Abstract

The Active2Gether intervention is an app-based intervention designed to help and encourage young adults to become and remain physically active by means of personalized, real-time activity tracking and context-specific feedback. The aim of this paper is to describe the development and the content of the Active2Gether intervention for physical activity (PA) promotion.

A systematic and stepwise approach was used to develop the Active2Gether intervention. This included formulating objectives and a theoretical framework, selecting behavior change techniques, specifying the tailoring, pilot testing and describing an evaluation protocol. Five steps were undertaken to develop the Active2Gether intervention: 1) definition of the intervention objectives, 2) definition of the theoretical framework, 3) development of the intervention content and communication channel (i.e., selection of behavior change techniques, writing messages, assessment for tailoring), 4) pilot testing, and 5) testing and evaluating the intervention. The primary objective of the intervention is to increase total time spent in moderate-vigorous PA (MVPA) for those who do not meet the Dutch guideline, to maintain PA levels of those who meet the guideline, or to further increase that if they indicate they want to improve further. The theoretical framework is informed by the social cognitive theory, and insights from other theories and evidence were added for specific topics. Development of the intervention content and communication channel resulted in the development of an app that provides highly tailored coaching messages that are framed in an autonomy-supportive style. These coaching messages include behavior change techniques aiming to address relevant behavioral determinants (e.g., self-efficacy, outcome expectations) and are partly context-specific. A model-based reasoning engine has been developed to tailor the intervention with respect to the type of support provided by the app, to send relevant and context-specific messages to the user and to tailor the graphs displayed in the app. For the input of the tailoring, different instruments and sensors are used, such as an activity monitor (Fitbit One), online and mobile questionnaires, and the location services on the user’s mobile phone.

The systematic and stepwise approach resulted in an intervention that is based on theory and input from end-users. The use of a model-based reasoning system to provide context-specific coaching messages goes beyond many existing eHealth and mHealth interventions.
This chapter is based on the article that is conditionally accepted as:

Anouk Middelweerd, Saskia J. te Velde, Julia S. Mollee, Michel C.A. Klein, and Johannes Brug (2018). “Development of Active2Gether: An app-based intervention combining evidence-based behavior change techniques with a model-based reasoning system to promote physical activity among young adults”. In: Journal of Medical Internet Research
13.1 Introduction

Insufficient physical activity (PA) is a risk factor for avoidable burden of disease (World Health Organization, 2010, 2014). About 25 percent of the adult population worldwide does not meet the recommended guidelines for PA (World Health Organization, 2014), while this is around 50 percent in many western countries like the US and the Netherlands (Volksgezondheidenzorg.info, 2016). Moreover, engagement in moderate to vigorous PA decreases with age, in particular when transitioning from adolescence into (young) adulthood (Bell and Lee, 2005; Kwan et al., 2012).

Research examining the determinants of PA mainly focuses on social cognitive and social-ecological factors (Anderson et al., 2006; Giles-Corti and Donovan, 2002; Luszczynska and R. Schwarzer, 2005; Plotnikoff et al., 2013; Ralf Schwarzer et al., 2008; Sniehotta et al., 2005; Young et al., 2014). Social cognitive theories and models, such as the health belief model (Abraham and Sheeran, 2005), the theory of planned behavior (Conner and Sparks, 2005), and the social cognitive model (Luszczynska and R. Schwarzer, 2005), have been developed to explain health behaviors and to guide research on health behavior and behavior change (Bauman et al., 2012; Conner and Norman, 2005). Whereas these models mainly focus on intrapersonal and interpersonal factors, social-ecological models more explicitly recognize that behavior may also be strongly influenced by contextual factors, such as the sociocultural and physical environments people live in (Bauman et al., 2012; Sallis, Cervero, et al., 2006; Sallis, Saelens, et al., 2009). For example, Sallis, Cervero, et al. (2006) propose a framework that recognizes that individuals are physically active within different domains (e.g., recreation, transport, household and occupation), where different factors on multiple levels influence their overall PA behavior. Thus, interventions that aim to increase levels of PA should not only target intra- and interpersonal factors, but should also take their physical and social environments into account.

Health promotion interventions targeting healthy lifestyle behaviors, including those aiming to promote PA (e.g., aiming to change PA behaviors), have been heavily influenced by information and communications technology (ICT) development. Where most health promotion interventions used to be face-to-face activities and/or printed materials, nowadays we rely much more on web-based and mobile (app-based) interventions—eHealth and mHealth interventions— that support and enable the personalized tailoring of face-to-face interventions and the large reach of print-based materials (Crutzen et al., 2013; Vandelanotte et al., 2016). Several reviews and meta-analyses of eHealth interventions targeting PA found small effects on levels of PA in favor of the intervention groups (Davies et al., 2012; Krebs et al., 2010; Webb et al., 2010). The majority of the studies included mainly respondents of Caucasian ethnicity (Davies et al., 2012; Krebs et al., 2010), the majority of the participants was female in most studies (Davies et al., 2012; Krebs et al., 2010), and in most studies higher-educated participants were over-represented (Davies et al., 2012), and thus the results are not generalizable to the populations at large.

A recently published systematic review reviewed studies that used apps in interventions to influence health behavior, including PA (Schoeppe et al., 2016). The majority of those studies that targeted adults reported significant intervention effects (Schoeppe et al., 2016). Furthermore, the majority of the interventions that reported significant changes in behaviors and health-related outcomes included behavior change techniques as goal setting, self-monitoring and feedback on the performance (Schoeppe et al., 2016).

Furthermore, several content analyses were conducted to identify if and how constructs
Chapter 13. Description of the development and content of Active2Gether

of behavior change theories and behavior change techniques (BCTs) are incorporated in PA promotion apps. Generally, the apps analyzed were lacking applications of behavior change theories and the use of evidence-based behavior change techniques (Conroy et al., 2014; Cowan et al., 2013; Direito et al., 2014; Middelweerd, Mollee, et al., 2014; West et al., 2012). Moreover, apps mostly provide generic advice or tips about PA, and gamification, punishment and context-aware feedback are rare among PA apps (Mollee, Middelweerd, et al., 2017). Only a few apps incorporate some form of adaption to the user (Mollee, Middelweerd, et al., 2017). Lastly, existing apps fail to meet guidelines for PA (Knight et al., 2015; Modave et al., 2015). Despite the fact that health and fitness apps are popular among smartphone users (Intelligence, 2016; Statista, 2016), recent research indicates that most presently available apps lack the necessary empirical basis to make a meaningful difference in PA promotion (Vandelanotte et al., 2016).

