



The use of the behaviour change wheel in the development of ParticipACTION's physical activity app

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ARTICLE INFO

Keywords:

Physical activity
mHealth
Behaviour change wheel
Mobile application

ABSTRACT

The purpose of this study was to provide a detailed and systematic outline of how a theoretical behaviour change framework was applied in the development of ParticipACTION's app to support a more active Canada. The app development process was guided by the Behaviour Change Wheel (BCW) framework, a theoretically-based approach for intervention development, in collaboration with the commercial app industry. Specifically, a behavioural diagnosis was used to understand what needs to change for the targeted behaviour to occur. Current literature, along with a series of surveys, and market research informed app development. Additionally, a validated app behaviour change scale, was consulted throughout development to help ensure app features maximized behaviour change potential. The behavioural diagnosis revealed that the app needed to target individuals' physical and psychological capabilities, physical and social opportunities, and reflective and automatic motivations in order to increase physical activity levels. To accomplish this, 6 of a possible 9 intervention functions and 2 of 7 policy categories were selected from the BCW to be included in the app. Goals and planning, feedback and monitoring, behaviour identification, action planning and knowledge shaping were selected as the main behaviour change techniques for the app. Collaboration with a mobile app development firm helped to embed the selected behaviour change techniques, policy categories, intervention functions, and sources of behaviour within the app. Using a systematic approach, this study used the BCW to ensure the health promotion app was theoretically informed. Future research will evaluate its effectiveness in increasing the physical activity of Canadians.

1. Introduction

Advancements in technology, passive transportation and urbanization have contributed to growing rates of physical inactivity worldwide. Identified by the World Health Organization (WHO) as the fourth largest behavioural risk factor for poor health and premature death (WHO, 2020), physical inactivity is linked to numerous immediate and long-term health consequences (Reiner et al., 2013). Current Canadian physical activity recommendations suggest adults (18 to 64 years) participate in a minimum of 150 min of moderate-to-vigorous physical activity (MVPA) each week, as well as muscle and bone strengthening activities two times a week (Canadian Society of Exercise Physiology,

2012). Unfortunately, only 16% of Canadian adults reach or surpass national physical activity guidelines (Clarke et al., 2019). With 87% of Canadians agreeing they need to be more physically active, and 75% feeling motivated and reporting strong intentions to make positive health changes (ParticipACTION Pulse Report, 2018), novel and effective strategies to support increased physical activity participation is an essential public health priority.

2. Mobile technology for behaviour change

The use of technology, in particular mobile health (i.e., mHealth), to encourage behaviour change has grown immensely in the past decade

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<https://doi.org/10.1016/j.pmedr.2020.101224>

Received 24 May 2020; Received in revised form 17 September 2020; Accepted 2 October 2020

Available online 11 October 2020

2211-3355/© 2020 The Authors.

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(Research2Guidance, 2017). mHealth is defined by the WHO as the “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices” (Kay et al., 2011). Specifically, smartphone applications (hereafter referred to as ‘apps’) have been recognized as a potentially promising approach to behaviour change, including increasing physical activity. In 2017, over 325,000 mHealth apps were available for smartphones with physical activity, diet and weight management apps being the most popular downloads (Research2Guidance, 2017). It is well-documented that these apps offer a number of attributes that maximize their potential for supporting healthy behaviour change including their *accessibility* (e.g., global proliferation, widespread adoption across socioeconomic and demographic populations, ubiquity (Bert et al., 2014)); *personal nature* (e.g., proximity, emotional attachment, and connectivity (Klasnja and Pratt, 2012)), and *programming flexibility* (e.g., tailored information, automated sensors (Klasnja and Pratt, 2014)). Additionally, apps are relatively inexpensive and allow users to engage with health information technology in any environment and at any time (Sarasohn-Kahn, 2010), highlighting its opportunistic qualities for promoting healthy behaviours. This point is further exemplified by Romeo et al. (2019) meta-analysis ($n = 6$) which found modest non-significant evidence supporting the effectiveness of smartphone apps for increasing objectively measured physical activity (~500 steps/day) in adults, indicating promise for the effectiveness of physical activity apps. Furthermore, the evaluation of a commercial physical activity app in two provinces in Canada ($n = 39,113$) revealed significant increase in step counts for ‘regular’ (24–51 weeks of valid step count data) and ‘committed’ (52 weeks of valid step count data) participants (1215 and 1821 steps/day, respectively) over a 12-month period (Mitchell et al., 2020).

