion of non-RCT studies and dichotomous coding of intervention effectiveness diminished the evidence power. Fifth, both the overall quality of the included studies and fidelity of the planning interventions were inadequate. Due to the dichotomous approach, the fidelity assessment failed to capture the degree of each fidelity item.	16
Conclusions	26	In conclusion, the prevalent BCTs for planning interventions vary by target behaviour, chronic condition, and intervention delivery. However, the most widely used BCTs are not always the most effective. To increase the success rate of exercise or diet planning interventions, it is best to employ BCTs that promote self-efficacy and volitional constructs of the HAPA model. The findings of this review may serve as an important reference for future research aimed at developing a rational and effective PA or DB intervention for individuals living in the community with chronic conditions.	17
FUNDING			
Funding	27	This study was supported by the National Key Research and Development Program of China (No. 2020YFC2003403, 2020YFC2006405), the Key Research and Development Program of Ningxia Hui Autonomous of China (No. 2020BFG02002), and the Major Science and Technology Project in Hainan Province of China (No. ZDKJ2019012)	17

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Additional file 2. Search strategies for each database.

Database	Strategies for combining keywords
EBSCO (CIHNAI, PsycINFO, Psychology and Behavioural Sciences Collection, psyARTICLES, Medline)	"Implementation intention" OR "implementation intentions" OR "action planning" OR "action plan" OR "action plans" for all fields.
	AND
	Obese OR overweight OR obesity OR hypertension OR "high blood pressure" OR hypertensive OR "heart disease" OR cardiovascular OR "cardiac rehabilitation" OR atherosclerosis OR "coronary artery disease" OR "myocardial infarction" OR "myocardial ischemia" OR "heart failure" OR stroke OR cerebrovascular OR infarct OR "chronic pulmonary disease" OR COPD OR "chronic airway disease" OR COPD OR "airflow obstruction" OR "chronic lung disease" OR diabetes mellitus OR diabetic OR t2dm OR "chronic disease" OR "chronic condition" for title part.
PubMed	"Implementation intention" OR "action planning" OR "if-then" OR "implementation intentions" OR "action plan" OR "action plans" for all fields
	AND
	"Cardiovascular Diseases" OR "Diabetes Mellitus, Type 2" OR "Lung Diseases, Obstructive" OR "Chronic Disease" as [MeSH Terms]
Web of Science	Obese OR overweight OR obesity OR hypertension OR "high blood pressure" OR hypertensive OR "heart disease" OR cardiovascular OR "cardiac rehabilitation" OR atherosclerosis OR "coronary artery disease" OR "myocardial infarction" OR "myocardial ischemia" OR "heart failure" OR stroke OR cerebrovascular OR infarct OR chronic pulmonary disease OR COPD OR chronic airway disease OR COAD OR "airflow obstruction" OR chronic lung disease OR diabetes mellitus OR diabetic OR t2dm OR "chronic disease" OR "chronic condition") for title part
	AND
	"implementation intention" OR "action planning" OR "if-then" OR "implementation intentions" OR "action plan" OR "action plans" for all fields

Additional file 3. Quality assessment of included studies

Study (Author, published year)	Risk of bias items							Selection bias due to selection into the study based on participants characteristic observed after the start of intervention. (Only non-RCT)
	Selection bias due to inadequate generalization of randomized sequence. (Only RCT were assessed)	Selection bias due to inadequate concealment of allocations prior to assignment. (Only RCT were assessed)	Performance bias due to knowledge of the allocated interventions by participants and personnel during the study or deviations from	Detection bias due to knowledge of the allocated interventions by outcome assessors.	Attrition bias due to amount, nature or handling of incomplete outcome data	Reporting bias due to selective outcome reporting	Confounding bias due to one or more prognostic variables predict the intervention effect. (Only non-RCT were assessed)	
Almeida et al. 2015	Low risk	Unclear risk	Low risk	Unclear risk	Low risk	Low risk	/	/
Armitage et al. 2014	Low risk	Low risk	Unclear risk	Low risk	Low risk	Unclear risk	/	/
Armitage et al. 2017	Low risk	Low risk	Unclear risk	Low risk	High risk	Unclear risk	/	/
Ayre et al. 2020	Low risk	High risk	Unclear risk	High risk	Low risk	Low risk	/	/
Bélangier-Gravel et	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk	/	/
Breslin et al. 2019	Unclear risk	Low risk	High risk	Low risk	Unclear risk	Unclear risk	/	/
Broekhuizen et al.	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk	/	/
Cheung et al. 2017	Low risk	Low risk	Low risk	Low risk	High risk	Low risk	/	/
de Freitas Agondi et	Low risk	Unclear risk	High risk	Low risk	Low risk	Unclear risk	/	/
Duan et al. 2018	Unclear risk	Unclear risk	Low risk	Low risk	Low risk	High risk	/	/
Groeneveld et al.	Low risk	High risk	High risk	Low risk	Unclear risk	Low risk	/	/
Hayes et al. 2020	Low risk	Unclear risk	Low risk	Unclear risk	High risk	High risk	/	/
Helena et al. 2014	Low risk	Low risk	Unclear risk	Low risk	Low risk	Unclear risk	/	/
Jackson et al. 2005	Unclear risk	Low risk	Unclear risk	Unclear risk	Low risk	Unclear risk	/	/
Janssen et al. 2014	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	/	/
Kim et al. 2019	Low risk	Low risk	Low risk	Low risk	High risk	High risk	/	/
Luszczynska 2006	Low risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	/	/
Luszczynska, Scholz	Low risk	Low risk	Low risk	High risk	Low risk	Unclear risk	/	/
Luszczynska,	Low risk	Low risk	Unclear risk	Low risk	Low risk	Unclear risk	/	/
Obara-Golebiowska	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Low risk	High risk	/	/
Rodrigues et al.	Low risk	Unclear risk	Unclear risk	Unclear risk	Low risk	Unclear risk	/	/
Rodgers et al. 2014	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	/	/
Scholz et al. 2007	Low risk	Low risk	Unclear risk	Low risk	Low risk	High risk	/	/