In general, it has been found that health promotion interventions informed by established health behavior theory are associated with higher effect sizes than interventions not based on theory (Michie, Abraham, et al., 2009; Vandelanotte et al., 2016; Webb et al., 2010). Likewise, when established BCTs are incorporated, effectiveness is more likely (Michie, Abraham, et al., 2009; Olander et al., 2013; Webb et al., 2010). More specifically, interventions that included a self-monitoring feature in combination with features as prompting intention formation, specific goal setting, providing feedback on performance, or reviewing behavioral goals, were significantly more effective than interventions that did not include these BCTs (Michie, Abraham, et al., 2009).

Systematic reviews further showed that ICT-supported individually-tailored interventions are superior to generic interventions in promoting PA; in effects as well as user engagement and appreciation (Broekhuizen et al., 2012; Brouwer et al., 2011; Krebs et al., 2010; Webb et al., 2010). Moreover, Krebs et al. (Krebs et al., 2010) demonstrated that dynamic tailoring (i.e., iteratively assessing and providing feedback) was associated with larger effect sizes compared to static tailoring (i.e., all feedback is based on one baseline assessment). Modern technology, such as smartphones, smartphone applications (apps) and activity trackers, offers new possibilities in health promotion, especially for young adults of whom the majority owns a smartphone (Center, 2016; TelecomNieuwsNet, 2016). Furthermore, the rapid growth of the popularity and variety of health and fitness apps and activity trackers suggests that young adults will appreciate and adopt an app-based PA intervention.

In summary, innovative mobile technology-based approaches that are evidence-based and include dynamic tailoring may help to effectively support achievement and maintenance of behavior change in the PA domain. However, both the empirical basis and dynamic tailoring are lacking in current apps. Thus, there is a need for PA apps that incorporate constructs of behavior change theories and BCTs, and that provide dynamically tailored feedback.

Therefore, we developed the Active2Gether intervention that combines mobile (app-based) technology with dynamically tailored feedback and aims to go beyond existing (mobile) PA interventions. The aim of the present paper is to describe the systematic development and content of this Active2Gether PA promotion intervention. Section 13.2 provides an overview of the methodology that was used to develop the intervention and a brief description of the target population. Section 13.3 provides detailed information on the systematic development and content of the intervention. A summary of the resulting intervention is presented in Section 4. Finally, Section 5 reflects on the process and looks
13.2 Methods

This section provides an overview of the methodology that was used to develop the Active2Gether intervention.

13.2.1 Intervention development

We used a 5-step systematic approach to develop and evaluate the intervention (see Table 13.1). In order to ensure that the app was informed by relevant health behavior and health behavior change theory and evidence, the development was guided by the program-planning model developed by Kreuter et al. (2013), the intervention mapping protocol (Bartholomew et al., 1998), and the Medical Research Council (MRC) framework for the development and evaluation of complex interventions (Goyal et al., 2016). Table 13.1 provides a detailed overview of the stepwise process of the development of Active2Gether. The five steps are further described in Section 13.3.

Table 13.1: Description of stepwise process for the development of Active2Gether.

<table>
<thead>
<tr>
<th>Step</th>
<th>Step description</th>
<th>Overlap with intervention mapping protocol</th>
<th>Overlap with MRC framework</th>
<th>Overlap with program-planning model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Defining the intervention’s primary and secondary objectives</td>
<td>Identifying relevant physical activity behaviors to increase MVPA</td>
<td>Step 1: State program goals</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Defining the main and sub objectives of the intervention</td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td>2</td>
<td>Defining the theoretical framework</td>
<td>Describing a theoretical framework on how to promote MVPA in general and stair use, active transport and sport in particular</td>
<td>Step 2: Select determinants for behavioral and environmental outcomes</td>
<td>Development: Identify and developing theory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Step 2: Developing a Program Framework</td>
</tr>
</tbody>
</table>
### Chapter 13. Description of the development and content of Active2Gether

#### 3 Developing the content of the Active2Gether intervention

- Selecting behavior change techniques based on theory and evidence in order to address determinants of behavior, based on existing studies and review
- Assessing existing applications, what is available?
- Exploring preferences of end-users
- Writing tailored messages
- Designing tailoring algorithms for in the reasoning system
- Channel of communication: building web-based app and system to combine, interpret data and to send messages

#### 4 Pilot testing

- Pilot testing the intervention to detect errors and impracticalities in order to improve the intervention prior to its implementation

#### 5 Testing and evaluating the intervention

- The intervention will be used by a larger group of participants and then will be analyzed and evaluated with respect to effect, process and impact

#### Step 4: Draft messages, materials and protocols

- Development: Identifying the evidence base
- Step 2: Developing a program framework
- Step 3: Developing the tailoring assessments
- Step 4: Designing feedback
- Step 5: Writing tailored messages
- Step 6: Creating tailored algorithms
- Step 7: Automating the tailoring process

#### Step 4: Pretest, refine and produce materials

- Feasibility and pilot testing

#### Step 6: Write effect and process evaluation questions

- Evaluation: Assessing effectiveness
- Understanding change process

#### Step 8: Implementing the program

#### Step 9: Evaluating the program

### 13.2.2 Target population

The Active2Gether intervention focuses on healthy, young adults. Therefore, participants in user studies that contributed to the development of the intervention, and participants in the quasi-experimental trial to assess the intervention’s effectiveness, were eligible for this study if they met the following criteria: (a) aged 18–30 years, (b) being (apparently) healthy, (c) Dutch speaking, (d) signed the informed consent form, and (e) in possession of a suitable smartphone running on iOS or Android.
13.3 Development of the Active2Gether intervention

This section provides more detail on the systematic development of and content of the Active2Gether intervention.

13.3.1 Step 1: Defining the intervention’s primary and secondary objectives

Step 1 resulted in the decision that the primary objective of the Active2Gether intervention is to increase total time spent in MVPA for those who do not meet the Dutch guideline, to maintain PA levels of those who meet the guideline, or to further increase that if they indicate they want to improve further. The secondary aims defined are: a) to increase the underlying specific categories of MVPA, i.e. minutes of weekly sports participation, weekly numbers of stairs climbed, and/or weekly minutes of active transport, and b) to enhance the underlying determinants of the PA behaviors.

13.3.2 Step 2: Defining the theoretical framework

As a result of Step 2, a theoretical framework was built based on the relevant scientific literature (please see further details below), since behavior change was to be established by changing the underlying behavioral determinants (Brug et al., 2005) and evidence shows that interventions grounded in evidence-based behavior change theories are more likely to be effective (Davies et al., 2012; Webb et al., 2010). The theoretical framework was subsequently used to develop the content of the intervention, and to explain and predict the PA behaviors of the users of the intervention so that the intervention content could be tailored to each individual user.