While smartphone apps have been found to be effective at increasing the physical activity levels of their users, engagement with these apps tends to be limited, and effects are short-term (Romeo et al., 2019). These two issues are fundamental problems which currently limit the ability to exploit the potential of mHealth as a long-term solution to behaviour change. The long-term efficacy of fitness apps (especially those that are free) is questionable. In a study conducted by Gouveia et al. (2015) looking at the adoption of a physical activity app (which is defined as using the app for longer than 2 weeks) in a naturalistic setting, only 38% of users remained engaged with the app after 2 weeks, and all participants had stopped interacting with the app within 10 months. While this app was created by researchers and released specifically for the purpose of the study, no additional marketing of the app was communicated. Consequently, a physical activity app promoted nationally through robust marketing by a well-recognized and credible not for profit organization could potentially lead to long-term engagement.

Individuals are keen to access health information on their mobile devices and smartphone technology is rapidly changing health promotion (Kratzke and Cox, 2012); however, research into the effectiveness of health behaviour change (short- and long-term) through these apps, particularly for physical activity, is in its infancy. Specifically, it is unclear what features of mHealth apps are necessary in order to elicit improved activity levels and if they can produce sustained changes. In 2019, McKay and colleagues conducted a systematic review of 50 studies to identify what app features are necessary to promote health behaviour change (e.g., physical activity, smoking, nutrition, alcohol, mental wellbeing). From this review, the App Behavior Change Scale was created – a reliable, theory-based scale used to assess the behaviour change potential of smartphone apps (McKay et al., 2019a).

3. Positioning within a theoretical framework

Despite the exponential growth of smartphone apps to support health behaviours, the majority lack embedded evidence-based behaviour change theories (de Korte et al., 2018; Direito et al., 2014). There is

growing consensus that mHealth apps should be underpinned by evidence and theory to increase effectiveness (Direito et al., 2014). Apps developed utilizing behaviour change theories and strategies such as goal setting, barrier identification, self-monitoring, and action planning have been reported to be particularly effective in initiating behaviour change among their users (Abroms et al., 2011; Direito et al., 2014; Lyszynski, 2014). Of note, several reviews of commercial health apps have revealed a significant lack of evidence-based guidelines (Abroms et al., 2011; Breton et al., 2011; Nundy et al., 2014) and behaviour change theories (Conroy et al., 2014; Direito et al., 2014; McKay et al., 2019b; West et al., 2013) embedded in their features. Most notably, a systematic review rating the behaviour change potential of physical activity apps ($n = 275$) found that most included a limited number of behaviour change techniques (BCTs; an average of 7 to 9; McKay et al., 2019a, 2019b). Further, of those theory-based apps, their development, quality and behaviour change potential are rarely documented in the literature. Arguably, apps would benefit from greater collaboration between behaviour change experts and the commercial app industry to help address these prominent gaps.

Many theories and models of behaviour change exist to guide individuals, clinicians, and researchers on which constructs can be utilized to elicit and maintain behaviour change, and the theories may differ in appropriateness depending on the behaviour in question. Michie et al. (2014) framework, the Behaviour Change Wheel (BCW) was chosen for this app because it is heavily grounded in behaviour change theory and linked to evidence-based intervention functions that can orient an intervention to a targeted setting and population. The BCW defines behaviour as an interaction between three necessary conditions: 1) *Capability*; 2) *Opportunity*; and 3) *Motivation* (i.e., the COM-B model). Surrounding this core is a second layer, comprising nine intervention functions (i.e., Education, Persuasion, Incentivization, Coercion, Training, Enablement, Modelling, Environmental Restructuring and Restrictions), which have been linked to a taxonomy of 93 replicable BCTs (Michie et al., 2013) – the active ingredients of behaviour change. The final, most outermost layer of the wheel comprises seven policy categories (Environmental/Social planning, Communication/Marketing, Legislation, Service provision, Regulation, Fiscal measures and Guidelines) which can be used to support the delivery of the intervention functions. Collectively, the interaction of these various layers is likely to elicit a behavioural shift. The BCW was the theoretical basis for the ParticipACTION App (Michie et al., 2011).

4. The ParticipACTION app

ParticipACTION is a national non-profit organization in Canada whose vision is “A Canada where physical activity is a vital part of everyday life.” To advance the organization’s mission, funding was secured from national government grants to undertake the research, testing, and development of a physical activity behaviour tool; notably, the ParticipACTION app. The uniqueness and potential of this app is underscored by the fact that it is a ‘national’ app being used as part of a broader social marketing strategy by ParticipACTION that includes strategic communications (“Everything gets better when you get active” campaign); and community challenges (“Community Better Challenge”). The overarching goal of this evidence-informed app is to offer educational knowledge, tracking capabilities and behavioural prompts to promote increased physical activity among its users (namely, Canadians over the age of 18 years).

