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Mapping behavior change techniques to characterize a social cognitive theory informed physical activity intervention for adults at risk of type 2 diabetes mellitus

Abstract

Background: Behavior change techniques (BCTs) are used to target theoretical mechanisms of action predicted to bring about behavior change. Reporting BCTs and connecting them to mechanisms of action is critical to understanding intervention processes of change. **Purpose:** This paper identifies the BCTs associated with an exercise intervention for individuals at risk of type 2 diabetes and determines the extent to which these BCTs target associated mechanisms of action. **Methods:** BCTs were mapped onto Social Cognitive Theory (SCT) and the Theoretical Domains Framework (TDF) using published literature identifying links between BCTs and SCT/TDF and expert consensus. Two coders then used the 93-item BCT taxonomy (BCTTv1) to independently code BCTs within the intervention. The BCTs used in the current intervention enabled identification of the theoretical mechanisms of action targeted in the intervention. **Results:** Over 70% of the intervention content incorporated at least one BCT. Over 50% of the BCTs used targeted SCT constructs and over 70% of BCTs used targeted at least one of the 14 TDF domains. Five BCTs did not map onto either SCT or TDF. **Conclusion:** This research provides a systematic method of linking BCTs to mechanisms of action. This process increases the transparency of intervention content and identification of the mechanisms of action targeted in the current intervention. Reporting interventions in this manner will enable the most potent mechanisms of actions associated with long-term behavior change to be identified and utilized in future work.

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Key words: behavior change techniques, mechanisms of action, intervention

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By 2040, approximately 642 million individuals worldwide will be diagnosed with diabetes, of which 90% will be type 2 diabetes mellitus (T2DM; [1]). Diabetes prevention programs that target lifestyle modification, including physical activity behavior, can prevent the onset of type 2 diabetes by up to 58% [2]. However, the effectiveness of such lifestyle modification programs for the prevention of diabetes are highly variable, with increased levels of physical activity not maintained in the long-term [3,4]. Given the high financial cost of diabetes prevention programs [5], it is important for research efforts to establish the most effective method of improving the long-term impact of behavior change programs.

Critical to improving the long-term effectiveness of lifestyle behavior change programs is an understanding of how an intervention was developed (i.e., the theoretical rationale) and detailed reporting of intervention content (i.e., the active components of an intervention). Historically, however, efforts to advance behavior change interventions have been slowed due to a lack of theoretical rationale and poor reporting of intervention characteristics, thereby limiting intervention replication and improvement [6].

In recent years there has been an increase in the number of standardized tools designed to assist in the reporting of intervention content. In 2008, Abraham and Michie [7] developed a taxonomy of distinct behavior change techniques (BCTs) in an effort to create a standardized vocabulary regarding intervention content. BCTs represent the smallest component of an intervention and are the active ingredients of behavior change interventions that aim to bring about change [8]. The 2008 BCT taxonomy was refined in 2013 by Michie and colleagues to include a comprehensive list of 93 BCTs, grouped into 16 categories (BCTTv1)[9]. The

characterization of interventions based on BCTs is becoming increasingly common place and has assisted in the consistent comparison of interventions [10]. Furthermore, checklists such as the Template for Intervention Description and Replication (TIDieR; [11]) encourage researchers to provide intervention details pertaining to what is delivered, by whom, to whom, when, and by which delivery mode. However, to develop a complete understanding of how interventions impact behavior change, the *BCTs need to be linked to the theoretical mechanisms of action* proposed to influence behavior change [12,13,14].

Theoretical mechanisms of action are defined as the ‘processes through which a behavior change technique affects behavior’ [12] and are conceptualized as a range of theoretically derived constructs. Outlining and subsequently empirically supporting the relationships between BCTs and the theoretical constructs will enable interventionists to target the theoretical constructs and their associated BCTs likely to bring about change [12]. Within physical activity and dietary interventions only 10.3% of published interventions link intervention components to the proposed theoretical constructs [15]. This could be because there has been no agreed upon consensus on how to link the active ingredients of interventions to hypothesized mechanisms of action. Without a coherent, systematic method of understanding how BCTs impact underlying theoretical constructs, researchers are unable to systematically synthesize evidence.