The social cognitive theory (SCT) was adopted as a basis for the theoretical framework, as it is one of the most prominent behavior change theories used to inform interventions targeting health behavior change (Greaves et al., 2011; Tougas et al., 2015; Young et al., 2014), and a recent meta-analysis reported that SCT concepts may explain 31 percent of variance in PA (Young et al., 2014). SCT addresses both individual and social factors and recognizes the reciprocal relation between the individual and her or his context or environment. For these reasons, SCT thus guided and informed the intervention’s theoretical framework; insights from other theories and evidence were added for specific topics. Figure 13.1a shows the structural pathways of SCT.

Self-efficacy as a key construct within SCT (as well as in other health behavior theories) (Bandura, 2004; Conner and Norman, 2005) was adopted as a key construct in Active2Gether. Self-efficacy is defined as someone’s beliefs in his or her own capabilities to perform certain actions needed to achieve a desired outcome. Self-efficacy affects PA both directly and indirectly (Figure 13.1). Self-efficacy may influence outcome expectations – one’s beliefs about the positive and negative consequences of one’s behavior, such as participating in physical activities (Bandura, 2004; Conner and Norman, 2005). In other words, people who are more efficacious about being physically active will also be more likely to expect the favorable outcomes of participating in physical activities (Bandura, 2004). Moreover, self-efficacy may also influence how people perceive potential obstacles and impediments (Bandura, 1989, 2004). Goal setting was adopted as a second important basis for change, where goals can be either proximal (i.e., shorter-term intentions to act) or distal (i.e., longer-term goals to achieve something) (Bandura, 2004). Proximal goals are goals set for the shorter term and tend to promote more detailed planning that help people to make action
plans (Bandura, 2004; Grant, 2012). Distal goals are goals set for the longer term and set the course of personal change (Grant, 2012). According to Bandura (Bandura, 2004), distal or long-term goals can initiate behavior change, but are not sufficient to change PA directly (Figure 13.1). Goal setting is dependent on levels of self-efficacy and perceived barriers and opportunities. In line with this notion, a meta-analysis inspired by the action-control framework indicated that 48% of the participants who intended to be physically active failed to do so. Therefore, forming intentions is often not sufficient to realize behavior change and self-regulatory and action-control techniques are needed to support behavioral enactment (Rhodes and Bruijn, 2013). A further meta-analysis on effective techniques in healthy eating and PA interventions concluded that interventions that offered self-monitoring and addressed self-regulation were more successful in increasing PA than interventions not including those techniques (Michie, Abraham, et al., 2009).

SCT posits that when individuals adapt and revise their behavior, they may adjust their beliefs and goals regarding this behavior (Bandura, 2004). In our theoretical framework, we therefore included ‘satisfaction’, defined as an evaluation of the PA behavior.

In line with SCT, we also recognized that the social environment influences behavior through social norms and that performing certain behavior can evoke social reactions, both positive and negative (Bandura, 2004). In the Active2Gether intervention, we do not only address intrapersonal (e.g., lack of motivation, tiredness) and social barriers (e.g., lack of support), but also contextual impediments (e.g., lack of time, weather, travel distance) (see Figure 13.1).

Lastly, it was decided that users will be categorized based on their awareness of their personal PA levels before they will be coached; people who are overly optimistic about their PA levels – i.e. who believe they engage in adequate amounts of PA while their data show insufficient levels – will be much less likely to be motivated to increase their PA levels (Lechner, 2006).

13.3.3 Step 3: Developing the Active2Gether intervention

In Step 3, the evidence-based behavior change techniques (BCTs) were identified and linked with the behavioral determinants of the theoretical framework and translated into tailored messages. These messages address specific behavioral determinants to create a ‘message library’ of actual feedback and advice messages tailored to all possible levels of the relevant behavioral determinants as recognized in the underlying theoretical framework. In order to actually tailor the messages to the individual users, the tailoring variables – i.e., the PA behaviors and their underlying determinants – are assessed for each individual user. The web-based Active2Gether app and accompanying same-content website are the communication channel to deliver the tailored intervention content. These elements, i.e. the BCTs, the development of the feedback messages and the assessment and tailoring methods are described hereafter, where we elaborate on the content. A more detailed description of the technical development of the Active2Gether intervention is published elsewhere (Klein et al., 2017).

I. Selection of behavior change techniques

We identified the relevant BCTs and linked these with the behavioral determinants of the theoretical framework described in Step 2 by means of a review of the relevant literature, based on an existing taxonomy of BCTs (see Table 13.2) (Abraham and Michie, 2008;
13.3 Development of the Active2Gether intervention

(a) Structural pathways of Bandura’s social cognitive theory.

(b) Specific theoretical framework used for the Active2Gether intervention. (The bold lines and boxes represent the elements that are based on the Social Cognitive Theory and the dotted lines and oval boxes represent behavioral determinants added to the theoretical framework.)

Figure 13.1: Theoretical framework in Active2Gether.
Michie, Richardson, et al., 2013). To explore which BCTs were used in already existing PA promotion apps, a systematic content analysis of such apps available in iTunes and Google Play was conducted (Middelweerd, Mollee, et al., 2014). This content analysis showed that the apps available to date generally lack sufficient incorporation of evidence-based BCTs (Middelweerd, Mollee, et al., 2014). BCTs that were applied most often were: providing feedback on performance, prompting self-monitoring of behavior, prompting specific goal setting, and planning social support or social change (Middelweerd, Mollee, et al., 2014). Additionally, focus group discussions with the target population indicated that participants preferred self-monitoring, goal setting and a ranking feature, but were not willing to share their accomplishments on social media for social comparison and to initiate social support (Middelweerd, van der Laan, et al., 2015). The focus groups further suggested that the Active2Gether app should be highly personalized, have an easy-to-use design and format, include a coaching feature that provided tailored feedback to self-set goals, enable competition with friends by ranking or earning rewards, and include the option to personally customize the application (Middelweerd, van der Laan, et al., 2015). The methods and results of these focus groups have been published in more detail elsewhere (Middelweerd, van der Laan, et al., 2015). Finally, an online cross-sectional survey among 179 young adults to assess their ratings with respect to the importance of specific BCTs applied in apps and their preferences for personalized tailoring (Belmon et al., 2015) confirmed the need for a personal coaching feature and showed that BCTs addressing goal setting, goal reviewing, feedback and self-monitoring were rated as important to be incorporated in an app, whereas social support and social comparison were considered less important (Belmon et al., 2015). The combined results of the review of the literature, the focus group discussions and the survey guided the selection of the BCTs to be included in Active2Gether (see Table 13.2).

Table 13.2: Overview of the behavior change techniques that were selected to target the behavioral determinants of the theoretical framework and how they were applied within the intervention.