Scholz et al. 2013	Low risk	Low risk	High risk	Unclear risk	High risk	High risk	/	/
Sniehotta et al. 2005	Low risk	Low risk	Unclear risk	Unclear risk	Unclear risk	High risk	/	/
Sniehotta et al. 2006	Low risk	Unclear risk	Unclear risk	Unclear risk	Low risk	Unclear risk	/	/
Sniehotta et al. 2011	Low risk	High risk	High risk	Low risk	Low risk	Low risk	/	/
Soureti et al. 2011a	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	/	/
Soureti et al. 2011b	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	/	/
Stevens et al. 2001	Low risk	Unclear risk	Unclear risk	Low risk	Low risk	High risk	/	/
Ströbl et al. 2013	High risk	Low risk	Unclear risk	Unclear risk	Low risk	Low risk	/	/
Svetkey et al. 2008	Low risk	Low risk	Low risk	Low risk	Low risk	High risk	/	/
Thoolen et al. 2009	Low risk	Unclear risk	High risk	Unclear risk	Low risk	Low risk	/	/
van Genugten et al.	Low risk	Low risk	Low risk	Unclear risk	High risk	Unclear risk	/	/
Vinkers et al. 2014	Low risk	Unclear risk	Low risk	Unclear risk	Low risk	Low risk	/	/
Wilczynska et al.	Low risk	Low risk	High risk	Unclear risk	Low risk	Low risk	/	/
Wooldridge et al.	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk	/	/
Zakrisson et al. 2019	Low risk	Low risk	Low risk	Low risk	Unclear risk	High risk	/	/
Zandstra et al. 2010	Low risk	Unclear risk	Unclear risk	Unclear risk	Low risk	High risk	/	/
Silva et al. 2020	Low risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	/	/
Christiansen et al.	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	/	/
Gagnon-Girouard et	Unclear risk	Unclear risk	Low risk	Low risk	Low risk	Unclear risk	/	/
Miller et al. 2016	High risk	Unclear risk	Unclear risk	Unclear risk	Low risk	Unclear risk	/	/
Kwasnicka et al.	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	/	/
Osborn et al. 2018	Low risk	High risk	High risk	Low risk	Low risk	Low risk	/	/
Boekhout et al. 2018	/	/	Low risk	Low risk	High risk	Low risk	High risk	Low risk
Dombrowski et al.	/	/	High risk	Low risk	Unclear risk	High risk	High risk	Low risk
Fleig et al. 2011	/	/	Low risk	High risk	Low risk	Low risk	High risk	High risk
Göhner et al. 2012	/	/	Low risk	Low risk	Unclear risk	Low risk	High risk	Low risk
Leung et al. 2019	/	/	High risk	Low risk	Unclear risk	High risk	Low risk	Low risk
Richardson et al.	/	/	Low risk	Low risk	Unclear risk	Low risk	Low risk	High risk
Kivelä et al. 2020	/	/	Unclear risk	Low risk	Unclear risk	Low risk	High risk	High risk

Additional file 4. Fidelity assessment of planning interventions

Study (Author, published year)	Fidelity assessment item				
	Treatment delivery (Is there any description of standardized procedure of planning intervention?)	Study design (Was there any auxiliary means for participants making qualified action plans?)	Provider training (Is there any description about standard training for intervention provider)	Enactment of Treatment skills (Was the action plan made by participant measured or documented)	Treatment receipt (Was the quality of action plans made by participant ensured or reviewed?)
Almeida et al. 2015	Yes	Yes	Online session	No	No
Armitage et al.	Yes	Yes	Online session	No	Yes
Armitage et al.	Yes	Yes	Online session	No	Yes
Ayre et al. 2020	Yes	Yes	No	Yes	Yes
Bélanger-Gravel et al. 2013	Yes	No	No	Yes	Yes
Boekhout et al.	Yes	Yes	Online session	No	No
Breslin et al. 2019	Yes	Yes	No	No	Yes
Broekhuizen et al. 2012	Yes	No	Online session	Yes	No
Cheung et al. 2017	Yes	No	No	Yes	No
de Freitas Agondi et al. 2014	Yes	Yes	No	No	No
Dombrowski et al. 2016	Yes	Yes	No	Yes	No
Duan et al. 2018	No	Yes	Online session	Yes	No
Fleig et al. 2011	No	No	No	Yes	No
Göhner et al. 2012	No	No	No	Yes	No
Groeneveld et al. 2011	No	No	No	No	No
Hayes et al. 2020	Yes	Yes	No	No	Yes
Helena et al. 2014	Yes	No	No	Yes	No
Jackson et al. 2005	Yes	Yes	No	No	No
Janssen et al. 2014	No	No	No	No	No
Kim et al. 2019	No	Yes	No	No	No
Leung et al. 2019	Yes	No	No	No	No

Study (Author, published year)	Treatment delivery (Is there any description of standardized procedure of planning intervention?)	Study design (Was there any auxiliary means for participants making qualified action plans?)	Provider training (Is there any description about standard training for intervention provider)	Enactment of Treatment skills (Was the action plan made by participant measured or documented)	Treatment receipt (Was the quality of action plans made by participant ensured or reviewed?)
Luszczynska 2006	Yes	Yes	No	Yes	Yes
Luszczynska, Scholz et al. 2007	Yes	Yes	No	No	Yes
Luszczynska, Sobczyk et al. 2007	Yes	Yes	No	Yes	Yes
Obara-Golebiowska et al. 2015	Yes	No	No	No	Yes
Rodrigues et al. 2013	Yes	No	No	No	Yes
Rodgers et al. 2014	Yes	Yes	No	No	No
Scholz et al. 2007	Yes	Yes	Yes	Yes	Yes
Scholz et al. 2013	Yes	Yes	Yes	Yes	Yes
Sniehotta et al.	Yes	Yes	No	Yes	Yes
Sniehotta et al.	Yes	Yes	Yes	No	Yes
Sniehotta et al.	No	Yes	No	Yes	Yes
Soureti et al. 2011a	Yes	Yes	Online session	Yes	Yes
Soureti et al. 2011b	Yes	Yes	Online session	Yes	Yes
Stevens et al. 2001	No	No	No	No	No
Ströbl et al. 2013	Yes	Yes	Yes	No	Yes
Svetkey et al. 2008	Yes	Yes	No	No	Yes
Thoolen et al. 2009	Yes	Yes	No	No	Yes
van Genugten et al. 2014	Yes	Yes	Online session	Yes	No
Vinkers et al. 2014	Yes	Yes	Yes	No	Yes
Wilczynska et al. 2019	Yes	Yes	No	Yes	No
Wooldridge et al. 2019	Yes	Yes	No	No	Yes
Zakrisson et al.	Yes	No	Yes	No	Yes
Zandstra et al. 2010	Yes	Yes	No	No	No

Study (Author, published year)	Treatment delivery (Is there any description of standardized procedure of planning intervention?)	Study design (Was there any auxiliary means for participants making qualified action plans?)	Provider training (Is there any description about standard training for intervention provider)	Enactment of Treatment skills (Was the action plan made by participant measured or documented)	Treatment receipt (Was the quality of action plans made by participant ensured or reviewed?)
Silva et al. 2020	Yes	Yes	No	No	Yes
Christiansen et al. 2010	Yes	Yes	No	No	Yes
Gagnon-Girouard et al. 2010	No	No	No	No	No
Richardson et al. 2012	Yes	Yes	Yes	Yes	No
Miller et al. 2016	Yes	No	No	Yes	Yes
Kwasnicka et al. 2020	Yes	No	Yes	Yes	Yes
Kivelä et al. 2020	Yes	Yes	Yes	No	No
Osborn et al. 2018	No	No	Yes	Yes	No

