Mobile Phones App to Promote Daily Physical Activity: Theoretical Background and Design Process

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Abstract. Considering advances from research and technologies concerning physical activity and health, this chapter presents the C2S's Project (Coaching Sport Santé). C2S is a French start-up aiming at designing a device for promoting Daily Physical Activity (DPA). Based on Self-Determination, Self-Esteem Self-Regulation theories, and on the Trans-theoretical Model of Behaviour Change, a mobile phone App was developed including pedometer technology. The app offer a five step-strategy aimed at taking in account a) initial or normal everyday steps counts, b) individual motivational factor, and c) personally-adapted feedbacks.

1 Introduction

Benefits of physical activity for improving health are well established. Regular physical activity is associated with enhanced health and reduced risk of mortality factors, including cardiovascular disease, ischemic stroke, non–insulin-dependent, diabetes, colon cancers, osteoporosis, depression, and fall-related injuries (for an review see [1]). Therefore, a survey of EU countries demonstrated that two thirds of the adult population did not reach recommended levels of physical activity (http://www.who.int/whr/2002/en). In contrary, the prevalence of a sedentary lifestyle has been established in the European Space (e.g. in the 15 Member States of the European Union, [2]). Sedentary lifestyle has been defined according to various criteria: the number of hours that individuals spend sitting down in a typical day, the number of hours expended walking or in other specific physical activities, or how many times a week they participated in an activity that induced sweating [3]. Recently Europeans have been identified as high-risk populations; thus, the European Union's council recommendation of 26 Nov 2013 on promoting health enhancing physical activity called for monitoring of physical activity levels across member states. The Determinants of Diet and Physical Activity (DEDIPAC) European knowledge hub (www.dedipac.eu) organizes a major workshop on physical activity and sedentary behaviour surveillance and assessment in may 2015.

Considering these advertising, and advances from research and technologies, this chapter presents **the C2S's Project (Coaching Sport Santé).** C2S is a French start-up aiming at designing tools for promoting Daily Physical Activity (DPA). Especially, an

interdisciplinary team of exercise psychologist, doctor and health experts, managers and engineers collaborated in designing a physical activity smartphone application. Based on Self-Determination, Self-Esteem Self-Regulation theories, and on the Transtheoretical Model of Behaviour Change, a device including a mobile phone App was developed to promote Daily Physical Activity (DPA).

The purpose of this chapter is to summarize reviews about physical activity interventions, to provide a framework for increasing DPA, and to present our App's design process and its outcomes.

2 Changing for Daily Physical Activity: Advances from research

Recommendations in order to benefit from regular physical activity are well-known: 30 minutes of moderate-intensity activity on 5 or more days per week, or 20 minutes of vigorous-intensity activity on 3 or more days per week. Activities that expend 3- to 6-fold the energy expenditure of sitting at rest (3 to 6 metabolic equivalents or METs, 1 MET=3.5 ml O2•kg-1•min-1) are defined as moderate (walking), those that expend more as vigorous, and less as light intensity (running) [4]. Strategies and interventions to promote DPA are problematic. Several reviews have been conducted in this area and provided us with guidance for our project. The conclusions can be summarized into three points.

2.1 Several types of interventions for the promotion of physical activity

Kahn *et al*. [5] produced a systematic review of interventions for the promotion of physical activity. Three categories of interventions have been distinguished:
-Informational approaches to change knowledge and attitudes about the benefits; especially in the self-regulation theory, knowledge about PA and health are a key component of the behavioural change mechanism. Knowledge help people to identify new goals and goals lead to behavioural strategies.
-Behavioural approaches to teach people the skills necessary for both successful adoption and maintenance of behaviour change. Especially studies including goal setting, self-monitoring, self-assessment, specific feedbacks showed that behavioural change in DPA could be achieved.
-Environmental and policy approaches to change the structure of physical and organizational environments to provide safe, attractive, and convenient places for physical activity. Especially, interpersonal setting is often thought to have potential for motivation (cooperation and competition) and social support are effective in increasing PA level.