<table>
<thead>
<tr>
<th>Determinant</th>
<th>BCT</th>
<th>How applied</th>
<th>Theory BCT</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome expectations</td>
<td>Provide general information on</td>
<td>Messages in general and tailored to aspects of the</td>
<td>Information-motivation-behavioral skills</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td></td>
<td>consequences of behavior in</td>
<td>intake questionnaire</td>
<td>model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>general</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>Action planning/ time management</td>
<td>Messages prompting the planning of physical activity, e.g. the suggestion to mark time and day in the calendar</td>
<td>Goal setting theory</td>
<td>(Olander et al., 2013; Sniejotta, 2009; Williams and French, 2011)</td>
</tr>
<tr>
<td>Social comparison</td>
<td>Graph tailored to preference</td>
<td>Social comparison theory</td>
<td>(Williams and French, 2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>social comparison (up-/downward)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Development of the Active2Gether intervention

<table>
<thead>
<tr>
<th>Persuasion</th>
<th>Persuasive messages on how to overcome barriers</th>
<th>Social cognitive theory</th>
<th>(Williams and French, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prompt self-monitoring</td>
<td>Messages that prompt to look at the monitoring graphs &amp; display of graph</td>
<td>Self-regulation, social cognitive theory, control theory</td>
<td>(Bandura, 1991; Olander et al., 2013)</td>
</tr>
<tr>
<td>Plan social support</td>
<td>Messages with suggestions to tell friends and ask for support</td>
<td>Social support theories</td>
<td>(Olander et al., 2013; Williams and French, 2011)</td>
</tr>
<tr>
<td>Imaginary reward</td>
<td>Messages that tell the user to be proud if they did well</td>
<td>Self-regulation, social cognitive theory, self-determination theory</td>
<td>(Bandura, 1991)</td>
</tr>
<tr>
<td>Intentions</td>
<td>Progress towards goal</td>
<td>Messages that tell the user how much he/she has already achieved &amp; display of graph</td>
<td>Self-regulation, social cognitive theory</td>
</tr>
<tr>
<td>Motivational messages</td>
<td>Messages telling the user how well he/she is doing and to keep up the good work or telling the user some advantage of being physically active</td>
<td>Social cognitive theory</td>
<td>(bandura et al., 2013; Williams and French, 2011)</td>
</tr>
<tr>
<td>Modeling</td>
<td>Messages stating how well others are doing &amp; display of graph</td>
<td>Social cognitive theory, theory of planned behavior</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td>Provide instruction</td>
<td>Messages that prompt the user to prepare the sports bag the night before</td>
<td>Social cognitive theory</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td>Prompt goal setting</td>
<td>Messages prompting the user to set a goal and providing a suggestion</td>
<td>Self-regulation, social cognitive theory</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td>Impediments</td>
<td>Prompt barrier identification</td>
<td>Messages that provide information on how to deal with a specific barrier</td>
<td>Social cognitive theory</td>
</tr>
</tbody>
</table>
### Chapter 13. Description of the development and content of Active2Gether

<table>
<thead>
<tr>
<th>Social norm (descriptive and inductive)</th>
<th>Prompt barrier identification</th>
<th>Messages that provide information on how to deal with a specific barrier</th>
<th>Social comparison theory</th>
<th>(Abraham and Michie, 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prompt barrier identification</td>
<td>Messages that provide information on how to deal with a specific barrier</td>
<td>Social cognitive theory</td>
<td>(Abraham and Michie, 2008)</td>
<td></td>
</tr>
<tr>
<td>Self-regulation</td>
<td>Self-monitoring</td>
<td>Messages that prompt the user to look at the monitoring graphs &amp; display of graph</td>
<td>Self-regulation, social cognitive theory</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td>Goal setting</td>
<td>Messages that prompt the user to set a weekly goal</td>
<td>Control theory</td>
<td>(Abraham and Michie, 2008)</td>
<td></td>
</tr>
<tr>
<td>Progress towards goal</td>
<td>Messages that tell the user how much he/she has already achieved &amp; display of graph</td>
<td>Control theory</td>
<td>(Abraham and Michie, 2008)</td>
<td></td>
</tr>
<tr>
<td>Self-evaluation</td>
<td>Messages prompting the user to evaluate how he/she is feeling about failing or achieving the self-set goal</td>
<td>Control theory, integrated theory of health behavior change</td>
<td>(Abraham and Michie, 2008)</td>
<td></td>
</tr>
<tr>
<td>Imaginary reward</td>
<td>Messages that tell the user to be proud if they did well</td>
<td>Self-regulation, social cognitive theory, self-determination theory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Self-evaluation</td>
<td>Messages prompting the user to evaluate how he/she is feeling about failing or achieving the self-set goal</td>
<td>Control theory, integrated theory of health behavior change</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
<tr>
<td>Long-term goals</td>
<td>Provide general information on consequences of behavior in general</td>
<td>Messages providing general information on consequences of behavior in general</td>
<td>Information-motivation-behavioral skills model</td>
<td>(Abraham and Michie, 2008)</td>
</tr>
</tbody>
</table>

#### II. Writing tailored messages

Next, the BCTs were translated into actual tailored feedback and advice messages. In line with the self-determination theory (Gagné and Deci, 2005), these messages were written in an autonomy-supportive style. Messages were also written in a way to support relatedness and individualization, e.g. by addressing the users personally by their names. By respecting their autonomy and by making them feel related to the Active2Gether intervention, we
aimed to increase the user’s willingness to follow up on the coaching messages. Moreover, the messages were written in a positive gain-framed style, i.e., a style that describes the potential gains (e.g., in health, fitness, relaxation) when participating in PA rather focusing on loss (e.g., ill health, lack of fitness, stress) when not engaging in PA (Riet et al., 2009). The majority of the messages were tailored to determinants in the theoretical framework, the weather and occupational status. Creating the message library was an iterative process of brainstorming, writing a set of messages (AM), and providing feedback and suggestions (JM, StV).

A pilot test of a subset of messages among seven female bachelor and master students to test whether the tone-of-voice and the content appealed to the target population indicated that the messages were friendly, motivational, empathic and some were perceived as autocratic whereas some were not. Some minor changes were made in the messages.

III. Assessment for tailoring
Further decisions were made on how to measure the characteristics for tailoring messages. The following subsections describe the assessment of physical activity, the assessment of behavioral determinants, the assessment of the users’ locations and the assessment of friendship connections.

(A) Assessment of physical activity
First of all, after considering functionalities, validity and costs of a range of available activity trackers, it was decided to monitor the user’s activity using the Fitbit One, which includes monitoring of steps and stairs climbed on a minute basis. The Fitbit One was chosen because of its functionalities and the small size. The Fitbit One is a lightweight tri-axial accelerometer with a built-in altitude monitor that (among others) assesses the user’s step activity and number of floors climbed. The activity monitor communicates with the Fitbit app and website that display the collected data, for example by showing a color-coded chart indicating the proximity to the step goal, which is set to a default of 10,000 steps per day. Our test of the validity of the Fitbit One indicated that Fitbit can be considered a valid device to assess step activity for real-time minute-by-minute self-monitoring, although an overestimation of 677 steps per day by the Fitbit was seen (Middelweerd, Ploeg, et al., 2017). However, the validation study indicated that the Fitbit is less suitable for providing instant real-time feedback and for daily feedback on PA intensity levels (i.e., minutes of moderate, vigorous or MVPA) as it substantially and systematically overestimates time spent per intensity level per hour (Middelweerd, Ploeg, et al., 2017). For that reason, the Fitbit is only used to assess step activity.