Reverse coding interventions can help to identify specific BCTs utilized and these can be mapped onto theoretical constructs or domains. This ‘reverse coding’ is important as it enables researchers to a) describe existing interventions in terms of BCTs, b) link BCTs to theoretical constructs from which an intervention has been designed, c) determine whether specified theoretical constructs have been targeted, through which BCTs and with what frequency, d) examine the effectiveness of these constructs on positively influencing behavior and e) make

suitable modifications to an existing intervention content based on the results. Steinmo and colleagues [16] outlined the process of reverse coding an implementation intervention within a primary care setting using the Behavior Change Wheel, 93-item BCTTv1 and the Theoretical Domains Framework (a consolidation of 33 behavior change theories into 14 domains, consisting of 84 constructs) to characterize the content and theoretical mechanisms of action. However, to date no studies have used this technique in the context of physical activity behavior in the general population or among individuals at risk of type 2 diabetes. Recent work published from the Theory and Techniques Project (<https://www.ucl.ac.uk/health-psychology/research/TaT>) has helped to create tools that can be used to ‘reverse code’ interventions by linking BCTs to mechanisms of action through synthesis of existing literature [17] and by expert consensus [18].

The aim of the present study is to a) identify the active ingredients (i.e., BCTs) associated with *Small Steps for Big Changes* (hereon in referred to as *Small Steps*), a 2-week supervised exercise intervention with long-term follow-up, using the 93-item BCTTv1 [9] and b) determine to what extent these BCTs target associated underlying mechanisms of action. To do this the 93-item BCTTv1 was mapped onto social cognitive theory (SCT) and the Theoretical Domains Framework (TDF).

The design of the *Small Steps* was informed by social cognitive theory [9,19] and evidence-based techniques associated with physical activity behavior change. In alignment with social cognitive theory, *Small Steps* was designed to target task self-efficacy, self-regulatory efficacy, and outcome expectations, which are shown to be strongly associated with physical activity among individuals with type 2 diabetes mellitus [20,21] and are considered effective theoretical constructs for physical activity behavior change [22,23]. The additional evidence-based theoretical constructs that are included in *Small Steps* target action planning, self-monitoring and

relapse prevention, which are constructs reported to significantly impact the effectiveness of physical activity interventions [24,25]. Mapping BCTs onto the theoretical domains framework is necessary to capture these additional evidence-based mechanisms of action that move beyond SCT given the explicit inclusion of techniques known to positively influence physical activity behavior. Initial findings from a pilot of the Small Steps program showed significant increases in self-efficacy, outcome expectations, and higher engagement in moderate-vigorous physical activity at 1- and 6-months post-program completion [26,27]. Reporting the outcomes of Small Steps was the first step to disseminating the program. To date, however, a detailed description of the Small Steps program content in the language of the BCTTv1 and how these link to the mechanisms of action is unknown.

Methods

The Intervention - Small Steps for Big Changes

Individuals completed 10 exercise sessions over a two-week period. Seven were one-on-one supervised sessions in the laboratory. Three sessions were conducted at home to promote the practice of independent exercise. Each supervised exercise session lasted 30 to 60 minutes and included a behavior change counselling component. Participants self-selected the exercise format (e.g., bike, treadmill, walking inside or outside) in four of the seven supervised sessions to encourage autonomy. Two sessions (session 1 and 10) were conducted on the cycle ergometer and one session (session 2) was conducted outdoors. Participants were assigned to either a high-intensity interval training intervention (HIIT) or a more traditionally prescribed moderate-intensity continuous training intervention (MICT). Following completion of the 2-week program, participants were instructed to engage in exercise, of the assigned modality (i.e., HIIT or MICT), three times per week for 12-months. Participants were provided with a mobile-based self-

monitoring application and asked to check-in daily and record their physical activity behavior. The mobile application allowed participants up to four “non-exercise days”, which were recorded as rest days. A counsellor monitored participants progress and, in the event of three consecutive missed check-ins, the participant was contacted via the messaging function on the mobile application. In addition, the counsellor provided monthly messages using the application messaging system on months with no scheduled follow-up appointments (months 1, 2, 4, 5, 7, 8, 10, and 11). The purpose of these messages was to reinforce content covered in the two-week program. A two-arm randomized controlled trial tested the effectiveness of combining behavior change counselling with HIIT or MICT on adherence to physical activity over one year. Secondary outcomes included cardiorespiratory fitness, metabolic and psychosocial outcomes (see Bourne et al., in press, for complete protocol details).