The purpose of this paper is two-fold: 1) to provide a detailed outline of the theoretical framework applied in the development of a theory and evidence-driven physical activity app created by ParticipACTION and informed by their advisory research and development committees; and, 2) to highlight the steps taken to maximize the behaviour change potential of the app through its design and features.

5. Methods

5.1. Overview

The development process of the app using the BCW followed three stages, as outlined by [Michie, Atkins, and West \(2014\)](#): understanding the problem and user preferences; translating research findings into app features; and, identifying app content and implementation options. These can be further subdivided into key sub-steps including: 1) defining the problem in behavioural terms; 2) selecting the target behaviour; 3) specifying the target behaviour; 4) identifying what needs to change; 5) identifying appropriate intervention functions; 6) selecting policy categories; 7) selecting behaviour change techniques; and, 8) determining the mode of delivery. In line with these steps, the development of the app – as the conduit for improving and supporting Canadians' physical activity behaviours – is outlined in the following sections.

5.1.1. Stage I: understanding the problem and user preferences

5.1.1.1. Step 1: define the problem in behavioural terms. Step 1 took specific behavioural contexts of the problem (e.g., low levels of physical activity) into account, including the social and environmental context in which the behaviour occurs and the individual, group, or population of focus. The research staff at ParticipACTION reviewed the literature (e.g., [Colley et al., 2018](#); [ParticipACTION, 2019](#)) to identify the global statistics on physical inactivity, major barriers and facilitators to improving physical activity, as well as the utility of using apps to support behaviour change.

5.1.1.2. Step 2: select the target behaviour. Step 2 involved considering all the possible factors that could be targeted in the intervention to increase physical activity levels through the mobile app. The BCW recommends a “less is more approach” whereby it is beneficial to start with small changes and build upon these incrementally ([Michie et al., 2014](#)). Selecting the target behaviour involved reviewing the literature surrounding the inactivity of Canadian adults (e.g., [Colley et al., 2018](#); [ParticipACTION, 2019](#)), physical inactivity as a risk factor for chronic disease (e.g., [WHO, 2010](#)), and the healthcare costs associated with inactivity (e.g., [The Conference Board of Canada, 2014](#); [Janssen, 2012](#)).

5.1.1.3. Step 3: specify the target behaviour. Upon selection of the target behaviour, this step involved specifying the context in which it occurs. For example, who needs to perform the behaviour, what needs to be done differently to achieve the change, where and when they need to do it, and how often and with whom.

5.1.1.4. Step 4: identify what needs to change. This step involved conducting a behavioural analysis by reviewing the literature (e.g., [Abroms et al., 2011](#); [Direito et al., 2014](#); [Lyzwinski, 2014](#)), conducting market research, followed by conducting surveys with the target population to identify which of the COM-B components (i.e., capability, opportunity or motivation to get more active) need to change and be included in the app for the behaviour to occur – essentially, a comprehensive needs assessment and literature comparison was undertaken at this stage. Collectively, these steps helped explore barriers and facilitators to individual's capability, opportunity, and motivation in enacting the target behaviour. Moreover, this stage of the process aided with exploring individual's preferences for app features. Members of the organization's digital team undertook a market review of competitor apps, the uptake of mobile app technology for health behaviours, and additional market trends. To complement the findings of these reviews, Maru/Matchbox, a third-party research marketing firm based in Toronto, Canada, conducted a survey with 1012 Canadians aged 18+ years to solicit information on Canadians receptivity to using a mobile app to help monitor weight and physical activity levels, functions they would be most

interested in utilizing, and reasons for wanting/not wanting to download the app. Additional information regarding the focus groups, its methodologies, and resulting data can be reviewed elsewhere ([Maru/Matchbox, 2018](#)). In addition to being compared to survey findings for further tailoring, a recent review by [McKay et al. \(2019b\)](#) was consulted to ensure key app features and attributes were being considered during developmental stages.

5.1.2. Stage II: Translating research findings into app features

5.1.2.1. Step 5: identify intervention functions. Based on the findings from Step 4, the research team used the BCW as a guide to select intervention functions as identified in the literature most likely to initiate behaviour change in each COM-B component.

5.1.2.2. Step 6: select policy categories. In this step, policy categories purported to support the intervention functions (Step 5) were identified in the literature (e.g., [Lefebvre, 2009](#); [Taylor et al., 2011](#)). Care was taken to ensure the policy categories selected were well-linked to the identified intervention functions for enhanced physical activity.

5.1.3. Stage III: identifying app content and implementation options

5.1.3.1. Step 7: select behaviour change techniques. Michie et al.'s taxonomy of BCTs describes how each technique is linked to various intervention functions ([Michie et al., 2013](#)). From the list of 93 possible BCTs ([Michie et al., 2013](#)), research staff selected the techniques deemed to be most effective and feasible in eliciting the desired behaviour change of helping adults move more. The list was created by reviewing the evidence on effective techniques for increasing adults' physical activity levels ([Brannan et al., 2019](#); [Keyworth et al., 2020](#); [McKay et al., 2019a, 2019b](#)), and mapping the BCTs on to the intervention functions.