Additional file 5. Intervention coding into BCTs

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Luszczynska	p1	Action planning	received instructions about what implementation intentions should include
Luszczynska, Scholze et al. 2007	C, d1	Information about health consequence	... patients were reminded about the nutrition and physical activity guidelines
	C	Social reward	The patients were complimented for seeking social support
	d1	Action planning	...patients received instructions about implementation intentions training
Sniehotta et al. 2006	p2, p3	Action planning	...participants formed up to three action plans about when, where, and how they intended to exercise...
	p3	Coping planning	participants formed up to three coping plans about strategies to overcome anticipated barriers
Luszczynska, Sobczyk et al. 2007	C, p4(d2)	Self-monitoring of behavior Reduce negative emotions Avoidance/reducing exposure to cues for th behavior Framing/reframing Social support (unspecified)	The program consists of weekly 1-hr group meetings focusing on nutrition and physical activity, behavioral weight control strategies (i.e., self-monitoring, stress management, problem solving, and cognitive restructuring), and social support by group members
	p4(d2)	Action planning	The participants were invited to write detailed plans regarding six food categories
		Coping planning	participants were asked to make coping plans regarding risky or tempting
Scholz et al. 2007	p5, p6	Action planning	Participants received a planning sheet...
	p6	Coping planning	Participants received a planning sheet to write down up to three coping plans.
Soureti et al. 2011a	C, d3, d4	Information about health consequence	...They also received educational information on the importance of a healthy diet low in saturated fat.
	d4	Biofeedback	...They then received feedback on their future CVD risk in the form of the HA risk message. Heart-Age (HA) is the age corresponding to someone of the same gender with the same CVD risk level
		Salience of consequences	
	d3, d4	Action planning	Participants who received the PT selected from a list of 13 situations, in which they were tempted to eat unhealthily and then chose an approach to change their behavior from a list of 13 solutions.
		Coping planning	
Soureti et al. 2011b	C, d5, d6	Information about health consequence	All groups received educational information on the importance of a healthy diet low in saturated fat, ...

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Broekhuizen et al. 2012	d5, d6	Action planning	Participants who received the planning tool selected from a list of 13 situations, in which they were tempted to eat unhealthily and then chose an approach to change their behavior from a list of 13 solutions.
		Coping planning	
	d6	Prompt/cues	After completing the planning session, participants in the PTT entered their mobile number and chose a time band to receive text reminders of their plans.
	p7(d7)	Information about health consequence	... generic online CVD risk information was presented, containing feedback on CVD risk behaviours and their contribution to overall CVD risk, as well as information on the changeability of these behaviours...
		Information about antecedents	
		Feedback on outcomes of behavior	participants received six tailored advice on smoking, physical activity, saturated fat intake, fruit intake, vegetables intake and compliance to statin therapy.
		Instruction on how to perform the behavior	
		Feedback on behavior	
		Pharmacological support	awareness of one's own performance...
		Information about health consequence	Personalised feedback on compliance to statin therapy...
		Credible source	the participant and the personal coach further established the level of the participant's knowledge/awareness about FH and cardiovascular risk factors.
		Social support (unspecified)	one to five counsellor-initiated booster telephone sessions were performed during a period of 9 months to encourage the participant's behavioural changes.
		Prompt/cues	
Bélanger-Gravel et al. 2013	C, p8	Social support (unspecified)	
		Information about social and environmental consequences	
		Action planning	Giving personal feedback to participant's self-reported attitude and self-efficacy and by involving the social environment of the participant in making action plans.
		Coping planning	Stimulating participants to make action plans and discussing how to overcome possible barriers in behavioural change.
		Feedback on behavior	Feedback on baseline level of physical activity
		Information about health consequence	Information regarding recommended level of physical activity, health benefits and safety
		Goal setting (behavior)	Establishment of behavioural goals
		Self-monitoring of behavior	Distribution of a physical activity logbook
		Adding objects to the environment	Revision of the physical activity logbook
		Review behavior goals	
		Social support (unspecified)	General encouragement

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
		Adding objects to the environment	pedometer
	p8	Action planning Coping planning Credible source Social support (practical)	participants in the experimental condition (i.e. CA+IIs) completed an II task ('if-then' plans) regarding the classical what, when and where components ...participants attended two additional sessions for a total of three face-to-face sessions with a physical activity counsellor
Scholz et al. 2013	C, d8	Instruction on how to perform the behavior Information about health consequence Adding objects to the environment Feedback on behavior Social support (unspecified)	All participants received educational leaflets on a low-fat diet, based on recommendations of the Swiss Society of Nutrition. Next, they completed a self-check knowledge questionnaire on low-fat diet. Subsequently, participants could compare their answers with the correct answers and discuss this with a trained interviewer
	d8	Action planning	In a face-to-face situation with an undergraduate psychology student, ... participants were instructed to form up to three action plans on their low-fat diet.
Ströbl et al. 2013	p9(d9)	Coping planning Information about health consequence Goal setting (behavior) Goal setting (behavior) Self-monitoring of behavior Action planning Prompt/cues Social support (unspecified) Review behavior goals Feedback on behavior Coping planning Adding objects to the environment Credible source Social support (unspecified) Pharmacological support	Following this, participants were asked to form up to three coping plans. provide general information on behaviour-health link, ...prompt intention formation, ...prompt specific goal setting, ...prompt self-monitoring of behaviour; Patients were offered templates for the individual plans ... use of follow-up prompts, provide general encouragement, ... prompt review of behavioural goals, ... provide feedback on performance ...prompt barrier identification, relapse prevention. ...patients were given their booklets and invited to make individual physical activity and coping plans for the time after discharge. usual care included medical and nursing consultations, general counseling about pharmacological and nonpharmacological treatment, and treatment optimization.
de Freitas Agondi et al. 2014	C, d10		

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Helena et al. 2014	d10	Information about health consequence	patients received a letter containing information on the benefits of reducing dietary salt intake
		Action planning	participants were asked to indicate up to three actionplans on when,where,and how they thought they could reduce the salt added to food preparation
		Coping planning	Then, the women were asked to indicate obstacles or barriers that could interfere with the implementation of the plans they had proposed...
		Restructuring the physical environment	The women were asked to repeat aloud the plans and instructed to put the plans in a visible and strategic place at home.
		Prompt/cues	the plans developed were reinforced by telephone call.
	C, p10(d11)	Social support (unspecified)	Continuous positive airway pressure (CPAP) regimen included diagnosis by a physician (consultant in lung medicine).
		Information about health consequence	patients were informed about the association between overweight and sleep apnea and about the aim ofthe CPAP treatment.
		Self-monitoring of behavior	In clinical practice, the patients are then followed up with a whole-night sleep registration at home
		Adding objects to the environment	
		Feedback on behavior	the therapists strove to evoke and strengthen the individual's motivation to change and to encourage the patient to explore his or her own perceptions and thoughts regarding the pending behavioral changes.
		Social support (unspecified)	
		Framing/reframing	
		Goal setting (behavior)	a S-M-A-R-T (specific, measurable, achievable, relevant, and time limited) goal was set for the week to come.
		Action planning	The participants were asked to transform their intentions into an action plan for the physical activity and eating behavior change...
		Self-monitoring of behavior	The participants were encouraged to self-monitor their physical activity behavior and eating behavior
		Review behavior goals	At each meeting, the behavioral goals and action plan of the patient were reviewed and feedback was given on performance
		Feedback on behavior	
		Information about antecedents	Functional behavioral analyses were performed in order to identify functional relationships between antecedents, behavior, and consequences in each individual.
		Feedback on behavior	

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Janssen et al. 2014	p11(d12)	Coping planning	the participants and therapists discussed perceived barriers that could constrain their planned actions for behavioral performance. ...
		Information on health consequences	Information on consequences & Normative information.
		Self-monitoring of behavior	Self-monitoring of behaviour
		Focus on past success	Focus on past success
		Goal-setting(behavior)	Goal-setting
		Action planning	Action planning
		Graded tasks	Set graded tasks
		Behavioural contract	Agree behavioural contract
		Prompts/cues	Use prompts/cues
		Restructuring the physical environment	Environmental restructuring
		Social support (practical)	Plan social support
		Behavioral practice/ rehearsal	Prompt practice
		Coping planning	Barrier identification/problem-solving & Relapse prevention/coping planning
		Self-monitoring of outcomes of behavior	Self-monitoring of behaviour/outcome
		Feedback on behavior	Feedback on performance
		Social comparison	Facilitate social comparison
		Self-reward	Rewards contingent on success
		Review behavior goals	Review of goals
		Reduce negative emotions	Stress management/emotional control
		Adding objects to the environment	pedometers
van Genugten et al. 2014	C, p12(d13)	Information about health consequence	general information on weight gain prevention
	p12(d13)	Prompts/cues	Reminders to (re)visit the intervention were sent to the participants every two
		Goal setting (behavior)	asking them to weigh the pros and cons of weight gain prevention, and to choose
		Pros and cons	one behavior change and plan for that change.
		Self-monitoring of behavior	giving participants feedback on their performance during the previous week, based on self-reported behavior change.
		Feedback on behavior	
		Action planning	people were guided in choosing what they wanted to change (goal setting) and where. when. and how to make the change in an open format.