Fitbit allows developers and researchers to access Fitbit data and thus to link and integrate the Fitbit data into health behavior interventions such as Active2Gether. In order to access the Fitbit data, Fitbit offers an application programming interface (API). The participants need to give permission once for the developers to access their activity data, this then can be collected regularly and a summarized version of the data is stored in the Active2Gether database. This data is utilized in several ways: for presenting the activity level to the user, for determining the type of coaching and to tailor coaching messages.

(B) Assessment of behavioral determinants
It was decided that behavioral determinants are assessed by means of a questionnaire, with a long and a short version, which were selected based on validations of such questionnaires. The long version is part of an ‘intake’
questionnaire before the actual intervention and as a point of departure for the tailored intervention, while the short version is used repeatedly throughout the intervention period to dynamically tailor the intervention content to the user. The literature was reviewed for relevant, existing and validated questionnaires. The long version is based on existing questionnaires that have previously been validated (i.e., Neighborhood Quality of Life Survey, Self-efficacy scales) or questions used in previous studies and were translated and adapted where necessary (Sallis, Cervero, et al., 2006; Sallis, Saelens, et al., 2009; Van Sluijs et al., 2004). In the short questionnaire, we decided to use single item questions to assess each of the behavioral determinants that are part of the framework and the system. In the short version of the questionnaire, all determinants are specified for each coaching domain (i.e., sports participation, stairs use and active transport). These items were not pretested as such, but were based on the long questionnaire. The Appendix provides an overview of the questions asked in the long and short version of the questionnaire, including the answer options.

(c) Assessment of location We also included questions about the participants’ significant places (e.g., home address, parental home, sports location, university, work location) in the intake questionnaire. These questions focus on travel options from home to the significant locations, thus information about the active and non-active transportation options. Additionally, information about the number of stairs available at each location and the maximal number of stairs that the participant is willing to climb in one go is assessed as well.

The user’s location (GPS coordinates) is collected using Google’s location services that can be linked with the Active2Gether app. The location data is used to determine whether the user visited his/her significant locations (e.g., home, study/work place, sports club) and to trigger user input about transport and travels that have been made. In addition, information about the characteristics of locations is used for personalized coaching messages to the user. For instance, if a person is being coached to using the stairs more often at work or at the university, it is only useful to suggest this when the option to climb the stairs is indeed present at the worksite/university.

(d) Assessment of friends Information regarding the participants’ friends is collected using the Facebook API. Users are asked to provide access to their Facebook ID and their connections by logging into Facebook once and giving permission for this. It is important to note that Facebook does not provide personal information about someone’s Facebook connections, but only a list of Facebook IDs of their connections. This information can be used to see whether any Active2Gether users are connected on Facebook. If two participants of the current intervention are connected on Facebook, they see a ranking within the app that shows both users’ achievements. In this way, the users only share their achievements with a closed group and not with ‘everybody’, according to the preferences stated in the focus group discussions.

IV. Tailoring and personalization
In order to realize high and dynamic tailoring, we combined evidence-based BCTs with predictive modeling (i.e., reasoning based on a computational model). Tailoring and personalization of the intervention content is realized in six ways: (A) determining the personally
appropriate type of support (i.e., education, coaching, or feedback), (B) selecting the personally preferred domain of PA for coaching (i.e., sports participation, stair use, active transport), (C) suggesting a weekly goal, (D) selecting the personally appropriate behavioral determinants for coaching, (E) sending relevant coaching messages, (F) tailoring and personalization of the app content. To realize such tailored coaching, we developed a system that combines detailed behavior monitoring with intelligent data interpretation and model-based predictions. Thus, combining the data from the different sources, the system enables personalization of the coaching strategies to try to achieve the most positive effect on behavior change. Detailed information on the system and the development of the system can be found elsewhere (Klein et al., 2017). In the following subsections, each of the tailoring levels is explained in more detail, after which the actual communication channel for the tailored feedback and advice is explained.

**A. Determining type of support** First, the type of support (i.e., education, coaching, feedback) is determined based on the user’s actual activity level (i.e., assessed with the Fitbit One) and the user’s perception of his/her activity level. If users do not meet the Dutch PA guidelines, but think they are sufficiently active, they will be educated to create more awareness (education). Users will be coached towards more physically active behavior (coaching) if they are aware that they are insufficiently active or if they are sufficiently active but still motivated to be more physically active. Users will receive positive feedback to maintain their activity level (feedback) if activity levels are already according to recommendations (and they don’t have the desire to increase their PA level). Users for whom the educational option was deemed most suitable will receive educational messages for a week and then they will automatically receive coaching messages.

**B. Selecting a coaching domain** As mentioned in Step 1, Active2Gether targets sports participation, stair use and active transport. Users that are being coached towards more PA can select one of the three coaching domains. Based on the user’s activity level and the opportunities for increasing PA in the three domains for a specific user in his own context (based on information about the user’s context from the intake questionnaire), the user receives a recommendation. However, the final decision about the coaching domain is up to the user, the system only provides an informed suggestion.

**C. Suggesting weekly individually tailored goals** Based on the user’s behavior, a suitable weekly goal is estimated for increasing or maintaining PA in the specific domain tailored to the specific. The system suggests individual domain-specific goals that are tailored towards the actual activity levels of the user. Users who did not meet their previous goal will be encouraged to stick to that goal, whereas users who met their goal will be encouraged to make further steps by raising their goal by 10%. However, the final decision about the coaching domain and actual goals set is again up to the user, as the system only provides tailored suggestions. Additional to the domain-specific goal, the app shows a chart that indicates the proximity to the 70,000 steps per week goal (i.e., averaging 10,000 steps per day) that is set as default in the Fitbit app as well.
(d) Selecting potentially effective behavioral determinants for coaching  In order to surpass existing app-based interventions, we used advanced artificial intelligence based techniques. The system makes use of a computational model of behavior change, based on the theoretical framework, that is used to predict behaviors (e.g., sports, stair use, active transport) for each participant. The relevant behavioral determinants are assessed with the short questionnaire on a weekly basis based on the single items described in the Appendix. The computational model is used to simulate how changes in scores on determinants can lead to changes in the behaviors. Different changes, in terms of which determinant is selected to change, are simulated and the results are ranked by the size of the effect on the behavior. This rank order is then used to probabilistically select the most relevant determinant to be coached on. This simulation process is repeated weekly based on the most recent answers on the short questionnaire to keep the dynamic tailoring up-to-date.