5.1.3.2. Step 8: determine mode of delivery. Upon identification of BCTs, steps were taken to embed these as app features. This involved liaising with the data science agency GALE (<https://gale.agency/>) and mobile app design and development firm Clearbridge Mobile (<https://clearbridgemobile.com/>). Once embedded, multiple rounds of pilot testing were conducted with a convenient sample of 34 internal members of the ParticipACTION staff, including a mix of physical activity researchers, marketing and communications staff, digital staff, and developers. These rounds of pilot tests were used to identify glitches with the functionality of the app and enhance app user experience. Tracking documents were used to record strengths and weaknesses of early iterations of the app and adjustments were made accordingly.

5.2. Behaviour change potential

The App Behaviour Change Scale was consulted during the developmental stages (Steps 5 through 8) of the ParticipACTION app to maximize the behaviour change potential of the app ([McKay et al., 2019b](#)). Utilized as a checklist, the development team ensured the inclusions of features that addressed all items on the App Behaviour Change Scale. The App Behaviour Change Scale comprises of 21 items in relation to knowledge and information ($n = 5$ items), goal setting and planning ($n = 3$ items) feedback and monitoring ($n = 7$), and action planning ($n = 6$ items).

6. Results

6.1. Stage I: understanding the problem and user preferences

6.1.1. Step 1: define the problem

Physical inactivity is a serious public health problem. In Canada, 84% of adults aged 18–64 years are not meeting national physical

activity guidelines of 150 min of MVPA per week (Clarke et al., 2019). Low levels of physical activity are linked to negative physiological and psychosocial outcomes (Reiner et al., 2013), and this comes at a cost to our healthcare system. In 2009 it was estimated that physical inactivity among adults cost the Canadian economy \$6.8 billion (Janssen, 2012). As such, it is critical to focus on increasing the physical activity levels of Canadian adults from an economic perspective.

Furthermore, adults' physical activity levels can be influenced by multiple social and environmental contextual variables depending on personal interests (Burton et al., 2012; Welk & Kim, 2015). Some of these variables include location (i.e., home, outdoors, at work, center-based), companions (i.e., alone or with a family member, coworkers, or friend), time of day (i.e., morning, afternoon, evening), structure (i.e., flexible or scheduled), and other aspects such as fun, music, and convenience (Burton et al., 2012; Lau & Faulkner, 2019; Welk and Kim, 2015). Therefore, there is no 'one model fits all' approach and effective strategies to increase physical activity participation must be diverse in order to reflect people's preferences (Sallis et al., 2000).

6.1.2. Step 2: select the target behaviour

Based on the decision to focus on increasing adults' weekly physical activity levels, and in line with current national physical activity recommendations, achieving more steps and encouraging higher-intensity movement (MVPA) were deemed appropriate behaviours by the app development team and research staff on which to focus. There were no specific step or MVPA targets set.

6.1.3. Step 3: specify the target behaviour

Upon selecting the target population and behaviour (i.e., increasing Canadian adults' weekly physical activity), the app development team and research staff specified the behaviour with regards to what needs to occur for the target behaviour to be carried out (Table 1). By reviewing the literature, it was determined: adults can and should be active every day, any time of the day, in multiple environments and social settings.

6.1.4. Step 4: identify what needs to change

The behavioural diagnosis revealed barriers and facilitators to the target behaviour in all three components of the COM-B core. From the literature, it was determined that the app needed to target individuals' physical and psychological capability, physical and social opportunity, and reflective and automatic motivation to change the target behaviour (see Table 2). Review of market research highlighted features and functions of other successful fitness and health apps, with potential implications for ParticipACTION's app to target all components of the COM-B model. For example, in addition to tracking individual's activity levels, fitness and health apps commonly include aspects of goal setting, evidence informed content (i.e., how-to videos, workout guides, articles on relevant topics) gamification (i.e., earning badges, competing in

Table 1
Specifying the Target Behaviour – Step 3.

Target behaviour	Canadians need to move more to reach the physical activity guidelines of 150 min of MVPA per week
Who needs to perform the behaviour?	All Canadians 18 + years
What do they need to do differently to achieve the desired change?	Move more every day (steps and higher-intensity physical activity)
When do they need to do it?	Everyday
Where do they need to do it?	Home Work Community
How often do they need to do it?	Everyday
With whom do they need to do it?	Alone In a group Friends Family Coworkers

Table 2
Behavioural Analysis and Diagnosis – Step 4.