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Vinkers et al. 2014	C	Coping planning	people were asked whether they expected to encounter a risk situation and to think about this situation and to describe their strategy to avoid or handle
		Self-monitoring of outcomes of behavior	they were provided with a tool to monitor and evaluate changes in their body weight.
		Feedback on outcomes of behavior	Furthermore, written feedback is provided.
		Information about health consequence	The group sessions ... were led by one of three dieticians who were explicitly required to only provide nutritional knowledge
		Social support (unspecified)	
		Goal setting (behavior)	participants were asked to make a list with 10 unhealthy eating habits, and choose one habit they wanted to change
		Self-monitoring of behavior	Two written assignments were sent requiring participants to reflect on their goal progress
		Information about health consequence	participants were asked to change an unhealthy habit they would be able to maintain, and the importance of behavior maintenance was emphasized.
		Goal setting (behavior)	
		Information about health consequence	participants' motivation, dietary knowledge and expectations towards the intervention were discussed.
Obara-Golebiowska et al. 2015	C, d16	Goal setting (behavior)	(a) concrete, realistic goal setting; (b) exploring conditions and barriers to goal attainment; (c) appraisal of the barriers to goal attainment; (d) making specific if-then plans for action initiation and mental simulation of plans; and (e) evaluating progress
		Action planning	
		Mental rehearsal of successful performance	Participants were given a workbook that provided basic background information about weight management, 5-step plans, and diaries...
		Self-monitoring of behavior	
		Adding objects to the environment	
		Social support (unspecified)	participants were stimulated to discuss and make use of each other's knowledge and experience with weight management.
		Review behavior goals	renewing a goal that proved difficult to achieve in the past weeks and identifying specific goal-threatening situations and coping strategies
		Coping planning	
		Material reward (behavior)	the participants were offered a special reward based on their individual
		Action planning	participants developed a list of techniques for resisting high-calorie foods during and after the weight-loss program.
Armitage et al. 2017	C, d17	Social support (unspecified)	The ideas generated by the participants were discussed with others
		Instruction on how to perform the behavior	The volitional help sheet provides participants with a list of critical situations they may encounter and the responses they might find useful

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Cheung et al. 2017	C	Avoidance/reducing exposure to cues for the behavior	participants were simply asked to tick all the critical situations and appropriate responses that applied to them
		Action planning	Participants were asked to draw links between as many critical situations and appropriate responses as they wanted thereby forming implementation intentions
	p15(d18)	Coping planning	asked participants to set goals;
		Goal setting (behavior)	provided feedback regarding their weight, behavior, and socio-cognitive beliefs
		Feedback on behavior	
		Feedback on outcomes of behavior	
		Action planning	asked participants to make if-then plans specifying when, where, and how they would take specific actions to realize the behavior change
		Coping planning	provided participants the option to make coping plans
		Feedback on behavior	participants received tailored feedback about their behavior change progress by assessing current behavior and comparing to their weight and behavior before
		Discrepancy between current behavior and goal	
		Social comparison	role models narrating about their own change process and how they dealt with difficult situations
		Review outcome goals	participants received tailored feedback on their weight change by indicating whether or not they had achieved their weight goal
Duan et al. 2018	p16(d19)	Information about health consequence	risk perception, outcome expectancies, and goal setting;
		Goal setting (behavior)	
		Goal setting (outcome)	
		Action planning	development of action plans;
		Review behavior goals	revision and adjustment of previous action plans and development of coping plans;
		Coping planning	
		Review behavior goals	revision and adjustment of previous coping plans and development of behavior-specific social support
		Social support (practical)	patients received individualized feedback on their self-reported behavior
		Feedback on behavior	short message service (SMS) text messages were sent as reminders
		Prompts/cues	provided nutrition education, information on physical activity, and social support for making and maintaining behavior changes.
Stevens et al. 2001	p17(d20)	Information about health consequence	
		Social support (practical)	
		Action planning	self-monitoring, setting explicit short-term goals and developing specific action plans to achieve those objectives, and developing alternative strategies for situations that trigger problem eating.
		Self-monitoring of behavior	
		Goal setting (behavior)	
		Coping planning	

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Sniehotta et al. 2005	p18, p19	Action planning Coping planning Mental rehearsal of successful performance Commitment Adding objects to the environment	Participants received a planning booklet with two planning sheets for action plans and for coping plans
	p19	Self-monitoring of behavior Adding objects to the environment	they received by mail six weekly diaries after discharge, tailored to individual requirements.
Jackson et al. 2005	C, d21	Information about health consequence Adding objects to the environment Goal setting (behavior)	By use of an information postcard, participants were told what constitutes a portion of fruit and vegetables. They were asked to eat two extra portions of fruit or vegetables each day for the next 3 months. They then completed the TPB questionnaire.
		Monitoring outcomes of behavior by others without feedback	
Svetkey et al. 2008	d21 C, p20(d22), p21(d23)	Action planning Social support (practical) Instruction on how to perform the behavior Goal setting (behavior) Goal setting (outcome) Information about health consequence Self-monitoring of behavior Adding objects to the environment	The two implementation intentions were then written onto the back of the postcard A trained interventionist led 20 weekly group sessions over approximately 6 Intervention goals were for participants to reach 180 minutes per week of moderate physical activity (typically walking); reduce caloric intake; adopt the Dietary Approaches to Stop Hypertension dietary pattern, which has been shown to reduce CVD risk factors; and lose approximately 1 to 2 lb per week.
	C p20(d22)	Information about health consequence Goal setting (behavior) Feedback on behavior Feedback on outcomes of behavior	Participants were taught to keep food and physical activity self-monitoring records accelerometer participants received printed lifestyle guidelines with diet and physical activity recommendations. Interactive features allowed participants to set personal goals and action plans and to graph personal data over time.