Behavioural approaches and individually adapted health behaviour change programs consist of the most successful way. There is strong evidence that this kind of face-to-face PA programs are effective in increasing level of physical activity. Thus, face-to-face interventions are considered to be the optimal means for changing health-related behaviour.

2.2 Findings of research on PA Interventions

Hillsdon *et al*. [6] summarized the evidence from sixteen systematic reviews and meta-analyses. Their 'review of reviews' provided a summary of the findings of research on interventions aiming at promoting physical activity for adults.

Evidences suggested that short-term change is achievable, and that use of a motivational and behaviour change theory will help. For instance, intervention could be based on various social cognitive theory of motivation (e. g., self-efficacy theory, self-regulation theory) or on the trans-theoretical model of change. Nevertheless, in many studies evidences were not consistent, or the research method could be criticized because PA was assessed thanks to declarative and self-administered questionnaires, such as the "International Physical Activity Questionnaire".

Moreover, the authors pointed out there are no consistent evidence for changes in workplace settings despite the fact that the importance of promoting physical activity through organisations is frequently pointed out. Especially the workplace, while targeted extensively in North America, has shown inconsistent involvement in physical activity promotion especially in European Space. Nevertheless, the workplace can offer large numbers of individuals and larger companies use to offer an infrastructure to support health promotion initiatives. Considering that adults spend about one quarter of their time at their place of work during their working lives, walking may be the best way to increase DPA, so that we suggested that pedometer technology could be relevant for the C2S project.

2.3 Pedometers: furnishing a realistic measure for DPA

Biddle & Mutrie [7] produced a synthesis of the literature in which the use of pedometers is considered an efficient motivational tool. Using pedometers is not new, and studies showed they are accurate to count steps and assess PA [8]. Then, researchers have pointed out the effect of pedometers on motivation and PA [9]. Even the presence of pedometers alone could increase walking steps, and feedbacks from pedometers seem to be relevant information in order to involve motivation and DPA [10]. Therefore, Biddle & Mutries [7] pointed that in other studies walking steps did not increase significantly. In one of their studies they demonstrated that pedometers provided a short-term effect, but that this effect was not evident in the long term.

Thus, all over the world, campaigns promoted the idea that 10,000 steps a day are required for health, and pedometers seems to be a reliable technological support for assessing DPA and providing feedbacks to people. Therefore, reported an overview of 32 studies Biddle and Mutries pointed that 10,000 steps could be too low or too high objectives for some people (active or sedentary individuals), so that the 10,000 steps goal might lead to reduce motivation, especially if people do not feel able to reach this goal.

In accordance with these authors, we suggested that pedometers measures could involve PA programs' efficiency, because they allow to promote more adapted or personalized step-goals.

2.4   Conclusions

Research advances are particularly relevant to design intervention in DPA. There was strong evidence that motivational support through social cognitive motivation framework, self-regulation theory, or trans-theoretical model for behavioural change, should increase DPA program effectiveness. Interventions should target behaviour change by personalized and adapted interventions. Therefore, Interventions aiming at increasing DPA are still problematic because:

a) Information about PA and health are relevant but few healthcare professionals are trained to promote PA's effects
b) PA program Intervention is efficient only if it is individually adapted or when people is face-to-face
c) In most of countries it seems to be hard to change DPA in workplace settings
d) There was insufficient evidence that technology-based support interventions effectively increased physical activity

Finally, the C2S project tried to take in account these advances. The global project is described on the web, and many informational resources on PA and health are provided (www. agircontrelasedentarite.org). The C2S Project included a promotion initiative, called "Challenging sedentary lifestyle", gathering together many companies or workplaces settings. Previous research showed that promoting DPA should consider the workplace setting. Workplace could be an interpersonal setting which has potential for DPA changes, only if companies are members or partners of the project. In 2015, 20 local companies (in the west of France) and 318 employees participated voluntarily in this ride.