(e) Compiling and sending individually tailored coaching messages  Users receive feedback and advice messages from the message library that are tailored to their personal activity and behavioral personal determinants and contextual factors. During the day, the system checks three times whether a relevant message can be sent to the user. To be specific, the system creates a new personal message library for each user three times per day that eliminates irrelevant coaching messages. Detailed information on how the system creates this new personal messages library is described elsewhere (Klein et al., 2017). For example, messages that should only be sent on a specific day of the week or within a specific time window will be eliminated when necessary. Thus, the user receives up to three coaching messages per day. By only including such personally tailored messages, irrelevant feedback and advice is reduced, increasing personal relevance. Some messages are further personalized by explicitly referring to data the users provided themselves, such as the goals they set, the number of steps taken, or the number of stairs climbed. Educational messages are sent in the same way. The messages are not individually tailored, but contain evidence-based information on the importance and benefits of PA.

The messages pop up on the smartphone with a push notification, and are presented as overlay on top of the dashboard (i.e., the collection of graphs in the app that depict the user’s data). As long as the app is not opened to read the message, the user will receive a notification every 15 minutes. In addition, the dashboard displays the five most recent messages.

(f) Further personalization of the app content  Finally, the messages and graphs displayed in the app are further personalized by mentioning the name of the user, presenting the user’s own activity data (a graph with step activity data and a graph with data from the coaching domain), and displaying the comparison with others in the user’s preferred way (i.e., up- or downward comparison) (Mollee and Klein, 2016). The other users are either Facebook friends or other participants (i.e., who are about equally active as the user and who will not be mentioned by name). Detailed information on the selection of users for the ranking feature can be found elsewhere (Klein et al., 2017). Figure 13.2 shows a screenshot of the app. This way, the users only share their achievements with a closed group and not with ‘everybody’, according to the preferences stated in the focus group discussions.
(6) Communication channel and display The Active2Gether app is a web-based application that is suitable for Android phones running on version 4.0 or higher. The app shows the website in a format that is viewable for smaller screens. Thus, the intervention content was accessible through the app or through the website.

The app shows a non-personalized, generic avatar with a welcome message that mentions the user’s current weekly goal. The app displays the current number of daily steps and stairs climbed. In addition, the app shows 4 graphs: 1) a bar chart with the step progress towards 70,000 steps per week, 2) a ranking with six other Active2Gether users – where possible Facebook friends – based on the step activity over the last seven days, 3) the activity data for each week day for the current coaching domain (i.e., minutes of sport activity, numbers of stair climbed or minutes of active transport), 4) the step activity for each week day. The third and fourth graph display the user’s own data as well as the average data assessed within Active2Gether. Moreover, these graphs can be adjusted according to the user’s preferences: they can show data for the last week, last month or from the first use.

Tailored messages and short questions are sent via push messages through the app. After the user reads the messages, they are displayed at the bottom of the app. Only the five messages sent most recently are displayed in the app. Figure 13.2 shows a screenshot of the app.
13.3.4 **Step 4: Pilot testing**

In order to detect possible bugs in the system, and to assess user friendliness and appreciation, the app was pilot-tested in two steps. First, the Active2Gether team (AM, JM, AMR, StV, MK) used the initial version of Active2Gether. Bugs and nuisances et cetera were monitored, listed and fixed accordingly when and where possible. Second, seven people from the target population (5 women, 21–28 years old) were recruited to use the adjusted version of the app, monitor bugs, nuisances and provide feedback in person and answered a questionnaire regarding use, user friendliness and appreciation. The app was further adjusted based on that information. For example, the timing of the different steps in the tailoring process (i.e., determining the type of feedback, the coaching domain, the weekly goal and the most promising behavioral determinants) did originally not account for exceptional cases, in which a user takes very long to complete a step, which caused a next step to be skipped. In the adjusted version, multiple checks and safety mechanisms were implemented to make sure that the tailoring process could still be finished correctly in such conditions. Also, automated messages to remind users to charge their Fitbit and to synchronize their data were added to the system, because of the observation that participants in the pilot study sometimes did not notice when it was necessary to do so.

13.3.5 **Step 5: Testing and evaluating the intervention**

After developing the intervention, the intervention was evaluated on effectiveness and user appreciation in March 2016. A three-arm quasi-experimental trial — with an active control group – with a baseline and two follow-up assessments at 6 and 12 weeks was conducted to examine the effectiveness of the Active2Gether intervention. This trial is registered in the Dutch trial registry, No. NTR5630.

13.4 **Summary of the Active2Gether intervention**

The Active2Gether intervention is an app-based intervention designed to help and encourage young adults to become and remain physically active by focusing on the domains of active transport, stair climbing and sports participation. To do so, participants are categorized into one of three awareness categories (education, coaching and feedback). Participants in the education category receive educational messages on the benefits of PA, and participants in the feedback category receive motivational messages to maintain their active lifestyle. Participants in the coaching category are coached on sports participation, taking the stairs or active transport. Every week, the participants are asked to choose one of these three coaching domains and to set a weekly goal. Participants receive a suggestion for a coaching domain and a weekly goal based on their previous behavior, but the final decision is up to the user. The participants receive a Fitbit One activity tracker that can be synchronized with the app and that allows the participants to monitor their PA behavior. Lastly, the app sends (daily) coaching messages addressing relevant behavioral determinants. The content of the messages is tailored to the user’s behavioral determinants, occupational status and the local weather conditions. Lastly, the app displays the activity data of the participant, including a graph displaying the activity data of six other participants, preferably friends. The graph with the activity data of others ranks the participants based on their weekly step activity and based on the user’s preferences for social comparison, i.e. upward or downward comparison. Detailed information on the assessment and tailoring are provided in Step 3 in Section 13.3.
13.5 Discussion

The current article describes the development and the content of Active2Gether, an app-based intervention, which was developed using a systematic and stepwise approach. The aim of the Active2Gether intervention is to empower young adults to become and remain physically active by providing them with app-based tailored coaching and feedback. Active2Gether makes use of an activity tracker and personalized, context-specific feedback. It focuses on three PA domains, builds on established behavior theory, and applies evidence-based BCTs and a model-based reasoning system in order to provide individually tailored coaching messages based on current scores on behavioral determinants. The development and the content of Active2Gether was a stepwise and time-consuming process. A strength of this approach is the involvement of the target population. However, as the possibilities of modern technology are constantly and rapidly changing and evolving, possibilities and preferences that were assessed at the beginning of the development might be outdated and/or no longer preferred today. The development and the content of Active2Gether were guided by relevant health behavior theories and scientific evidence, thereby aiming to develop an intervention that provides highly tailored feedback. Consequently, less attention was paid to app design and aesthetics, which might have resulted in a less appealing app compared to commercial apps. Furthermore, the app is only available for Android devices running on a 4.0 version and therefore is not available for older Android devices and iPhones or smartphones running on other operating systems.