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Thoolen et al. 2009	p21(d23)	Action planning	Modules addressed problem solving and motivation, and a bulletin board facilitated social support
		Coping planning	
		Social support (unspecified)	
		Self-monitoring of behavior	
		Self-monitoring of outcomes of behavior	
		Prompt/cues	participants were required to enter current weight and were encouraged to use the Web site for self-monitoring of physical activity and caloric intake.
		Prompt/cues	
		Social support (unspecified)	they were sent an e-mail reminder that was repeated after another week of no Participants had telephone contact with an interventionist each month, ...
		Goal setting (behavior)	
		Action planning	Each personal-contact session began with a self-reported weight and a review of progress since the last contact, including number of days on which a food diary was kept, frequency of weighing, average number of minutes of exercise, and progress on additional goals and action plans.
		Review behavior goals	
		Review outcome goals	
		Feedback on behavior	
		Feedback on outcomes of behavior	
		Self-monitoring of behavior	Each contact discussed the individual's barriers to weight loss maintenance and plans to overcome those barriers.
		Self-monitoring of outcomes of behavior	
		Coping planning	
	p22(d24)	Information about health consequence	The control group received a brochure on diabetes self-management.
		Instruction on how to perform the behavior	
		Adding objects to the environment	set small, concrete and attainable goals, recognise barriers to goal achievement, generate strategies for solving potential problems in specific situations, formulate specific action plans, and consider beforehand how to evaluate progress.
		Goal setting (behavior)	
		Coping planning	
		Action planning	
		Instruction on how to perform the behavior	During the sessions, the nurse primarily functions as coach, facilitating group interaction and practice with the proactive skills. ... keep a written daily register of goal-attainment
		Social support (unspecified)	
		Behavioral practice/ rehearsal	
		Self-monitoring of behavior	

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Zandstra et al. 2010	C, d25	Adding objects to the environment Mental rehearsal of successful performance Monitoring outcomes of behavior by others without feedback Instruction on how to perform the behavior Self-monitoring of behavior	Course material includes a patient workbook and a nurse's handbook Mental simulation is employed in each session to help patients become more proactive. participants were weighed on an electronic scale, received instructions on how to use the MR products and how to record consumption of the MR products
		Action planning Information about health consequence Instruction on how to perform the behavior Adding objects to the environment	Participants formed implementation-intentions Participants received two British Heart Foundation (BHF) booklets
Sniehotta et al. 2011	C, p23(d26)	Goal setting (behavior) Self-monitoring of behaviour (behavior) Action planning Coping planning Review behavior goals Behavioral practice/ rehearsal Self-reward	intention formation/goal setting, self-monitoring of behaviour, action planning, barrier identification/coping planning, review of behavioural goals, prompting practice, planning contingent rewards and relapse prevention.
Armitage et al. 2014	C, d27	Instruction on how to perform the behavior	Participants were both told that identifying situations in which they might be tempted to eat.
	C	Avoidance/reducing exposure to cues for the behavior	Participants were asked to tick as many or as few critical situations and appropriate responses that applied to them.
Rodrigues et al. 2013	d27	Action planning Coping planning	Participants were asked to draw links between as many critical situations and appropriate responses as they wanted
	C, p24	Goal setting (behavior) Instruction on how to perform the behavior	Participants were recommended to engage in regular exercise they were advised to increase their everyday PA, for example, by using a bicycle instead of a car
	p24	Action planning Coping planning	Participants received three identical planning sheets participants established up to three coping plans

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Wilczynska et al. 2019	p25	Prompt/cues	phone calls were made
		Framing/reframing	Increase motivation, Increase self-efficacy, self-reward
		Reduce negative emotions	Change negative outcome expectancies related to PA
		Instruction on how to perform the behavior	Provide strategies for overcoming barriers
		Action planning	Provide planning strategies and instructions
		Coping planning	Implement problem solving strategies, help change unhelpful automatic thoughts
		Self-monitoring of behavior	Provide self-monitoring strategies
		Social support (practical)	Social support
		Demonstration of behavior	Model or demonstrate behavior
		Feedback on behavior	Provide feedback on performance
		Behavioral practice/ rehearsal	Behavior reinforcement
		Social support (unspecified)	General encouragement
		Information about health consequence	Provide information about eCoFit Challenges
		Instruction on how to perform the behavior	Provide cognitive strategies to increase motivation and PA maintenance
		Information about social and environmental consequences	Promote outdoor environment for RT and aerobic activities
		Goal setting (behavior)	Goal setting
		Self-monitoring of behavior	Self-monitoring
		Restructuring the social environment	Social support
		Feedback on behavior	Progress tracking
		Adding objects to the environment	Pedometer
Hayes et al. 2020	C, d28, d29	Goal setting (behavior)	All participants were assigned five dietary goals.
		Self-monitoring of outcomes of behavior	Participants also were assigned the goal to weigh daily as regular weight self-monitoring promotes weight loss.
		Reduce negative emotions	Participants were introduced to the dietary goals and asked to read through brief psychoeducational materials regarding dietary change for weight loss.
		Information about health consequence	
		Information about emotional consequence	
		Action planning	Participants formed an implementation intention for each of the six goals.
	d28, d29	Prompt/cues	Text messages containing all implementation intentions and goal reminders

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Zakrisson et al. 2019	p26	Social support (emotional) Goal setting (behavior) Action planning Instruction on how to perform the behavior Behavioral practice/ rehearsal Social support (practical) Information about health consequence Prompts/cues	The group meeting was to achieve a positive and supporting atmosphere among the group members. Individual action plans and goal setting discussions for better self-management and behavioural changes were performed supporting the patients to practice skills and gain the knowledge they needed for better self-management and behavioural changes.
Ayre et al. 2020	C, d30, d31	Goal setting (behavior)	During the first, second, and third weeks, participants were emailed a reminder of their plan.
	C	Goal setting (behavior)	Participants were given a brief description of each action plan and then could choose which one they would like to use.
	d30, d31	Goal setting (behavior)	Participants were asked to select from a list 3 situations and to select the situation they would be happiest to change.
	d30	Action planning Review behavior goals Reduce negative emotions	Participants were asked to select 1 option from a list of possible plans participants were asked to imagine how it might feel to enact the plan Participants were advised to select a different plan from the list to reduce their perceived difficulty of enacting the plan.
	d31	Action planning Coping planning	Participants formulated a plan to reduce their unhealthy snacking Participants entered their selected situations and plan into text boxes.
Kim et al. 2019	C, p27(d32), p28(d33)	Information about health consequence Monitoring outcomes of behavior by others without feedback Pharmacological support Instruction on how to perform the behavior	nurse diabetes educators provided initial diabetes self-management education in which the content consisted of general information on diabetes mellitus, complications, blood glucose monitoring, nutritional management, exercise, and medication utilization, using different strategies.
	p27(d32), p28(d33)	Information about health consequence Social support (unspecified) Action planning	the educators distributed an easy-to-read diabetes education brochure The study interventionist encouraged patients to make an action plan for each week and provide answers to their questions
	p28(d33)	Restructuring the social environment	The social media-based self-management support was operated as a closed social media service