The global project and the challenge need efficient technological support. A mobile phone App (www.bouge-application.fr) was designed in order to deliver an individually adapted program. The design process was theoretically based on motivational and behavioural change frameworks. These frameworks and their implications for the program will be presented in the second section.

The mobile phone application includes pedometer technology and may offer efficient strategies aiming at taking into account a) initial or normal everyday steps counts, b) individual motivational factor, and c) personally-adapted feedbacks. The design process will be presented in the third section.

3   Enhancing Daily Physical Activity: Impact of Psychological Factors

The development of exercise psychology has led to the proliferation of theories, primary tested in social and health psychology. Thus psychological factors of physical activity have been studied extensively and helped us understand why people are motivated or not ("amotivated") and why they adopt a physically active lifestyle or not (sedentary). The study of human motivation has been central to exercise psychology. Vallerand and colleagues [11] offered an operational definition of motivation, considering some the following behavioural indicators: the initiation, the direction, the persistence, the intensity, and continued motivation. These components of a motivated

behaviour could be influenced by social and cognitive factors.

More precisely, considering this perspective and previous empirical studies we chose to take in account many models of motivation and behaviour in an exercise setting. They were supposed to lead to principles for DPA program and to guide the App's design process. Thus each model we chose can be considered as a blend of theoretical and practical support for our strategy and device. Consequently, our intervention strategy consisted of five steps (see figure 1), including diagnosing, initiating, monitoring, maintaining and evaluating. Each step has to be theoretically based, in order to insure the all-strategy reliability.

3.1 Diagnosing attitude towards behaviour change: the trans-theoretical model

The first model we took in account was the trans-theoretical model (TTM) of behaviour change. The TTM is not a model of motivation, but it as been classified as a stage-based behavioural model [7]. The TTM was developed as a comprehensive theory of behaviour change and was initially applied to smoking cessation [12]. The TTM has been applied to physical activity, it could be considered as a precious tool aiming at diagnosing the attitudes towards PA. The stages are [13]:
- Pre-contemplation: no intention to start physical activity
- Contemplation: considering starting physical activity
- Preparation: beginning a limited program of exercise
- Action: engaging in regular physical activity for less than six months
- Maintenance: engaging in regular physical activity for more than six months.
Studies [13] showed that TTM is a modest predictor of exercise.

Therefore, these stages are useful to diagnose if individuals are ready or not to accept the program; they should lead designers or practitioners to adapt their program.

In the TTM, the processes of change are the strategies used to progress along the stages of change. The processes are divided into cognitive (thinking) and behavioural (doing) strategies so that self-regulation theories should constitute a complementary resource for modelling changes in DPA.

3.2 Initiating and monitoring behavioural change: the role of self-regulation components

Aiming at understanding the initiation and the monitoring of behaviour, early attempts in exercise psychology favoured theories of perceived control. One of the most popular is the self-regulation theory advocated by Flavell [14]. Thus, goals, strategies, metacognition and knowledge are considered as components within the self-regulation process. Goals are considered as internal specific or general representations of a desired state: people could try to involve daily steps, or to be more active; sometimes they want to please a parent or the doctor, or to take care of themselves. Researchers interested in self–regulation showed that goals depend on prior knowledge about the concerned domain, and on metacognition.

Knowledge about PA and health (sometimes researchers called them beliefs) determines motivation and behaviour towards PA. If someone knows that walking is the

most reliable way to well being, he might adopt goal to change his sedentary behaviour. Then, self-regulation theory describes a relationship between goals and behavioural strategies: people whose goals are to enhance their DPA would adopt strategies to walk everyday. Strategies are means or solutions that people imagine, or that coaching should offer in order to reach a goal (e.g., walking during you're phoning; walking to get the next bus stop). These strategies are supposed to help people to monitor and involve DPA.