Active2Gether incorporates a number of conditions to secure high levels of engagement. First, our approach, integrating a model-based reasoning system, allows us to provide the user a dynamically tailored intervention that adjusts to the changes in the user. Second, by applying multiple levels of tailoring in the app and the content of messages (i.e., type of support, coaching domain, coaching messages, weekly goals), the app is likely to be regarded as personally relevant and to increase feelings of relatedness. Third, by comparing the user’s PA with other Active2Gether users (preferably with their Facebook friends), we expect to further increase the personal relevance and relatedness. Lastly, by giving the user the option to select from three PA domains and set their own goals with guidance and suggestions based on their own input, we expect higher levels of autonomy, resulting in higher motivation to follow up on the coaching messages. However, in order to implement these different levels of tailoring, detailed user information is needed repeatedly and thus frequent user input is needed, which increases user burden.

To date, mobile phones and PDAs have been used to monitor and PA with either smartphone apps or external devices, to deliver feedback, to provide information and to offer a support system to the participants (Vandelanotte et al., 2016). Active2Gether makes use of an external device, the Fitbit One, to monitor PA and to provide feedback through the app based on the user’s behavior. However, Active2Gether goes beyond existing interventions by combining data from multiple sources in order to send context-specific messages. Furthermore, the majority of the published interventions focuses on step activity (Kirwan et al., 2012; Poirier et al., 2016), whereas Active2Gether focuses on sports activity, climbing the stairs and active transport as well. Therefore, the app may be more appealing to participants who do not like to participate in sports, especially because the user can adapt his/her coaching domain every week. However, Active2Gether does not yet incorporate geo-fencing (i.e., sending location-triggered messages), which would further improve the possibilities for context specificity and real-time feedback and advice by for example sending
a reminder to climb the stairs at work when users are close to their work location.

So far, the majority of app-based interventions to promote PA showed positive effects (Schoeppe et al., 2016). In line with other app-based PA interventions, Active2Gether makes use of self-monitoring, goal setting and providing feedback. However, Active2Gether provides dynamically tailored feedback using artificial intelligence based techniques and including conditional factors (i.e., weather), whereas other interventions use logic statements and decision rules to specify which messages should be sent to the user. For example, Active2Gether uniquely assesses the behavioral determinants every week to provide tailored advice and feedback on the current behavior, whereas most studies mostly provide feedback on the current behavior only (Glynn et al., 2014; Kernot et al., 2013; King et al., 2013, 2016; Stuckey et al., 2011). Current app-based interventions to promote PA focus on step activity or overall MVPA (Fukuoka et al., 2010; Glynn et al., 2014; Kernot et al., 2013; King et al., 2013, 2016; Stuckey et al., 2011), whereas Active2Gether focuses on sports activities, active transport and climbing the stairs as well. As the majority of the app-based interventions reported significant effects (Schoeppe et al., 2016), and Active2Gether goes beyond those apps and includes proven to be effective BCTs, we expect to see significant intervention effects compared to the control groups.

Active2Gether is ambitious and innovative and incorporates certain risks. For example, the intervention highly relies on input from the activity monitor and location sensor and thus on the user to turn on and synchronize the tracker with the server. Furthermore, it relies on responses from the users on repeated questionnaires. If they do not provide input at all or if they do not provide true and honest answers, the coaching messages that are informed by this information may become irrelevant and non-tailored. Moreover, if a participant is not a Facebook user or has no appropriate contacts, the personalization could be limited. Finally, if technical problems are encountered, this may result in errors in synchronization and sending messages late or not at all. To limit the burden for the participants and to minimize their input to reduce potential technical problems, future research could make use of smartphone sensors to assess the participant’s behavior.

The overall effectiveness of Active2Gether thus needs to be – and was – evaluated in a quasi-experimental trial with a 12 week follow-up. However, as app-based interventions offer the possibility to deliver just-in-time interventions that are relevant for the user’s situation for that particular moment, a study is needed to examine the possible effectiveness of specific real-time feedback and advice moments (Klasnja et al., 2015). Ecological momentary assessment (Shiffman et al., 2008) in such a quasi-experimental trial setting may help to assess potential specific effects throughout the intervention period. Evaluation of the efficacy of the intervention and the usability can help to further adapt and improve the intervention for future research. Furthermore, data collected during the trial can provide insights on how to further personalize content to the users. The quasi-experimental trial also includes monitoring of app use as well as a process evaluation of app use and appreciation that will provide information on larger scale dissemination and implementation, as well as information on changes required to improve conditions for wider use of the app.

As the intervention has been developed with an early consideration of the preferences of the target population, it is more likely to meet the expectations of the target population. Consequently, the intervention is more likely to be adopted by them. However, the intervention might be prone to technical errors and a significant input from the user is needed to provide tailored feedback. This might be a burden for the participants, leading to a lower adoption
rate. We conducted a small pilot study to test the Active2Gether app and to detect bugs and technical errors, but ideally the pilot study would have been conducted with a larger sample. The current version of the Active2Gether intervention has been developed for healthy young adults owning a smartphone running on Android version 4.0 or higher. The content needs to be adjusted before offering the intervention to other target populations.

**Abbreviations**

API  Application programming interface  
App  Smartphone application  
BCT  Behavior change technique  
ICT  Information and communications technology  
MRC  Medical Research Council  
MVPA  Moderate-vigorous physical activity  
PA  Physical activity  
PDA  Personal digital assistant  
SCT  Social cognitive theory

**Competing interests**

This research is partly funded by Philips. The authors declare that there is no conflict of interests regarding the publication of this paper.

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References


Belmon, Laura S., Anouk Middelweerd, Saskia J. te Velde, and Johannes Brug (2015). “Dutch young adults ratings of behavior change techniques applied in mobile phone apps to promote physical activity: a cross-sectional survey”. In: JMIR mHealth and uHealth 3.4.


Intelligence, SurveyMonkey (2016). These fitness app statistics show what’s going right (and wrong) for Fitbit. https://medium.com/@sm_app_intel/these-fitness-app-statistics-show-whats-going-right-and-wrong-for-fitbit-da2c4c3be142. [Online].
Chapter 13. Description of the development and content of Active2Gether


Michie, Susan, Michelle Richardson, Marie Johnston, Charles Abraham, Jill Francis, Wendy Hardeman, Martin P. Eccles, James Cane, and Caroline E. Wood (2013). “The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an
international consensus for the reporting of behavior change interventions”. In: *Annals of behavioral medicine* 46.1, pages 81–95.


