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

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		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, CIHNAL (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

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		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	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. 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.	8-9

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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
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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

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