Metacognition is simply defined as cognition about self [14]. People engaging in metacognition will internally design knowledge about their own capabilities, and their own skills. If someone knows that he is not able to walk more than 5,000 steps a day, he spontaneously might not adopt a goal up to 10,000 steps a day. In contrary, if a PA program is addressed to him, and seems too difficult, too high, he simply would give up. Thus, metacognition is a precious component when designers want to select appropriate goals and strategies in exercise settings [15]. In this perspective pedometers should be helpful tools for people to know their own real DPA, and lead them to adopt a relevant goal.

Complementary, when one wants to initiate PA, goal setting theory, and the self-determination theory are also well-known resources. Research shows that motivation for physical activity is likely to be more robust if environment offers choices and self-determination rather than external control. This conducted us to consider that the program should offer alternative goals. Individuals should be invited to choose the best goals for themselves, or the most motivating one.

3.3 Maintaining active behaviour: interest of achievement motivation

Because goals are personal representations, people are usually motivated through various types of goals. According to the Achievement Motivation Theory goals and behaviour could be referred to mastery – oriented or performance – oriented elements. Closely related to the issue of Goal Achievement Motivation Theory, the climate, or the relationships, within the exercise environment [16]. Perceptions of the motivational climate within a workplace or a training group can be classified as "mastery" or "performance". A mastery climate is one in which the participants perceive that self-improvement is the most important. A "performance" climate is one where participants are often compared with each other or with normatively superior performance (e.g. 10,000 steps a day).

A meta-analysis of climate studies across all physical activity settings quantified the links between climates and outcomes [16]. The overall effects from fourteen studies involving over 4,000 participants showed a large effect for mastery climate on positive outcomes and a moderate effect for performance climate on negative outcomes.

Because feedbacks in a device are important elements of a perceived climate, this line of research provides an important rationale for designing PA setting. Mastery oriented feedbacks or performance oriented feedbacks should be addressed to participant depending to their personal motivation orientation or to their physical self-esteem.

3.4 Evaluating outcomes of DPA Intervention

Contemporary self-esteem theory proposes that our global view of ourselves ("global self- esteem") is underpinned by perceptions of specific domains of our lives, such as social, academic and physical domains. Based on this approach and on Fox previous work [17], Ninot et al. [18] has developed an operational measure of physical self-perceptions and its self-perception subdomains of sport competence, perceived strength, physical condition, and attractive body. Self – esteem theory proposed that everyday events are likely to affect more specific perceptions of self, such as the belief that one can walk 10,000 steps a day, which may eventually contribute to enhanced self-perceptions of physical condition or even physical self-worth. Self-perceptions could be important psychological constructs guiding general motivated behaviour, when people have to initiate PA. Self-perceptions can also be viewed, such as consequences or outcomes of a PA program.

Finally both of Physical – Self Esteem Scale and TTM of behaviour change furnished guides to implement the evaluation stage of the five-step intervention strategy.

3.5 Conclusions

The C2S Project aimed at implementing a technological solution, more specifically a mobile phone application, based on advances from research in exercise psychology.
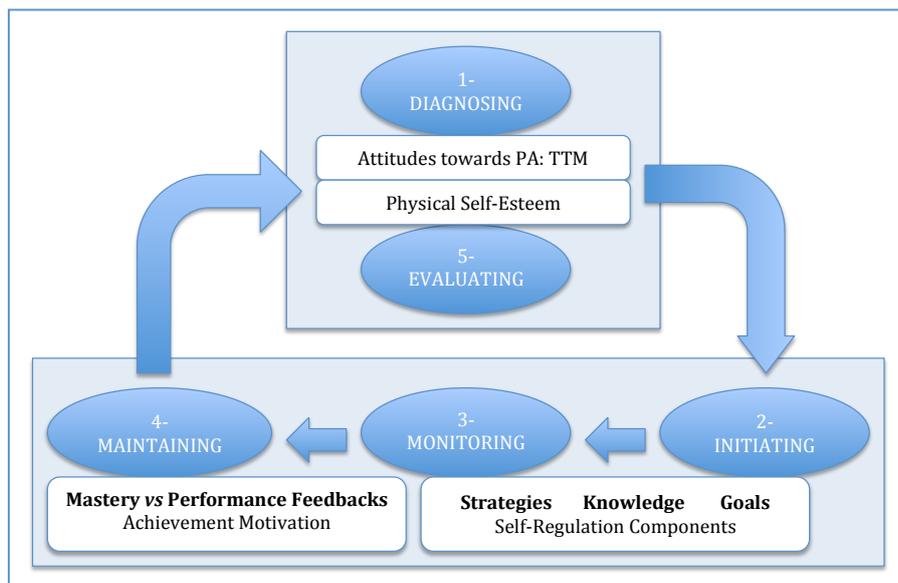

