D1.3a User needs study for person-centric well-being: Towards a balanced and active lifestyle

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Summary

The document at hand can be used as input for the development of an application that aims at increasing the level of physical activity. A definition of physical activity is provided and the desired scenario is described. As to identify gaps, the scenario is compared to the current state of the art with respect to methods and available technologies for assessing level of physical activity. For the same purpose, health behaviour models and theories from behavioural sciences are described. After this we provide an overview of currently available applications and interventions, based on the type of feedback-loop that is used. Concluding remarks concern the gaps between the current state of the art and the desired scenario.

Contents

1 Introduction

The average age of the Dutch population is rapidly increasing. This implies that a decreasing number of the working population (aged 20 to 65) has to ‘finance’ an increasing number of (healthcare consuming) elderly. As a consequence, the costs of healthcare are expected to rise to even higher levels and further increase pressure on healthcare professionals (CBS, 2010). Furthermore, an increasing number of people tend to live a sedentary lifestyle, which is related to a decrease in health and therefore poses a risk for numerous diseases.

1.1 Towards a balanced and active lifestyle

Regular physical activity has a significant positive effect on prevention of chronic diseases such as cardiovascular disease, diabetes, cancer and obesity (Warburton, Nicol & Bredin, 2006), but also on mental health condition through reduced perceived stress and lower levels of burnout, depression and anxiety (Jonsdottir, Rödjer, Hadzibajramovic, Börjesson & Ahlborg, 2010). This means that influencing people to change their sedentary lifestyle to a more physically active lifestyle should lead to better well-being, less chronically ill and higher life expectancy. In other words and with respect to figure 1 (adapted from D5.1a): improving level of physical activity is profitable and a key aspect for healthy, as well as for chronically ill individuals, during one’s entire life.

Figure 1. Continuum spanning different stages of health (from healthy to chronically ill), associated with differential contributions of self-management and professional management

This document can provide input for the development of a service that is able to achieve just the above. Thus, for pursuing a higher level of well-being our focus was on increasing level of physical activity and not on taking measures to prevent or reduce stress. For making explicit the design process, we used the socio-technical design approach (Figure 2). Unstructured interviews were held with researchers from Roessingh Research and Development who were involved in the development of an activity monitoring system. These interviews were used to develop a common vision with respect to which people are involved when using the system, what building blocks are needed

(Figure 3) and how physical activity can be defined (section 1.2). In addition a literature study on the current state of the art with respect to the service we envision was performed, together leading to a common vision about the to be developed conceptual scenario.

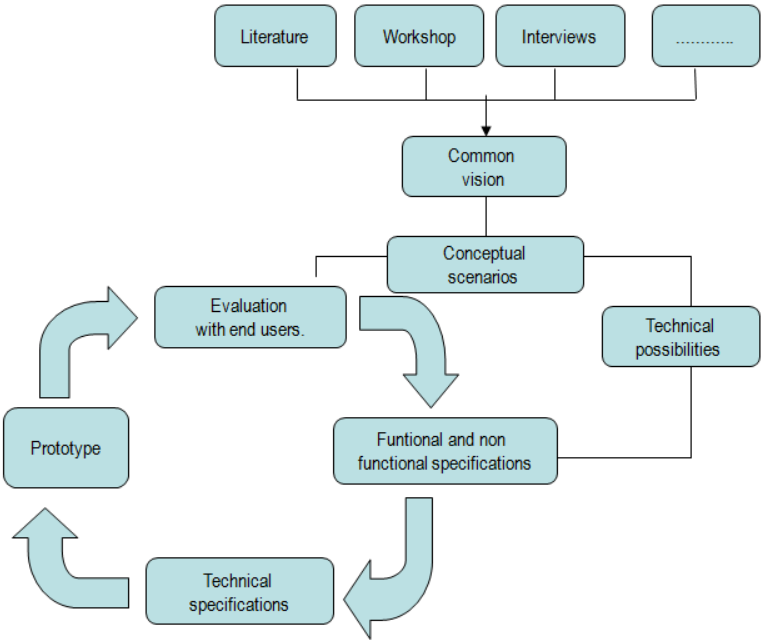

Figure 2. Socio-technical design approach

Concerning the literature, the focus was on various aspects.

- A clear definition of physical activity is provided (section 1.2) to overcome confusion, but also to ensure conformity and comparability between investigations concerned with this particular construct.
- Hereafter, various technologies and methods that are available to measure physical activity are described (chapter 2).
- Once insight is obtained in what physical activity is and how it can be assessed, the next topic is about how people can be influenced to change their sedentary lifestyle into a more active one and how the information on physical activity can be used to reach this (chapter 3). In research on health behaviour, several theories have been composed that describe constructs which are believed to underlie behavioural change (Conner & Norman, 2005). Knowing the variables that influence behavioural change allows the development of tools for health behaviour interventions. The major theories on behavioural change will be discussed. These models also provide information about how the measured data should be used; what should be presented to users, how this information should be presented and how feedback should be given. According to Hermens (2008) this feedback can be provided through three loops (Figure 3): 1) Local/on-device feedback, 2) through a remote database, 3) through a professional.