Procedures

The content of the Small Steps program was collected from intervention material that included: a) intervention scripts (seven per condition), b) take home sheets (three per condition) and c) follow-up material consisting of a program booklet (one for each condition) and eight standardized messages sent to individuals in the follow-up period (one per month over 12 months, excluding months that the individual visited the laboratory). The content of the interventions differed due to the different exercise modalities prescribed. Therefore, the content of the two exercise conditions were analyzed separately. Coding the conditions separately enabled the researchers to determine if there were fundamental differences in the behavioral counseling due to the nature of the exercise modality. Two researchers, trained in the behavior change coding, read, and re-read the intervention documents and carried out the data analysis as described below.

Mapping Behavior Change Techniques to Mechanisms of Action

To map the 93-item BCTTv1s to social cognitive theory (SCT), two sources of information were used: i) guidance from a published expert consensus linking 26 BCTs to SCT [8], and ii) feedback from an expert in SCT and the intervention developer (XX). (Supplementary File 1 provides an explanation and schematic of the steps involved in linking the BCTs to SCT). Three researchers met to review the mapping and a consensus was reached among the group (see Supplementary File 2 for final SCT and BCT coding framework).

To map the 93-item BCTTv1 to the Theoretical Domains Framework (TDF) two published papers that used expert consensus to link earlier iterations of the BCT taxonomy to the TDF were used [13,28]. Specifically, the 2008 expert consensus conducted by Michie and colleagues [13] mapped 11 domains to 35 BCTs and the 2015 expert consensus by Cane and colleagues [28], mapped all 14 domains from the TDF onto 87 BCTs (see Supplementary File 3 for an explanation and schematic to see the steps involved in linked BCTs to the TDF). See Supplementary File 4 for mapping Michie and colleagues [13] and Cane and colleagues [28] expert consensus onto the current 14 domain TDF and 93-item BCTTv1.

Intervention Content

The content of Small Steps was characterized using the 93-item BCTT(v1) developed by Michie and colleagues [9]. Intervention content was analyzed based on utterance, which was defined as a ‘complete thought’ according to the manual for the Motivational Interviewing Skills Code version 2.1 (p 8. MISC; [30]. In this study, the intervention content did not include responses from the participants, thereby an utterance ended when the complete thought from the counsellor ended, and another thought from the *same speaker* (or counsellor) began [30]. Utterances were extracted by one researcher. A second researcher reviewed the utterance

extraction and any parsing discrepancies were discussed and resolved if necessary. Two individuals trained in BCT identification independently coded each utterance from both HIIT and MICT intervention days and follow-up material. Coders initially coded two intervention days then met to discuss their codes and any discrepancies. If agreement could not be reached, an expert who has conducted several BCT analyses was consulted (XX). Decisions regarding coding were recorded in a coding manual. The coders met once again after coding three additional days of intervention scripts. The objective of the meeting was to compare and discuss codes. Subsequently, one final coding meeting was set to compare and discuss coding and resolve any disagreements. Cohen's kappa and PABAK calculations were used to establish inter-coder reliability of BCTs present and not present within the intervention.

Intervention Theoretical Mechanisms of Action

The BCTs utilized in Small Steps were specified. These BCTs were then linked to the SCT constructs and to the TDF. This final step therefore listed the theoretical constructs utilized in Small Steps and the BCTs targeting these theoretical constructs.