Target Behaviour:	Canadians to increase their physical activity levels (by taking more daily steps and engaging in more high-intensity movement).	
COM-B components	What needs to happen for the target behaviour to occur?	Is there a need for change?
<i>Physical capability</i>	Have the physical skills to be active.	Change is needed as not all Canadians may have the necessary skills (ParticipACTION, 2019).
<i>Psychological capability</i>	Know the correct technique to perform exercises and skills to be physically active.	Change is needed as not all Canadians may have the necessary knowledge (ParticipACTION, 2019).
<i>Physical opportunity</i>	Create the opportunity to be active in a variety of settings	Change is needed to create an environment which is supportive of physical activity (McCormack, 2017).
<i>Social opportunity</i>	See members in close social networks valuing physical activity and getting active.	Change is needed to create supportive social environments to be active (Yun et al., 2018).
<i>Reflective motivation</i>	Hold beliefs that being physically active impacts various facets of health.	Change is needed as not all individuals have these beliefs (ParticipACTION Pulse Report, 2018).
<i>Automatic motivation</i>	Create established routines and habits for physical activity.	Change is needed to establish routines and habit formation (ParticipACTION Pulse Report, 2018).
Behavioural diagnosis of the relevant COM-B components:	All COM-B components need to change for the target behaviour to improve.	

Note. COM-B = capability, opportunity, motivation, behaviour

challenges), rewards (i.e., points to be entered into a contest, cash) and connecting with a social community (i.e., sharing activity on a social media platform, leaderboard comparing stats with friends). Results from Maru/Matchbox's survey indicated the receptive market for an app to help monitor physical activity levels. Over one third of Canadians currently track their physical activity level and number of steps, with 41% using smartphones and apps to do so. Additionally, participants indicated they would be more likely to interact with the app and change their target behaviour if the app summarized their data and progress over time, included a physical activity/step counter, and provided the opportunity to earn rewards.

6.2. Stage ii: Translating research findings into app features

6.2.1. Step 5: identify intervention functions

A total of 6 out of the 9 possible intervention functions were selected: education, persuasion, incentivization, training, environment restructuring, and enablement. Table 3 shows an excerpt of how these intervention functions were mapped to the corresponding COM-B components, along with examples of how they could be applied to supporting Canadians to move more.

6.2.2. Step 6: select policy categories

The following policy categories were selected to support the delivery of the previously identified intervention functions: 1) communication and marketing; and 2) environment and social planning.

6.3. Stage iii: identifying app content and implementation options

6.3.1. Step 7: select behaviour change techniques

BCTs linked to the relevant chosen intervention functions were identified using the Behaviour Change Technique Taxonomy (BCTTv1;

Table 3

Excerpt of Mapping App Functions to the Corresponding COM-B Components and BCTs – Steps 5 & 7.

COM-B	Sub-themes	Intervention functions	Examples of BCTs	Example from ParticipACTION app
Physical capability	Adults lack the physical skills (physical literacy) to engage in activity	Education, Training	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour	Videos provide step-by-step instructions on how to perform an exercise
Psychological capability	Adults have difficulty knowing how to be active	Education, Training, Enablement	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour	Videos provide step-by-step instructions on how to perform an exercise
Physical opportunity	Adults environments are highly sedentary	Environmental Restructuring, Enablement	12.1 Restructuring the physical environment 12.5 Adding objects to the environment	Articles provide suggestions on how to restructure environments to encourage physical activity (e.g., standing desk, Take 10)
Social opportunity	Adults social networks are not always supportive of physical activity	Environmental Restructuring, Enablement	12.2 Restructuring the social environment	Articles provide suggestions on how to be active with your family, friends, co-workers, or significant other. Activity can be shared via social media.
Reflective motivation	Adults have a lack of confidence in their ability to make changes	Education, Persuasion, Enablement	1.1 Goal setting (behaviour) 1.2 Problem solving 1.3 Goal setting (outcome) 1.4 Action planning 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 8.1 Behavioural practice/rehearsal 8.3 Habit formation 15.1 Verbal persuasion about capability	Articles educate, persuade, and enable adults to increase their self-confidence in making changes to their physical activity habits
Automatic motivation	Adults struggle to create healthy activity routines	Education, Incentivization, Persuasion	2.3 Self-monitoring of behaviour 5.6 Information about emotional consequence 10.2 Material reward (behaviour) 11.2 Reduce negative emotions	Streaking badges motivate users to routinely engage in activity, and reward users with additional entries in draws for prizes

Note. COM-B = capability, opportunity, motivation, behaviour; BCTs = behaviour change techniques.