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Groeneveld et al. 2011	C, p29(d34)	Information about health consequence	The study interventionist uploaded diabetes self-management information in both video and short text formats
		Identification of self as role model	The study interventionist encouraged patients to share their diabetes management experiences on the discussion board.
		Information about health consequence	brochures were provided containing information on PA, healthy eating, smoking cessation, and CVD.
		Adding objects to the environment	
Almeida et al. 2015	C, p30, p31	Biofeedback	The participants received brief oral or written information from the occupational physician about their risk profile
		Feedback on behavior	This counselor applied a client-centered counseling style using MI techniques
		Social support (unspecified)	(1) participant's CVD risk profile was presented and his current health status was discussed. (2) participant decided to aim at PA and diet, or smoking. (3) participant was encouraged to indicate advantages and disadvantages of current and 'desired' behavior. (4) participant was asked to indicate his willingness, readiness, and perceived confidence. (5) participant formulated implementation intentions.
		Biofeedback	In the following counseling sessions, progress and barriers were discussed.
		Feedback on behavior	participants received 3 interactive voice response (IVR) support calls and 3 tailored newsletters
		Pros and cons	interventions began with an opening message about the importance of PA to achieving good health
		Goal setting (behavior)	the session included an interactive geographic information system (GIS) interface that allowed participants to select a free 12-month voucher to a fitness facility
		Action planning	
		Feedback on behavior	
		Social support (unspecified)	
Silva et al. 2020	p32	Prompt/cues	the session included personal action planning to improve self- and response-
		Information about health consequence	The session included an assessment of the patient's PA level
		Restructuring the physical environment	The program provided a range of minutes of PA that would be an appropriate starting point for the patient and used a collaborative goal setting process
		Adding objects to the environment	the session included assisting the patients with PA barrier identification and strategies to overcome barriers
		Action planning	with the researcher's help, participants were asked to form a plan on when, where and how they intended to walk for at least 30 minutes five times a week
		Feedback on behavior	... participants described the barriers to walking and formulated strategies to overcome them

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Fleig et al. 2011	p33(d35)	Goal setting (behavior) Framing/reframing Action planning Focus on past success Action planning Review behavior goals Mental rehearsal of successful performance Self-monitoring of behavior	post rehabilitation exercise goal setting, checking the self concordance of these goals, the formation of action plans, and the recall of positive exercise experiences. the formation of action plans, the reflection of positive exercise experiences, and an action control diary to self-monitor one's home-based behavior
Leung et al. 2019	p34	Information about social and environmental consequences Information about health consequence Behavioral practice/rehearsal Action planning Restructuring the physical environment Commitment Social support (practical) Instruction on how to perform the behavior Demonstration of the behavior Credible source Coping planning Social support (unspecified)	introduction of the concept of photovoice and the importance of doing regular physical activity; warm-up stretching exercises; capturing photos in the neighbourhood; sharing of thoughts when the participants reviewed the photos; identifying resources and facilities related to physical activity within the neighbourhood; formulating action plans for physical activity A health and fitness officer was invited to rectify the myths of physical exhaustion and guide the participants to do exercise
Dombrowski et al. 2016	C, p35(d36) p35(d36)	Behavioral contract Commitment Action planning Social support (unspecified) Credible source Coping planning Prompt/cues	...all participants worked together to find possible solutions/strategies to remove barriers for each individual. All people who participate in this programme are sufficiently motivated to actively sign up and commit personal time and money. The dietician then explained the idea of forming a detailed plan and provided an additional form participants specified which barriers they foresee and how to cope with them Participants were encouraged to use the planning form as a prompt/cue in their home environment.
Göhner et al. 2012	p36(d37)	Goal setting (behavior) Pros and cons Commitment	clarification of personal health objectives decisional balance sheet decision-making approach

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Christiansen et al. 2010	C, p37	Action planning Coping planning Self-monitoring of behavior Social support (unspecified)	generation of implementation intentions (“when-where-and-how plans”); anticipation of personal barriers and development of counter-strategies self-monitoring of the new behavior A trained psychologist (the principal investigator) delivered the modules in one-on-one sessions...The control group participated in the standard treatment such as physiotherapy under the guidance of qualified personnel
	p37	Information about health consequence Instruction on how to perform the behavior Reduce negative emotions Information about antecedents Pros and cons	The patients receive general information about pain (e.g., the relationship between pain and stress, interaction between the psychological and somatic factors of pain) in addition to medical care and consultation, physiotherapy, and physical therapy (e.g., massage) and education (relaxation techniques). To begin with, the patient, assisted by the psychologist, listed four positive and four negative aspects associated with “exercising more”... Next, the patients verbally elaborated two positive aspects of the desired future and two negative aspects of impending reality.
Gagnon-Girouard et al. 2010	d38, d39	Coping planning Action planning Information about health consequence Social support (emotional) Behavioral practice/rehearsal Reduce negative emotions Framing/reframing Avoidance/reducing exposure to cues for the behavior Goal setting (behavior)	We applied common cognitive behavioral therapeutic principles of problem solving, in particular the strategies of planning changes Finally, we assisted the patients in the formation of implementation intentions. Different themes such as enjoyment of physical activity and healthy nutrition, recognition of internal cues of hunger and satiety, identification of external influences on eating behaviors and food intake, and acceptance of one’s own and others’ body image were addressed through guided self-reflection and observations, group discussions, practical exercises, and lectures.
	d39	Action planning Social support (unspecified) Social support (practical) Goal setting (outcome)	...participants were asked to choose a personal objective and to design and present their own action plan in line with this objective. In the HAES group, the interveners were active leaders, providing specific information, structured activities, and counselling to participants.
Richardson et al. 2012	p38	Goal setting (behavior) Action planning	patients participated in collaborative goal setting with the therapist, Patients then created weekly action plans related to the goal using a self-management behaviour that addressed the functional goal.

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Miller et al. 2016	p39(d40)	Information about health consequence	The goals of the program were to build self-management skills, identify goals, set action plans and engage in problem solving approaches in a group setting.
		Instruction on how to perform the behavior	
		Information about social and environmental consequence	All participants ... received a Personal Health Record (PHR) booklet to record details of physical functioning and other aspects of their health.
		Self-monitoring of outcomes of behavior	
		Adding objects to the environment	
		Feedback on behavior	The study coordinator summarized the results of the assessment in terms of age- and sex-based norms within the record and responded to the participants' questions
		Social support (unspecified)	
		Self-monitoring of behavior	Weekly 60-minute group sessions were held and facilitated by a lifestyle coach using the program manual. The first 8 sessions presented the intervention goals, taught fundamental information about modifying energy and fat intake and increasing energy expenditure, and helped participants self-monitor....participants received a written manual with session material, food and PA trackers for self-monitoring, a graph for tracking weekly weights, and a booklet with the nutrient content of commonly consumed foods for self-monitoring
		Self-monitoring of outcomes of behavior	
		Adding objects to the environment	
		Information about health consequence	
		Instruction on how to perform the behavior	
		Social support (unspecified)	
		Goal setting (behavior)	
		Goal setting (outcome)	
		Action planning	
		Coping planning	
		Discrepancy between current behavior and goal	
		Information about health consequence	The lifestyle intervention was goal-based with a goal of losing 7% of initial body weight, progressively increasing PA to 150 minutes/week of at least moderate
		Adding objects to the environment	
		Social support (unspecified)	The latter 8 sessions focused on problem solving to achieving lifestyle goals, relapse prevention, and motivational factors for sustaining behavioral change...
Kwasnicka et al. 2020	p40(d41)	Discrepancy between current behavior and goal	The following week, participants were asked to review the success of their action plan and how it could be modified, if unsuccessful.
		Information about health consequence	The control group received an information booklet regarding lifestyle changes for diabetes prevention
		Adding objects to the environment	...to create more need supportive and less controlling environments
		Social support (unspecified)	
		Instruction on how to perform the behavior	The program supported participants to make small sustainable changes to their eating through portion control; reduced consumption of sugary drinks, energy-