Results

Step 1. Mapping the 93 Behavior Change Techniques (BCTs) onto Social Cognitive Theory (SCT) and to the Theoretical Domains Framework (TDF)

Twenty of the 93 BCTs mapped onto at least one of the four theoretical constructs associated with SCT. Specifically, 10 BCTs mapped onto self-efficacy, 7 BCTs mapped onto outcome expectations, 2 BCTs mapped onto goal setting, and 1 BCT was mapped onto barrier-focused self-regulatory efficacy. Refer to Supplementary file 2 for the specific BCTs that target each of the theoretical constructs.

A total of 75 BCTs (out of a total of 93) mapped onto at least one of the 14 theoretical domains, with several BCTs mapping on multiple domains. For example, the BCT *Goal Setting (behavior)* mapped onto three separate theoretical domains, namely *Skills*, *Behavioral Regulation*, and *Goals* from the TDF. Supplementary File 4 lists the specific BCTs that were mapped to each of 14 theoretical domains. Of the 75 BCTs that mapped onto the 14 domains, the four domains mapped to the largest number of BCTs included *Skills*, *Belief about Capabilities*, *Belief about Consequences* and *Reinforcement*.

Step 2. SSBC intervention content coded for BCTs

The high-intensity interval training intervention (HIIT) consisted of a total of 404 utterances, while the moderate-intensity continuous training intervention (MICT) consisted of 303 utterances in total. Inter-rater agreement of BCTs used, determined by Cohen's kappa was 0.75 and 0.83 for HIIT and MICT respectively. Ratings of PABAK were 0.99 for both HIIT and MICT. In total, 79% of the HIIT intervention used at least one BCT (319 of 404 utterances), while 76% of the MICT intervention used at least one BCT (230 of 303 utterances). Table 1 summarizes the BCTs used in the interventions, separately by exercise modality (i.e., HIIT or MICT). Forty-one BCTs were used in HIIT and 36 in MICT. The frequency of BCTs used was 561 in HIIT compared to 412 in MICT. The most commonly utilized BCTs across both interventions were: *feedback on behavior*, *self-monitoring of behavior*, *social support (unspecified)*, *instruction on how to perform a behavior*, *monitoring of emotional consequences*, *social reward*, *verbal persuasion about capability*, and *focus on past success*. Together these 8 BCTs accounted for 69% of the BCT frequency in HIIT and 63% in MICT. BCTs present in HIIT but not MICT included: *monitoring outcome(s) of behavior by others without feedback*,

feedback on outcome(s) of behavior, salience of consequences, information about emotional consequences and non-specific reward.

Step 3 SSBC theoretical constructs – Linking the BCTs in Small Steps to the SCT and TDF

Of the 20 BCTs that mapped onto SCT, 10 were used in MICT and 12 in HIIT. In total, 46% of the MICT intervention targeted SCT constructs and 53% of BCTs used targeted SCT constructs. In HIIT, 60% of the intervention content targeted SCT constructs, with 58% of BCTs targeting SCT constructs (see Table 2). The frequency with which the SCT constructs were targeted through BCTs was 203 in MICT and 304 in HIIT. ‘*Self-efficacy*’ was the most commonly targeted SCT construct in both conditions, which accounted for 77% of the targeted SCT constructs in MICT and 83% in HIIT. ‘*Outcome expectations*’ were targeted by 20% of BCTs in MICT and 15% in HIIT, and ‘*self-regulatory efficacy*’ was targeted 3% of the time in MICT and 2% in HIIT.

Of the 75 BCTs that mapped onto the TDF, 29 were used in MICT and 34 in HIIT. Seventeen of the BCTs that mapped onto SCT also mapped onto the TDF. The three BCTs that did not map onto TDF but mapped onto SCT were: *instruction on how to perform a behavior*, *exposure*, and *focus on past success*. Of these three, two (*instruction on how to perform a behavior* and *focus on past success*) were used in the current interventions. All fourteen TDF domains were targeted in both HIIT and MICT. In total, 73% and 76% of MICT and HIIT respectively targeted at least one of the 14 TDF domains. A total of 74% and 76% of BCTs used in MICT and HIIT respectively targeted at least one of the TDF domains. The most frequently targeted TDF domain was ‘*belief about capabilities*’ (%_{MICT} = 16, %_{HIIT} = 16). This domain was predominantly targeted through the BCTs of *social support (unspecified)* and *verbal persuasion*

about capabilities. The most infrequently targeted domains were *environmental context and resources* and *goals* in both HIIT and MICT.