### Appendix – Overview of questions used for the long and short versions of the questionnaires.

<table>
<thead>
<tr>
<th>Behavioral determinant</th>
<th>Example question in long version</th>
<th>No. of items in long version</th>
<th>Question in short version</th>
<th>Answer options</th>
</tr>
</thead>
</table>
| Outcome expectations [NQLS¹, (Sallis, 2010)] | If I participate in regular physical activity or sports, then:  
- I will improve my health  
- I will feel more attractive  
- I will lose weight  
- I will improve my physical fitness  
- I will feel relaxation  
- I will feel less tension and stress | 6 | If I participate in regular sports, then it will have a positive effect, for example on my healthy, appearance, weight or how I will feel.  
If I regularly take the stairs, then it will have a positive effect, for example on my healthy, appearance, weight or how I will feel.  
If I regularly bike or walk, then it will have a positive effect, for example on my healthy, appearance, weight or how I will feel. | 1 – No reason at all  
2 – A slightly important reason  
3 – A quite important reason  
4 – A very important reason |
| Self-efficacy [Self-efficacy scales for exercise (Sallis, Pinski, et al., 1988), NQLS¹ (Sallis, 2010)] | How confident are you that you could do PA, in each of the following situations? I’m confident that I could:  
- Do PA even when I’m tired  
- Do PA even when I’m in a bad mood  
- Do PA even when I feel I don’t have time  
- Do PA even when I am on holiday  
- Do PA even when it is raining | 12 | How confident are you that you will do sports in the next week even when you’re tired, busy or when it’s bad weather?  
How confident are you that you will take the stairs in the next week even when you’re tired, you’re in a hurry or you’re with others?  
How confident are you that you will cycle or walk to work/the university in the next week, even when you’re tired, you’re busy or when it’s bad weather? | 1 – Not at all confident  
2 – Slightly confident  
3 – Moderately confident  
4 – Very confident  
5 – Extremely confident |
### Perceived barriers for sport

[ NQLS¹ (Sal-lis, 2010) ]

How often do the following barriers prevent you from doing sports activities?

- Bad weather
- Lack of time
- Lack of interest in exercise
- Other priorities
- Lack of skills or knowledge
- Lack of equipment
- Lack of facilities or space
- Lack of physical fitness
- Lack of energy
- Lack of money
- Lack of company
- Self-conscious about my looks when I exercise

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### Perceived barriers for active transport

How often do the following barriers prevent you from traveling by bike or by walking instead of traveling by car or public transport?

- Bad weather
- Lack of time
- Lack of physical fitness
- Lack of energy
- Too many pieces of luggage
- Travel distance is too far away
- No suitable bike

7

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### Perceived barriers for stairs climbing

How often do the following barriers prevent you from climbing the stairs?

- Lack of physical fitness
- Lack of energy
- Too many pieces of luggage
- Too many flights of stairs

4

---

### How often do barriers prevent you from participating in sports or exercise activities? Think for example of lack of time, lack of energy, costs, lack of company.

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often

---

### How often do barriers prevent you from participating in sports or exercise activities? Think for example of lack of time, lack of energy, costs, lack of company.

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often

---

### How often do barriers prevent you from cycling or walking to work / the university instead of traveling by public transport or car? Think for example of lack of time, lack of physical fitness, lack of energy or too many pieces of luggage.

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often

---

### How often do barriers prevent you from cycling or walking to work / the university instead of traveling by public transport or car? Think for example of lack of time, lack of physical fitness, lack of energy or too many pieces of luggage.

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often

---

### How often do barriers prevent you from climbing the stairs? For example, barriers as being in a hurry, lack of physical fitness, lack of energy or carrying too many pieces of luggage?

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often

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### Social norm descriptive

| My friends think that I should be sufficient physically active. |
| My fellow students think that I should be sufficient physically active. |
| My brother(s) and/or sister(s) think that I should be sufficient physically active. |

For the people around me (friends, fellow students, family), it’s important that I sufficiently participate in sports.

For the people around me (friends, fellow students, family), it’s important that I use the stairs instead of the elevator.

For the people around me (friends, fellow students, family), it’s important that I regularly bike or walk to work/the university.

### Social norm injunctive

| How often do your friends / roommates / brothers or sisters / parents participate in physical activities? |
| Not applicable² |

1 – Never
2 – Rarely
3 – Sometimes
4 – Often
5 – Very often
6 – Not applicable

### Intentions

| Do you intend do sports (more often) within the next week / month / 6 months even if you think you’re already sufficiently active? |
| I intend to do sports (more often) within the next week. |
| I intend to climb the stairs (more often) within the next week. |
| I intend to bike or walk to work/the university (more often) within the next week. |

1 – Most definitely will not
2 – Probably will not
3 – Maybe / maybe not
4 – Probably will
5 – Most definitely will
Self-regulation [Anderson et al, 2006 (Anderson et al., 2006)]

I keep track of how active I am. I check whether I met my goals. In the last three months, I:

- Set aside time for my daily physical activity
- Walked or biked instead of drove or traveled by public transport
- I exercised or did physical activities with someone else
- I wrote it down in my calendar to do sports/physical activity
- I planned do sports/exercise even when the weather was bad

I planned and set goals do regular sports/exercise. When I wasn’t able do it I evaluated why I wasn’t able to do it and whether I needed to change something.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>1 – Never</th>
<th>2 – Rarely</th>
<th>3 – Sometimes</th>
<th>4 – Often</th>
<th>5 – Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>I planned and set goals do regular sports/exercise. When I wasn’t able do it I evaluated why I wasn’t able to do it and whether I needed to change something.</td>
<td>1 – Never</td>
<td>2 – Rarely</td>
<td>3 – Sometimes</td>
<td>4 – Often</td>
<td>5 – Very often</td>
</tr>
</tbody>
</table>

Satisfaction

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>How satisfied are you about how physically active you are?</td>
<td>1</td>
</tr>
<tr>
<td>How satisfied are you about how often you did sports in the last week?</td>
<td>0 – Very unhappy</td>
</tr>
<tr>
<td>How satisfied are you about how often you climbed the stairs last week?</td>
<td>10 – Very happy</td>
</tr>
<tr>
<td>How satisfied are you about how often you biked or walked to work/the university last week?</td>
<td>0 – Very unhappy</td>
</tr>
</tbody>
</table>

Long-term goals

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>How motivated are you to be more physically active?</td>
<td>1</td>
</tr>
<tr>
<td>How important do you think it is to be more physically active?</td>
<td>1 – Very important</td>
</tr>
</tbody>
</table>

1 NQLS: Neighborhood Quality of Life Study (Sallis, 2010).
2 Questions assessing social norm injunctive were not included in the short questionnaire.