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Kivelä et al. 2020	C, p41(d42)	Information about health consequence	dense foods, and alcohol; and a gradual increase in physical activity by choosing the activity that the men enjoy the most or could most easily incorporate into daily life.
		Goal setting (behavior)	
		Social support (practical)	This content was delivered in coach training with discussion of the basic principles of the theory, interactive activities (for example, scenarios, role-playing), detailed descriptions of these environmental components,...
		Behavioral practice/rehearsal	
		Demonstration of the behavior	
		Information about social and environmental consequence	
		Action planning	Aussie-FIT participants were supported in how to best form habits [14] and how to form specific action and coping plans (expanding on their initial SMART goals); these plans were revisited and revised during subsequent Aussie-FIT sessions.
		Coping planning	...participants and coaches being invited to join closed Facebook groups
		Review behavioral goals	
		Restructuring the social environment	Automated text messages, written in language to promote feelings of autonomy, competence, and relatedness, were sent each week to encourage session attendance
Osborn et al. 2018	C	Social support (unspecified)	In session 1, participants received an Aussie-FIT booklet with session summaries and space to complete in-session activities and to self-monitor their weight-loss progress and goals. Men also received activity monitors (Fitbit Zip), club t-shirts, and reusable 'LiveLighter' branded water bottles.
		Self-monitoring of behavior	
		Self-monitoring of outcomes of behavior	
		Adding objects to the environment	
		Social support (emotional)	Participants were free to communicate through the Facebook group with the coach and with each other.
		Social support (unspecified)	They received the usual care regarding their health problems from the physicians and nurses at the primary healthcare centres if they needed it... included assessment for the need of treatment, physical examination, problem assessment, laboratory and X-ray tests, medical advice and patient support and education during their visits.
		Information about health consequence	
		Feedback on outcome(s) of behavior	...nurse coaches helped ... to identify their life situations and define their goals for the plans. The goals and health coaching focused on the management and
		Reduce negative emotions	The frequent attenders received their written plans for home self care support.
		Goal setting (behavior)	
	p41(d42)	Action planning	
		Adding objects to the environment	
		Social support (emotional)	In the follow-up sessions, the nurse coaches assessed their stage of changes, motivated them toward lifestyle and behavioural changes, gave emotional support. The usual clinical pathways for cardiovascular disease risk factors were continued in this group. British Heart Foundation leaflets were mailed out to participants.
		Feedback on behavior	
		Adding objects to the environment	

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Boekhout et al. 2018	p42(d43)	Information about health consequence Monitoring outcomes of behavior by others without Social support (unspecified) Goal setting (behavior) Feedback on behavior Review behavioral goals Action planning Coping planning Adding objects to the environment	These included setting a behavioural goal, involving supportive others, creating an action plan, recording progress, providing positive feedback, reviewing progress, coping with setbacks, and forming habits.
	p43	Pros and cons Information about social and environmental consequences Feedback on behavior Action planning Coping planning Restructuring the social environment Information about health consequence	British Heart Foundation leaflets on keeping your heart healthy were given to intervention nurses or health-care assistants to distribute to participants at their first Primrose appointment. raise consciousness of the current level of PA; motivates participants to increase physical activity participants receive planning sheets that the participant is stimulated to use in order to plan PA: formats how they plan to deal with difficult situations that may interfere with PA received brochures from local PA-exercise groups received medical information on exercising with a physical limitation.
Breslin et al. 2019	C, p44	Information about health consequence Credible source Social support (practical) Instruction on how to perform the behavior	Participants received a weekly multicomponent weight loss program, delivered in a group setting by a trained professional weight loss practitioner Participants received an eating plan to promote a healthier life
	p44	Social support (unspecified) behavioral practice/rehearsal Demonstration of the behavior Instruction on how to perform the behavior	... individual physical activity 30-minute long consultations took place in weeks two, three and four participants attended a 30-minute long group educational physical activity session

Studies	Intervention group ID	Behavior change technique	Coding based on the original article
Rodgers et al. 2014	p45	Goal setting (behavior)	The consultation session included discussions about possible discrepancies between the individual's activity levels and recommended guidelines; goal setting; and problem solving
		Discrepancy between current behavior and goal	
		Coping planning	
		Self-monitoring of behavior	
		Action planning	
Wooldridge et al. 2019	C, p46, p47	Feedback on behavior	Participants completed a physical activity log each day to enhance self-monitoring participants formed weekly physical activity implementation intentions researcher checked the log details matched with what was said to be performed One investigator delivered an information lecture on the importance of exercising
		Information about health consequence	
		Social support (unspecified)	
		Information about antecedents	
		Action planning	
	p46, p47	Instruction on how to perform the behavior	Participants received educational materials including a worksheet for overcoming barriers to physical activity
		Information about health consequence	
		Adding objects to the environment	
		Action planning	
		Social support (practical)	
	p47		accelerometer
			To develop plans, participants followed a template in which they completed IF-THEN statements
			The plan was made jointly with partners

Note: In the second column, "C" refers to control group. Lowercase "P" followed by a number refers to the group with interventions aiming to improve physical activity. Lowercase "D" followed by a number refers to the group with interventions targeting diet behavior.

Additional file 6. Intervention effectiveness coding

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Luszczynska, Scholz et al. 2007	Diet behavior	d1	6	Effective	Self-reported behavior	Medium	1
Luszczynska, Sobczyk et al. 2007	Diet behavior	d2	2	Effective	Physiological	Small	1
Soureti et al. 2011a	Diet behavior	d3	1.25	Effective	Self-reported behavior	Medium	1
Soureti et al. 2011a	Diet behavior	d4	1.25	Ineffective	Self-reported behavior	No effect	0
Soureti et al. 2011b	Diet behavior	d5	1.25	Effective	Self-reported behavior	Small	1
Soureti et al. 2011b	Diet behavior	d6	1.25	Ineffective	Self-reported behavior	No effect	0
Broekhuizen et al. 2012	Diet behavior	d7	12	Ineffective	Physiological	No effect	0
Scholz et al. 2013	Diet behavior	d8	6	Ineffective	Self-reported behavior	No effect	0
Ströbl et al. 2013	Diet behavior	d9	6	Ineffective	Physiological	No effect	0
de Freitas Agondi et al. 2014	Diet behavior	d10	2.5	Effective	Physiological	Medium	1
Helena et al. 2014	Diet behavior	d11	6	Effective	Physiological	Medium	1
Janssen et al. 2014	Diet behavior	d12	6	Effective	Physiological	Small	1

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
van Genugten et al. 2014	Diet behavior	d13	6	Ineffective	Physiological	No effect	0
Vinkers et al. 2014	Diet behavior	d14	1	Effective	Physiological	Small	1
Vinkers et al. 2014	Diet behavior	d15	1	Effective	Physiological	Small	1
Obara-Golebiowska et al. 2015	Diet behavior	d16	0.5	Effective	Self-reported behavior	Medium	1
Armitage et al. 2017	Diet behavior	d17	6	Effective	Physiological	Medium	1
Cheung et al. 2017	Diet behavior	d18	6	Ineffective	Physiological	No effect	0
Duan et al. 2018	Diet behavior	d19	2	Effective	Self-reported behavior	Large	1
Stevens et al. 2001	Diet behavior	d20	6	Effective	Physiological	Medium	1
Jackson et al. 2005	Diet behavior	d21	3.2	Ineffective	Self-reported behavior	No effect	0
Svetkey et al. 2008	Diet behavior	d22	30	Effective	Physiological	Small	1
Svetkey et al. 2008	Diet behavior	d23	30	Effective	Physiological	Small	1
Thoolen et al. 2009	Diet behavior	d24	12	Effective	Physiological	Small	1
Zandstra et al. 2010	Diet behavior	d25	1	Effective	Physiological	Small	1