Five of the BCTs utilized in both interventions did not map onto either SCT or the TDF. These included: *discrepancy between current behavior and goal*, *behavioral substitution*, *conserving mental resources*, *framing/reframing*, and *identity associated with changed behavior*. These BCTs accounted for a total of 13.35% of BCTs used in MICT and 13.55% of the BCTs used in HIIT.

Discussion

The aim of this study was to a) characterize the content of an exercise-based intervention for individuals at risk of type 2 diabetes, *Small Steps for Big Changes (Small Steps)* using a common vocabulary as set out by the 93-item Behavior Change Technique Taxonomy (BCTTv1) [9] and b) identify the underlying mechanisms of action targeted through use of these BCTs that have the potential to positively impact the behavior of interest, physical activity. Through documenting this process, this research demonstrates how a systematic method of retrospectively characterizing interventions can be used to understand the fundamental differences of two exercise interventions which utilized different exercise modalities.

Findings from the *Small Steps* pilot study revealed a significant increase in physical activity adherence at 6-month follow-up for both the high intensity interval training intervention (HIIT) and the moderate intensity continuous training intervention (MICT), however adherence was greater in HIIT than MICT with a 53 and 34-minute increase in moderate to vigorous physical activity of 10-minutes or greater from baseline to 24-weeks respectively [27]. In addition, increases in self-efficacy, self-regulatory efficacy and outcome expectations were seen post intervention with self-efficacy beliefs remaining higher at 6-month follow-up to a similar

extent between conditions. These findings suggest that *Small Steps* successfully targeted the proposed social cognitive theory constructs, and this may suggest that the proportion of intervention content containing BCTs could be more potent than frequency in targeting underlying constructs.

The results revealed that approximately half of the 20 BCTs identified as targeting social cognitive theory constructs were included in the *Small Steps* program (10 were included in MICT and 12 in HIIT). The social cognitive theory construct most frequently targeted in HIIT and MICT was '*Self-Efficacy*', and the least targeted construct was '*Self-Regulatory Efficacy*'. The BCT most frequently used in HIIT, which maps onto the construct of self-efficacy, was *Social Support (unspecified)* with 88 occurrences. This is substantially different to the utilization of the same BCT in MICT at 25 occurrences. This finding suggests that engagement in HIIT could present greater opportunities for positively impacting self-efficacy beliefs. This could be because HIIT includes brief bursts of high-intensity exercise, followed by very low intensity bouts. During this recovery period counsellors can provide more verbal support in terms of celebrating the success of completing the previous interval. As such, completion of each interval represents an achievement in its own right.

Social cognitive theory based physical activity interventions have consistently been found to be effective at positively impacting physical activity behavior in a variety of populations [31,32,33]. However, the active ingredients used in interventions to target specific social cognitive theory constructs have not been easily identifiable. This makes it difficult to determine how to target these theoretical constructs in the future and hinders intervention replication. We therefore encourage others to provide information on how specified theoretical constructs are targeted within interventions using the common vocabulary provided through use of the 93-item

BCTTv1. Subsequently, identified BCTs can be linked to the underlying theoretical mechanisms of action using the reverse coding process outlined in the current study. The three-step approach outlined above increases the transparency of whether BCTs associated with social cognitive theory are indeed used in *Small Steps* and lists other BCTs included in the intervention. All fourteen domains of the theoretical domains framework were targeted in both the HIIT and MICT conditions of the *Small Steps* program through a variety of BCTs. The most frequently targeted domain, in both conditions, was '*Belief about Capabilities*', which, as with self-efficacy, was primarily targeted through *Social Support (unspecified)*. The theoretical domains that were targeted the least frequently through BCTs were the '*Environmental Context and Resources*' and '*Goals*' in both HIIT and MICT. The infrequent use of the former domain was likely because the *Small Steps* program provided all the necessary resources, including a treadmill, elliptical, and cycle ergometer for participants to select their choice of equipment. Thereby, additional environmental resources were not incorporated as part of the intervention. The infrequent use of the '*Goals*' domain, on the other hand, was likely because the participants did not have to create specific personal goals, rather goals were outlined as part of the intervention (i.e., gradual increase in physical activity until reaching 150 min/week of MICT or 75 min/week of HIIT). This explains why the social cognitive theory construct of '*Goal Setting*' was not targeted as this requires participants to set personal goals. Within the theoretical domains framework, the '*Goals*' domain incorporates the BCT of *action planning* which was used in both HIIT and MICT. This explains why differences in two seemingly similar constructs are seen in the current interventions. As with SCT, the HIIT condition led to greater occurrences of targeting the TDF domains compared to MICT.