(Michie et al., 2013)). The main BCTs selected for the app were: 1) goals and planning [1.1–1.9]; 2) feedback and monitoring [2.1–2.6]; 3) barrier identification [1.2, 12.1, 12.2]; 4) action planning [1.4]; and, 5) shaping knowledge [4.1–4.4]. Examples of BCTs mapped onto the intervention functions and COM-B components can be found in Table 3.

6.3.2. Step 8: determine mode of delivery

Consulting with the data science agency GALE and the mobile app design and development firm Clearbridge Mobile facilitated the process of how the BCTs identified in Step 7 could be integrated into app features. For example, to address the BCT feedback and monitoring, a progress wheel was included on the homepage of the app so users could visually track their progress towards reaching their activity goal. Additional elements of gamification techniques were included in the app to enhance engagement and motivation, such as logging activity minutes, and answering quiz questions.

Aspects of machine learning and data science were utilized to tailor and deliver content to users' preferences and current levels of physical activity. Once registered in the app, users will be grouped into clusters based on three types of data, so they receive a tailored experienced accurately aimed at their physical activity level. First, users will be clustered based on their **behavioural** data, including proposed activity goals and current activities. Next, **transactional** data, such as device app information data and daily activity minutes collected by the app, will be utilized. The final layer applied to the clustering is user **demographic** data, like age, gender, and postal code. As users continue to engage with the app, the data science and machine learning aspects of the app begin to provide customized content such as activity suggestions to motivate

and keep users on track toward their goal. The more the user engages with the app, the more learning and personalization the app can undertake.

The tracking documents from the pilot tests were consulted to determine what aspects of the app had glitches, and adjustments were made accordingly to correct errors. Piloted app functionalities included: does the dashboard work?; are steps being tracked?; do notifications appear when scheduled?; can users complete the onboarding process?; and do both French and English versions of the app work?

6.4. Behaviour change potential

After reviewing the App Behaviour Change Scale as a checklist, the ParticipACTION app included all 21 items on the scale, indicating a high number of BCTs embedded in the app, and strong behaviour change potential. See Table 4 for examples of app features linked to each App Behaviour Change Scale item.

7. Discussion

This paper provides a step-by-step example for how evidence, theory, and a validated assessment tool were incorporated into the development of an mHealth app targeted at increasing the physical activity levels of Canadian adults. The use of the BCW to inform intervention development offers a systematic method for designing a theory driven intervention, beginning with a behavioural diagnosis of what needs to be changed, and then linking that diagnosis to intervention functions, policy categories and BCTs to bring about change. This approach allows

Table 4
Behaviour Change Potential of the ParticipACTION App – App Behaviour Change Scale.

Scale: item number and question	Definition	Included in App?	Example from ParticipACTION App
Knowledge and information			
1.1 Does the app have the ability to customize and personalize some features?	Elements of the app can be personalized through specific tools or functions that are specific to the individual using the app.	✓	Through machine learning, content is delivered specific to users' activity level.
1.2 Was the app created with expertise and/or Does the app provide information that is consistent with national guidelines?	This would be found in the about section or generally in the app.	✓	Created by experts in the field.
1.3 Does the app ask for baseline information?	This includes BMI, weight, smoking rate, exercise, or drinking behaviours.	✓	When registering, individuals are asked for their age, gender, postal code, and current physical activity levels.
1.4 Does the app provide instruction on how to perform the behavior?	The app is clear in telling the person how to perform a behavior or preparatory behaviours, either verbally, through video, or in written form.	✓	Articles and videos are used to guide users through activities.
1.5 Does the app provide information about the consequences of continuing and/or discontinuing behaviour?	The app gives the user information about the consequences of behaviour in general, this includes information about the relationship between the behaviour and its possible or likely consequences in the general case. This information can be general or personalized.	✓	Long- and short-form articles describe the consequences of not engaging in enough physical activity.
Goals and planning			
2.1 Does the app ask for willingness for behaviour change?	Is there a feature during setup where you describe how ready you are for behaviour change?	✓	While the app does not specifically ask users their willingness to change their behaviour, the assumption was made that downloading the app and registering are indicative of a user's willingness to change their physical activity behaviours.
2.2 Does the app allow for the setting of goals?	The person is encouraged to make a behavioural resolution. The person is encouraged to set a general goal that can be achieved by behavioural means.	✓	Users can set their own weekly activity goal.