Fig. 1. The Five-Steps Strategy: a rationale for the App design process.

The program was considered as a set of personalized walking goals, behavioural strategies and knowledge about PA and health, and daily-individualized feedbacks. The question for the designer of a DPA program is how to deliver these information

or artefacts to individuals? The whole strategy and its backgrounds are summarized in figure 1. These rational have been presented to the designers at the beginning of the design process.

4 Delivering a Personalized Physical Activity Program: a Design Process

Despite an explosion of mobile phone applications concerning PA, few have been based on theoretically derived constructs in order to promote health behaviours and reduce sedentary behaviour [19].

During the period from September 2013 – May 2014, the interdisciplinary team undertook initial app design, programming, and iterative user testing. Following these activities, initial app was developed and feedbacks from potential users were obtained. The Android smartphone platform was used. The smartphone battery life sufficiently to allow continuous accelerometer data capture throughout the day. The data collected via the smartphone's built-in accelerometer were transmitted to the project's local servers each evening for data storage and to allow researchers to monitor the quality of data while the design progressed. Feedbacks from users and ergonomic analysis lead to involve the design. During the period from September 2014 – January 2015, a second version of the app, called MOVE ("BOUGE" in French language), was developed, and was able to be commercialized. MOVE delivered an 8-weeks program aiming at involving DPA

The 5-steps intervention strategy was implemented within the design of the App.

4.1 Diagnosing

The initial session is used to provide instruction on the general use of the App, and to collect data including age, size, weight and gender. Especially, attitudes towards PA and Physical Self-Esteem are diagnosed. The user has to answer the Physical-Self Inventory (PSI-6), a six-item questionnaire developed and validated by Ninot, Fortes and Delignières [18]. The PSI-6 is a short version of a previously validated questionnaire, the PSI-25, adapted from the Physical Self-Perception Profile [18]. PSI-6 contains one item for global self-esteem (GSE), one item for physical self-worth (PSW), and one item for each of the four sub-domains identified by Fox and Corbin [17]: physical condition (PC), sport competence (SC), attractive body (AB) and physical strength (PS). This questionnaire was proven to reproduce the factorial structure of the corresponding multi-items inventories [18] and to possess the same hierarchical properties. Each item is a simple declarative statement, to which participants was invited to respond using an analogic visual scale.

Attitude towards PA and behaviour change is measured using the stage of exercise behaviour change scale, adapted from Cardinal [20]. Users are asked to place themselves in one the five stages. During this first week, descriptions of the physical activity recommendations for health and sedentary lifestyle risks are available on a single screen.

Fig. 2. User's profile on a screen.

The first week of the 12-weeks program is used as a baseline or a testing period for delivering an adapted program. Users are requested to continue with their normal physical activity and sedentary behaviours during the baseline week. The main screen of the app provides the user's current daily number of steps.

At the end of this initial week, the program can be personalized and users receive goals and advices.

4.2   Initiating and monitoring

At the beginning of each week, users receive specific goal setting, which emphasized walking steps increase. For each week a distal goal is assigned depending both based on the score or number of walking steps the user reached at the end of previous week (e.g., 30 000 steps a week), and on his psychological profile (i.e., Physical Self-Esteem score). Depending on previous data, 5, 10, 15, 20% enhancement in weekly walking steps was used as references points. Participants were provided with three goal options of varying difficulty (e.g., 33 000 steps, or 34 500 steps, or 36 000 steps). These choice options were given based on the self-determination and goal-setting theory principles.