The findings presented here provide several recommendations for future research. First, research is needed to evaluate whether the hypothesized mechanisms of action and the associated BCTs predict positive changes in physical activity behavior. In addition, a randomized controlled trial is needed to examine whether the two exercise conditions lead to different outcomes at 12-month follow-up. This will provide insight as to whether the two interventions are fundamentally different, leading to different adherence rates, independent of exercise modality. If differences in outcomes are reported research is needed to determine the significance of the BCT frequency use between the exercise conditions and their impact on the mechanisms of action and subsequent behavior. Once the impact of the mechanisms of action on physical activity has been established and the role of BCT frequency explored future iterations of the program can be refined to target the most potent BCTs in appropriate frequency. Understanding the link between BCTs and mechanisms of action is key in this process.

Recent work has been undertaken by the Theories and Techniques project (<https://www.ucl.ac.uk/health-psychology/research/TaT>) to map the 93-item BCTTv1 to the 14-domains of the theoretical domains framework and the 12 most frequently occurring mechanisms of action (which do not overlap with the theoretical domains framework). This project consisted of expert consensus from over 100 international experts [18] and analysis of published literature linking BCTs to mechanisms of action [17]. Findings from these two studies have been triangulated to highlight links between BCTs and mechanisms of action [34]. Links identified between BCTs and the 14 domains of the theoretical domains framework in the Theories and Techniques project have been compared to those identified in the current study and are presented in Supplementary File 5. This table shows considerable overlap between the mapping conducted as part of this research and that of the Theory and Techniques project.

As the field continues to advance and outline links between BCTs and mechanisms of action researchers should be encouraged to reverse code pre-existing interventions. Knowledge of the links between BCTs and theory can also be used prospectively during intervention development for researchers to clearly define the active ingredients of an intervention and the associated underlying theoretical constructs being targeted. This will enable researchers to assess intervention implementation and to determine the fidelity of implementation. To assist in this process, we encourage researchers to use the newly available Theory and Techniques Tool (<http://www.ucl.ac.uk/behaviour-change-techniques>) to reverse code intervention content to potential mechanisms of action.

A limitation of this study is the use of earlier versions of the BCT taxonomy to an 11-domain framework [13] and the most recent 14 domain TDF [28] which was conducted before the researchers were aware of the mapping working conducted by the Theory and Techniques project [17,18,34]. The Theory and Techniques project represents substantial progress in identifying hypothesized links between BCTs and mechanisms of action. We encourage future researchers to continue to comprehensively examine and report their hypothesized links between BCTs and specific mechanisms of action targeted. To our knowledge this is one of the first studies to map the BCTs to the hypothesized mechanisms of action in order to understand the underlying processes of change of two exercise interventions for individuals at risk of type 2 diabetes.

The major strength of this study is that it demonstrates a clear process of retrospectively characterizing behavior change interventions by their component techniques and linking these techniques to potential mechanisms of action using a common language. Characterizing existing interventions, such as Small Steps, in this manner is important for programs to evolve and to

maximize public health outcomes. This process can be used by other researchers to classify existing interventions in a variety of contexts to different behaviors.