Table 4 (continued)

Scale: item number and question	Definition	Included in App?	Example from ParticipACTION App
2.3 Does the app have the ability to review goals, update, and change when necessary?	This includes sub-goals or preparatory behaviours and/or specific contents in which the behaviour will be performed. The behaviour in this technique will be directly related to or be a necessary condition for the target behaviour. Involves a review or analysis of the extent to which previously set behavioural goals (regardless of short or long) were achieved.	✓	The user can either manually adjust their goal or after repeated missing or meeting a goal, the app will automatically adjust one's goal.
Feedback and monitoring			
3.1 Does the app give the user the ability to quickly and easily understand the difference between current action and future goals?	Allows user to see how they are tracking against a goal and to see the difference between what they want to do and what they are currently doing. This will give some feedback on where they are at and what they need to change to get to where they want to be.	✓	The user is able to view their progress towards their weekly goal visually on the home screen.
3.2 Does the app have the ability to allow the user to easily self-monitor behaviour?	The app allows for a regular monitoring of the activity.	✓	Users can input their active minutes manually. The app also connects with smart watches to track minutes of activity.
3.3 Does the app have the ability to share behaviours with others (including social media or forums) and/or allow for social comparison?	The app allows the person to share his or her behaviours on social media or in forums. This could also include a buddy system or leaderboard.	✓	Activity can be shared via social media and text messages.
3.4 Does the app have the ability to give the user feedback – either from a person or automatically?	The app is able to provide the person with feedback, comments, or data about their own recorded behaviour. This might be automatic or could be personal.	✓	Notifications are sent to users when they meet (or miss) their weekly goals, and once the user has achieved a particular % of their weekly goal.
3.5 Does the app have the ability to export data from the app?	The app allows for the export of information and progress to an external user.	✓	Activity data can be exported to an external user.
3.6 Does the app provide a material or social reward or incentive?	App provides rewards for attempts at achieving a behavioural goal. This might include efforts made toward achieving the behaviour or progress made in preparatory steps	✓	By engaging with the app, users are entered into weekly, monthly and quarterly draws for gift cards.

(continued on next page)

Table 4 (continued)

Scale: item number and question	Definition	Included in App?	Example from ParticipACTION App
3.7 Does the app provide general encouragement?	toward the behaviour or in achieving a goal. The app provides general encouragement and positive reinforcement on actions leading to the goal.	✓	Users work towards achieving badges by engaging with the app (e.g., tracking activity, reading articles, and answering survey questions).
Actions			
4.1 Does the app have reminders and/or prompts or cues for activity?	The app prompts the user to engage in the activity. The app has the ability to give notifications or reminders to cue the behaviour.	✓	The app nudges users to engage in active breaks by “Taking 10” and participating in small bouts of physical activity.
4.2 Does the app encourage positive habit formation?	The app prompts explicit rehearsal and repetition of the behaviour – not just tracking or logging.	✓	The app reinforces positive behaviours awarding users badges and prizes
4.3 Does the app allow or encourage for practice or rehearsal, in addition to daily activities?	App does not have a lock on activities or a number that you cannot exceed daily.	✓	Users are able to log an infinite number of active minutes per day.
4.4 Does the app provide opportunity to plan for barriers?	The app encourages the person to think about potential barriers and identify ways of overcoming them.	✓	In app articles provide users with suggestions on how to identify and overcome barriers to getting active.
4.5 Does the app assist with or suggest restructuring the physical or social environment?	The app prompts the person to alter the environment in ways that it is more supportive of the target behaviour.	✓	In app articles provide users with suggestions on how to restructure their environment to promote physical activity participation.
4.6 Does the app assist with distractions or avoidance?	The app gives suggestions and advice on how the person can avoid situations or distract themselves when trying to reach their goal.	✓	In app articles provide users with the necessary information to assist with distractions or avoidance of physical activity engagement.
Total Score (out of 21):		21	

Note. Scored using the App Behaviour Change Scale (McKay et al., 2019).

for the ability to tailor interventions to meet the needs of a desired user. In this study, a behavioural diagnosis using the BCW revealed that Canadian adults experienced barriers in their capability, opportunity, and motivation to engage in the recommended 150 min of MVPA per week. This led to the selection of six intervention functions and five overarching BCTs to bring about change in the target behaviour. Explicit links exist between the COM-B model, located at the hub of the BCW, intervention functions which form the inner ring, and policy categories which form the outer ring, which is why interventions guided by the BCW need to be created in a systematic fashion following the steps provided by Michie and colleagues. Due to the interplay between all components of the BCW, choosing appropriate intervention functions, policy categories, and BCTs is essential to maximize the behaviour change potential when designing interventions. For example, in order to

improve individuals’ physical opportunity to be active (COM-B) through the ParticipACTION app, it was deemed necessary to intervene by restructuring the physical environment (intervention function) and focus on environmental and social planning (policy category). Specific BCTs chosen to be integrated into the app to compliment the intervention function and policy category were: 7.1 Prompts/cues; 12.1 Restructuring the physical environment; and 12.5 Adding objects to the environment. Without synergy between the various layers of the BCW, an intervention is likely to be unsuccessful at changing one’s behaviour,