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Sniehotta et al. 2011	Diet behavior	d26	6	Effective	Physiological	Medium	1
Armitage et al. 2014	Diet behavior	d27	1	Effective	Physiological	Small	1
Hayes et al. 2020	Diet behavior	d28	1	Ineffective	Physiological	No effect	0
Hayes et al. 2020	Diet behavior	d29	1	Ineffective	Physiological	No effect	0
Ayre et al. 2020	Diet behavior	d30	1	Ineffective	Self-reported behavior	No effect	0
Ayre et al. 2020	Diet behavior	d31	1	Ineffective	Self-reported behavior	No effect	0
Kim et al. 2019	Diet behavior	d32	2.25	Ineffective	Physiological	No effect	0
Kim et al. 2019	Diet behavior	d33	2.25	Ineffective	Physiological	No effect	0
Groeneveld et al. 2011	Diet behavior	d34	6	Ineffective	Self-reported behavior	Small	1
Fleig et al. 2011	Diet behavior	d35	1.5	Ineffective	Self-reported behavior	Small	1
Dombrowski et al. 2016	Diet behavior	d36	2.5	Ineffective	Physiological	No effect	0
Göhner et al. 2012	Diet behavior	d37	6	Effective	Physiological	Medium	1
Gagnon-Girouard et al. 2010	Diet behavior	d38	6	Ineffective	Physiological	No effect	0

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Gagnon-Girouard et al. 2010	Diet behavior	d39	6	Ineffective	Physiological	No effect	0
Miller et al. 2016	Diet behavior	d40	3	Effective	Physiological	Large	1
Kwasnicka et al. 2020	Diet behavior	d41	6	Effective	Physiological	Small	1
Kivelä et al. 2020	Diet behavior	d42	12	Ineffective	Physiological	No effect	0
Osborn et al. 2018	Diet behavior	d43	12	Ineffective	Physiological	No effect	0
Luszczynska 2006	Physical activity	p1	8	Effective	Self-reported behavior	Medium	1
Sniehotta et al. 2006	Physical activity	p2	2.5	Ineffective	Self-reported behavior	No effect	0
Sniehotta et al. 2006	Physical activity	p3	2.5	Effective	Self-reported behavior	Medium	1
Luszczynska, Sobczyk et al. 2007	Physical activity	p4	2	Effective	Physiological	Small	1
Scholz et al. 2007	Physical activity	p5	2.5	Ineffective	Self-reported behavior	No effect	0
Scholz et al. 2007	Physical activity	p6	2.5	Ineffective	Self-reported behavior	Small	1
Broekhuizen et al. 2012	Physical activity	p7	12	Ineffective	Physiological	No effect	0
Bélanger-Gravel et al. 2013	Physical activity	p8	6	Effective	Device-based	Medium	1

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Ströbl et al. 2013	Physical activity	p9	6	Ineffective	Self-reported behavior	Small	1
Helena et al. 2014	Physical activity	p10	6	Ineffective	Device-based	No effect	0
Janssen et al. 2014	Physical activity	p11	6	Effective	Device-based	Medium	1
van Genugten et al. 2014	Physical activity	p12	6	Ineffective	Physiological	No effect	0
Vinkers et al. 2014	Physical activity	p13	1	Effective	Physiological	Small	1
Vinkers et al. 2014	Physical activity	p14	1	Effective	Physiological	Small	1
Cheung et al. 2017	Physical activity	p15	6	Ineffective	Physiological	No effect	0
Duan et al. 2018	Physical activity	p16	2	Effective	Self-reported behavior	Medium	1
Stevens et al. 2001	Physical activity	p17	6	Effective	Physiological	Medium	1
Sniehotta et al. 2005	Physical activity	p18	4	Ineffective	Self-reported behavior	No effect	0
Sniehotta et al. 2005	Physical activity	p19	4	Ineffective	Self-reported behavior	No effect	0
Svetkey et al. 2008	Physical activity	p20	30	Effective	Device-based	Small	1
Svetkey et al. 2008	Physical activity	p21	30	Effective	Device-based	Small	1

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Thoolen et al. 2009	Physical activity	p22	12	Effective	Physiological	Small	1
Sniehotta et al. 2011	Physical activity	p23	6	Effective	Physiological	Medium	1
Rodrigues et al. 2013	Physical activity	p24	2	Ineffective	Self-reported behavior	Small	1
Wilczynska et al. 2019	Physical activity	p25	5	Effective	Device-based	Small	1
Zakrisson et al. 2019	Physical activity	p26	12	Ineffective	Device-based	No effect	0
Kim et al. 2019	Physical activity	p27	2.25	Ineffective	Physiological	No effect	0
Kim et al. 2019	Physical activity	p28	2.25	Ineffective	Physiological	No effect	0
Groeneveld et al. 2011	Physical activity	p29	6	Ineffective	Self-reported behavior	No effect	0
Almeida et al. 2015	Physical activity	p30	1	Effective	Self-reported behavior	Medium	1
Almeida et al. 2015	Physical activity	p31	1	Effective	Self-reported behavior	Medium	1
Silva et al. 2020	Physical activity	p32	6	Effective	Physiological	Small	1
Fleig et al. 2011	Physical activity	p33	1.5	Ineffective	Self-reported behavior	Small	1
Leung et al. 2019	Physical activity	p34	2.5	Ineffective	Device-based	No effect	1

Study (Author, published year)	Dependent variable	Group ID	Follow up time (month)	Intervention effectiveness	Category of key indicator	Effect size magnitude	Statistical power of group difference in outcome (1-significant, 0-insignificant)
Dombrowski et al. 2016	Physical activity	p35	2.5	Ineffective	Physiological	No effect	0
Göhner et al. 2012	Physical activity	p36	6	Effective	Physiological	Medium	1
Christiansen et al. 2010	Physical activity	p37	3	Effective	Physiological	Medium	1
Richardson et al. 2012	Physical activity	p38	6	Effective	Self-reported behavior	Medium	1
Miller et al. 2016	Physical activity	p39	3	Ineffective	Device-based	No effect	0
Kwasnicka et al. 2020	Physical activity	p40	3	Effective	Device-based	Small	1
Kivelä et al. 2020	Physical activity	p41	12	Ineffective	Physiological	No effect	0
Osborn et al. 2018	Physical activity	p42	12	Ineffective	Physiological	No effect	0
Boekhout et al. 2018	Physical activity	p43	6	Inconclusive	Self-reported behavior	Unclear	0
Breslin et al. 2019	Physical activity	p44	1.5	Inconclusive	Device-based	Unclear	1
Rodgers et al. 2014	Physical activity	p45	6	Inconclusive	Device-based	Unclear	1
Wooldridge et al. 2019	Physical activity	p46	1.5	Inconclusive	Device-based	Unclear	1
Wooldridge et al. 2019	Physical activity	p47	1.5	Inconclusive	Device-based	Unclear	1