Conclusion

This study has demonstrated a systematic method of reverse coding an intervention to characterize the content and to make inferences about the underlying theoretical mechanisms of action targeted within the Small Steps program. Transparent reporting of *Small Steps for Big Changes* in this manner can help identify potential future areas of improvement for the program. Documenting this three-step reverse coding process provides guidance for researchers on how to evaluate current behavior change interventions. This process can be used across a variety of behavior change contexts and its implementation will enable the field to synthesize intervention findings with the aim of building robust rationale for future intervention content.

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Table 1. BCTs used with Small Steps for Big Change HIIT and MICT

| | BCT | Frequency used in HIIT | Frequency used in MICT |
|----|--|------------------------|------------------------|
| 1 | 1.2 | 6 | 6 |
| 2 | 1.4 | 17 | 19 |
| 3 | 1.5 | 1 | 1 |
| 4 | 1.6 | 3 | 3 |
| 5 | 2.2 | 40 | 28 |
| 6 | 2.3 | 29 | 27 |
| 7 | 2.4 | 3 | 3 |
| 8 | 2.5 | | |
| | Monitoring outcome(s) of behavior by others without feedback | 3 | 0 |
| 9 | 2.6 | 19 | 15 |
| 10 | 2.7 | 1 | 0 |
| 11 | 3.1 | 88 | 25 |
| 12 | 3.2 | 2 | 3 |
| 13 | 4.1 | 59 | 50 |
| 14 | 4.2 | 10 | 7 |
| 15 | 5.1 | 15 | 15 |
| 16 | 5.2 | 2 | 0 |
| 17 | 5.4 | 26 | 24 |
| 18 | 5.6 | 1 | 0 |
| 19 | 6.1 | 1 | 1 |
| 20 | 6.2 | 19 | 12 |
| 21 | 7.1 | 1 | 1 |
| 22 | 8.1 | 12 | 15 |
| 23 | 8.2 | 1 | 1 |
| 24 | 8.6 | 6 | 5 |
| 25 | 10.2 | 1 | 1 |
| 26 | 10.3 | 1 | 0 |
| 27 | 10.4 | 32 | 26 |
| 28 | 10.9 | 6 | 6 |
| 29 | 11.2 | 2 | 2 |
| 30 | 11.3 | 1 | 1 |
| 31 | 12.1 | 1 | 1 |
| 32 | 12.2 | 2 | 1 |
| 33 | 12.5 | 4 | 4 |
| 34 | 13.1 | 5 | 5 |
| 35 | 13.2 | 3 | 1 |
| 36 | 13.5 | 11 | 10 |
| 37 | 14.5 | 1 | 1 |
| 38 | 15.1 | 56 | 41 |
| 39 | 15.3 | 57 | 40 |
| 40 | 15.4 | 2 | 2 |
| 41 | 16.3 | 11 | 9 |

Table 2. BCTs and Mechanisms of change in Small Steps for Big Changes

| Theoretical Domains Framework constructs | Frequency of use in HIIT content | % of total frequency | Frequency used in MICT content | % of total frequency |
|---|--|-------------------------|--------------------------------------|-------------------------|
| Belief about capabilities | 209 | 16 | 138 | 16 |
| Social influences | 167 | 13 | 86 | 10 |
| Reinforcement | 152 | 12 | 80 | 9 |
| Social/professional role and identity | 131 | 10 | 66 | 8 |
| Belief about consequences | 124 | 9 | 99 | 12 |
| Skills | 93 | 7 | 82 | 10 |
| Memory, Attention, Decision processes | 95 | 7 | 87 | 10 |
| Optimism | 77 | 6 | 44 | 5 |
| Knowledge | 66 | 5 | 50 | 6 |
| Intention | 70 | 5 | 9 | 1 |
| Behavioral regulation | 51 | 4 | 49 | 6 |
| Emotion | 46 | 4 | 36 | 4 |
| Goals | 18 | 1 | 13 | 2 |
| Environmental context and resources | 9 | 1 | 10 | 1 |
| Social Cognitive Theory constructs | | | | |
| Self-efficacy | 252 | 83 | 157 | 77 |
| Outcome expectations | 46 | 15 | 40 | 20 |
| Self-regulatory efficacy | 6 | 2 | 6 | 3 |
| Goal setting | 0 | 0 | 0 | 0 |