Whenever he wants, the user can see on the same screen his just-in-time score, the score for previous days, and the target at the end of the week.

Fig. 3a and 3b. User's daily current screens.

In addition to having access to some "help" as part of this app, users participants can edit a set of behavioural strategies. On a specific screen, written solutions for increase DPA are listed and the user is invited to choose some of them. Twice a day brief health information and knowledge about benefits of PA (e.g., 1 minutes for PA = 10 minutes for life) are displayed.

Thus, goals, knowledge and strategies are supposed to stimulate self-regulation behaviour aiming at initiating and monitoring DPA.

4.3 Maintaining

It was attempted that personalized feedback delivered by the app aim maintain motivation and PA. Balance sheets are provided in the middle of the fourth, the eighth and the eleventh week of the program. An email is sent to the user including graphs and encouragements or advices. Feedbacks' content depends on scores and on psychological profile. Thus they can be mastery – oriented (e.g., Congratulations! An increase of 15% over the previous weeks! Go on! You walk for your health!), or performance – oriented (Congratulations! You've reached 50 000 steps a week! You're now considered as an active person!).
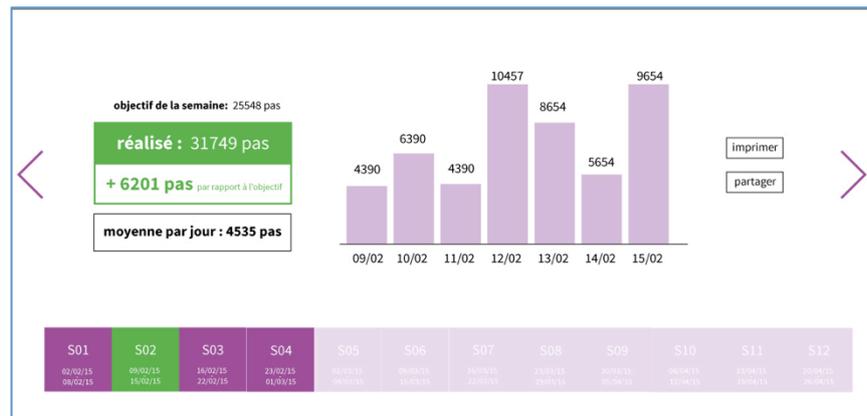
Fig. 4. User's balance sheet.

2.4 Evaluating

In line with previous research in exercise psychology, pedometers are reliable for furnishing a realistic and objective measure about everyday walking steps. Such an on-going evaluation is supposed to impact motivation and behaviour control. Users perceived the gap between the goal they have chosen and their own DPA. Consequently, self-regulation mechanisms consist in imagining solutions, imitating pairs' behaviour, seeking for advices. The app helps people in taking in charge their own behaviour.

Finally, as soon as the program is closed, users receive a final balance sheet and advices for future. This constitutes a milestone in our 5-steps strategy; when someone is able to evaluate his own progress, it was hypothesized that his own self-perception would enhance. Thus at the end of the program, users are asked to answer the Physical Self-Esteem. If users observe increases concerning both of DPA and Physical Self-Esteem, they would get confidence in the device effectiveness. These psychological effects would favour continued motivation for DPA.

5 Perspectives

Benefits of Physical Activity are attempted for adults in the European Space. The C2S Project including a web resource, a ride for companies called "Challenging sedentary lifestyle", and the MOVE App, is a medical, technologic and scientific project. Thus, an empirical study (200 participants in experimental group *vs* 100 participants in control group) has been conducted to assess the effect of the program on DPA. Results could have important implications for advancing the field of PA sciences, and will be precious to involve the design of the App. Moreover collected data on daily PA or behaviour changes in a workplace setting will be stored and should be useful for health institutions.

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