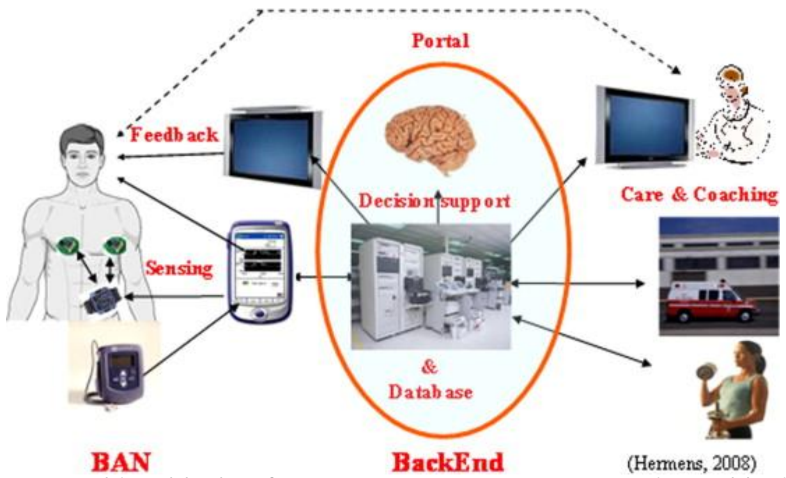

*Figure 3.*Building blocks of remote monitoring systems and possible data streams.

- Several existing applications to monitor and/or improve level of physical activity will be discussed (chapter 4).
- Finally, in chapter 5 we will provide a description of the application or service we envision, based on a scenario. Hereafter we will summarize the current state of the art and compare it to our needs, which will allow us to identify gaps and directions for future research.

1.2 Physical activity

First, the term physical activity needs to be defined. Research shows that the way level of physical activity is defined varies highly between (groups of) subjects, but also between researchers (Tuder-Locke, Henderson, Wilcox, Cooper, Durstine & Ainsworth, 2003). This evidently calls for a clear definition to be used in the current project and ideally also in future research on physical activity. For these reasons, we recommend the use of the description of physical activity as proposed by Caspersen, Powell and Christenson (1985), who identify four elements of physical activity: 1) physical activity consists of bodily movements via skeletal muscles, 2) physical activity results in energy expenditure, 3) energy expenditure (kilocalories) varies continuously from low to high, 4) physical activity is positively correlated with physical fitness. This definition makes it possible to discriminate categories of physical activity, but also to distinguish between physical activity, exercise and physical fitness. Next to the elements 1, 2 and 3, the same authors define exercise as 4) very positively correlated with physical fitness, 5) a planned, structured, and repetitive bodily movement, and 6) an objective is to improve or maintain physical fitness component(s) (i.e. cardio-respiratory endurance, muscular endurance, muscular strength, body composition and flexibility). Physical activity differs from physical fitness in that the former relates to the actual movements that people perform and the latter comprises a set of beliefs people have or achieve.

2 Methods and techniques for measuring physical activity

There are several options to estimate one's level of physical activity. The 'doubly labelled water' method is considered to be the gold standard to measure total energy expenditure, which is directly related to level of physical activity (Thorsen, Shriver, Racine, Richman & Schoeller, 2011). It, however, is an expensive procedure and proves to be a burden for the subject; unpractical when applied to large groups of subjects. Other examples include the use of questionnaires, observation by trained professionals, and oxygen consumption. Questionnaires have limitations due to their subjectivity and lack of accuracy (Weering, Vollenbroek-Hutten, Hermens, 2011). Observation by a trained professional is considered to be more accurate. However, the need for training of the observer and the observer only being able to attend to one subject at a time makes this an unpractical and inefficient option if one would want to measure physical activity throughout the entire day(s). Finally, energy expenditure can be calculated using devices that measure oxygen consumption. These are considered to be highly accurate and are usually applied when researchers are interested in (changes in) physical capacity (Wergel-Kolmert & Wohlfart, 1998).

2.1 Available technology

It will be clear that the instruments described above are not ideal for daily measurements. Instead, small hardware systems can be utilized to provide estimates of someone's level of physical activity. Several available options are: pedometers (2.1.1), heart rate monitors (2.1.2), accelerometers (2.1.3) and the Global Positioning System (GPS) (2.1.4). All these instruments are thought to give an estimation of energy expenditure due to physical activity, which in turn is widely accepted as representing an index for physical activity (Laporte, Montoye & Caspersen, 1985).

2.1.1 Pedometers

Probably the first known assets capable of objective measurement of physical activity were the pedometer and the lesser known actometer. Both are mechanical devices that count the number of movements (steps) of an individual; the actometer additionally provides an indication of the intensity of the movement. The first studies on reliability and validity of these devices date back to 1977 (Saris & Brinkhorst, 1977a-b), which indicated the pedometer to have limitations with respect to measurement of the intensity of a movement. When intensity of the movement is normal, the pedometer gives an accurate estimation; when intensity is low or high, however, it tends to over- and underestimate. Other discussions with respect to these devices pertain to their mechanical nature: movements are attenuated by tilt and are only counted when a certain threshold is passed (Bouten, Koekkoek, Verduin, Kodde & Janssen, 1997). Despite the development of digital pedometers and high correlations between number of steps and directly observed physical activity (Kilanowski, Consalvi & Epstein, 1999), pedometers still provide no information about frequency, intensity or duration of physical activity (Trost, 2001). This lack of detail clearly limits usability in mapping physical activity in daily life.