Unlike other behaviour change theories like Self-Determination Theory (Ryan & Deci, 2017) and the Transtheoretical Model (Prochaska & Velicer, 1997), the BCW is a comprehensive framework, underpinned by the dynamic COM-B model that takes into account the context of behaviours, automatic processes, and environmental influences (Baranowski et al., 2003; Jackson et al., 2014). The BCW also uses a standardized language of theoretical constructs and BCTs which is essential for the replication and synthesis of research and evidence (Abraham & Michie, 2008). Although the BCW framework is extremely valuable in guiding the creation of health behaviour change interventions, similarly to other psychological models and health behaviour change intervention frameworks, it is not able to translate BCTs into app features due to the infancy of the mHealth field. Thus, it was integral to partner with agencies within the commercial app industry during development to ensure BCTs could feasibly be integrated into app features without losing their rigor. Future app developers in the mHealth field should consider following this approach to ensure that theory can be integrated into app features to amplify their behaviour change potential.

The use of the App Behaviour Change Scale as a checklist during the development of the ParticipACTION app helped maximize the behaviour change potential of the app. While the developers tried to integrate all 21-items of the scale into app features (examples shown in Table 5), external review of the app’s behaviour change potential may be beneficial. Overall, we believe the app has excellent behavioural change potential. It is important to note; however, that the App Behaviour Change Scale only measures the theoretical behaviour change potential of apps; it does not seek to investigate the relationship between actual features of apps and behavioural outcomes. Ongoing evaluation of the effectiveness of the ParticipACTION app at improving physical activity levels of Canadians and the uptake, engagement, and user retention of the app is being conducted following the RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance) framework, and will be published in the future.

Being a well-established national organization in the physical activity field, ParticipACTION is in an ideal position to help improve Canadians physical activity levels on a large scale. As part of a broader social marketing strategy, the ParticipACTION app has the potential to reach a large number of individuals. Yet it’s more than “just an app”. It is one important component of a broader integrated social marketing strategy. The organization’s “Everything gets better when you get active” campaign can draw Canadians to the app for additional content and behavioural prompts to promote increased physical activity, while the “Community Better Challenge” will encourage users to download and engage with the app for its tracking capabilities. Therefore, being rooted in theory and evidence is critical to maximize the app’s potential to improve physical activity behaviours and promote sustained engagement for a wide audience.

8. Limitations

There are several limitations with the current approach that must be acknowledged. First, technology development is rapidly advancing. Unfortunately, by the time prototypes for mHealth interventions are developed, implemented and tested, technology may have potentially evolved. There are many necessary steps and tests (e.g., alpha and beta testing) that must be conducted prior to implementing a mHealth

intervention, thus it is not always possible to keep up with the advancements in technology. Additionally, the ParticipACTION app is continuously evolving; therefore, it is difficult to determine at what point it is appropriate to assess the app's behaviour change potential, quality, and effectiveness. Secondly, the target behaviour chosen for this app was to significantly increase users' activity levels. It is important to note; however, that there are other behaviours related to movement that can be targeted in the app. For example, in addition to encouraging Canadians to be active, the app can also support Canadians to be less sedentary (i.e., sit less). Thirdly, while the BCW provides a systematic framework for creating a health behaviour change intervention, it stops short of a guide when it comes to translating BCTs into mHealth app features. Therefore, the task of translating BCTs to app features relied heavily on the expertise and creativity of the research team, and third-party agencies GALE and Clearbridge Mobile.

9. Conclusion

Apps rooted in theory, evidence, and market research have great, arguably untapped, potential to cause a shift in health behaviour. To this end, the current study demonstrates how the ParticipACTION app was developed and the evidence and theory used to inform its creation. A step-by-step outline was provided demonstrating how the BCW can serve as a comprehensive framework to ensure that a health promotion app is underpinned with relevant theory and evidence. Integrating this systematic approach, along with consulting with individuals in the commercial app industry, was demonstrated to be effective at integrating BCTs into app features and improving the overall quality and behaviour change potential of the app. This work provides a practical guide for future researchers and app developers looking to apply a similar systematic approach developing a mHealth intervention.

Funding

The development of the ParticipACTION app was supported by the Public Health Agency of Canada, Sport Canada, the Ontario Trillium Foundation and the Government of Newfoundland & Labrador. ST is supported by an Ontario Graduate Scholarship, and the Mitacs Accelerate Program. LMV is supported by a CIHR Fellowship Award.

Acknowledgements

The authors would like to thank the participants who partook in the various research stages that informed the development of the ParticipACTION app.

Declaration of Competing Interest

ST is an intern at ParticipACTION and LMV is an employee at ParticipACTION.

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