2.1.2 Heart rate monitors

With time, more sophisticated monitors came into existence. Most of the problems and limitations of the (electronic/mechanical) pedometers were overcome with the introduction of accelerometers and heart-rate monitors. Especially the last option seems to be an attractive option, because of the linear association between heart rate and energy expenditure. Trost (2001), however, mentions various disadvantages. Firstly, interpersonal differences like age, body size and stress have a significant influence on the relationship between heart rate and energy expenditure. Secondly, heart rate tends to remain elevated even after activity has stopped, thereby possibly masking brief activity patterns. Thirdly, stress can cause an increase in heart rate, without the subject being more physically active. Finally, most accurate heart rate monitors come with a chest strap or electrodes and thereby cause a burden for the wearer. These issues, however, do not take away the high correlation between heart rate and oxygen consumption during exercise, and physical activity measured by observation (Eston, Rowlands & Ingledew, 1998; Welk, Corbin & Kampert, 1998).

2.1.3 Accelerometers

Accelerometers are built on the assumption that "limb movement and body acceleration are theoretically proportional to the muscular forces responsible for the accelerations, and therefore energy expenditure may be estimated by quantifying these accelerations" (Lee, Kim, Jee & Yoo, 2010). The output of the most commonly used accelerometers is given in activity counts, which are calculated by piezoelectric sensors. In short, these sensors record a voltage signal of which the amplitude corresponds to the detected acceleration (see Chen & Basset, 2005 for a comprehensive description). Distinctions between available devices can be made based on the number of planes in which movement can be detected; uni-, bi- and triaxial accelerometers measure movement in one, two and three planes respectively. Intuitively, more information is better, so triaxial accelerometers should provide the better indication of a subject's level of physical activity. Although initial reports revealed a low inter-instrumental reliability of triaxial accelerometers, later devices provided comparable reliability and accuracy (Bouten, Koekkoek, Verduin, Kodde & Janssen, 1997). Other arguments are in favour of the triaxial accelerometer; it shows a higher correlation with energy expenditure during sedentary activities (Westerterp, 1999). This enables the device to provide detailed data about frequency and intensity of physical activity of a subject in daily life, during the entire day. It does, however, still have limitations when it comes to static physical activity like dish washing, walking while carrying a heavy load and cycling. Research, however, shows that this does not have profound impact since these static movements are thought to contribute little to the total level of physical activity (Saris & Brinkhorst, 1977b). Although wrist or ankle placement of the accelerometer is thought to provide a better estimate of energy expenditure during sedentary behaviour and cycling, hip-placement is thought to better represent total energy expenditure during an entire day of measuring (Lee, Kim, Jee & Yoo, 2010).

2.1.4 The Global Positioning System

A final option to monitor a subject's level of physical activity is to use Global Positioning System (GPS) technology. Instead of the technology described above, this satellite based positioning system can provide information about location, distance travelled and speed. This is an advantage, especially with respect to some of the static physical activity that accelerometers are insensitive to, like cycling. In their review about applicability of GPS technology to measure physical activity, Maddison and Mhurchu (2009) suggest that GPS can be especially useful for providing information about the way people interact with their environment, for example, what route people take to their work, where sedentary or active behaviour takes place. The main disadvantage concerns the considerable connectivity problems and data loss when surrounded by tall buildings, under trees or inside buildings. Consequently, GPS is recommended not to be used as a standalone measurement instrument, but as a complementary tool to provide extra information about the context of physical activity.

2.2 Implications

Considering the above, the most suited candidate for obtaining an objective measure of daily level of physical activity seems to be a combination of a triaxial accelerometer with GPS technology, as commonly available in smartphones, and/or a heart rate monitor. The inability of accelerometers to distinguish cycling from sedentary behaviour can be overcome by the ability of GPS technology to provide information about speed. Accelerometers, in turn, can provide information when GPS suffers from connectivity problems. The same is true for heart rate monitors; when accelerometers identify sedentary behaviour while heart rate is high, this can be classified as a subject cycling.

3 How to influence level of physical activity

In research that focuses on health behaviour interventions (e.g. increasing the level of physical activity) theories and models from behavioural sciences are frequently utilized to determine content of feedback and information (Conner & Norman, 2005). These theories describe constructs that are thought to underlie behavioural change; when one wants to influence another, they should be taken into consideration. Some well-known examples will be discussed, after which we will describe persuasion principles (Cialdini, 2001), Cognitive Behavioural Therapy (CBT) and the concept of tailoring; creating communications in which information about a given individual is used to determine what specific content he or she will receive (Hawkins, Kreuter, Resnicow, Fishbein & Dijkstra, 2008). Finally, implications for user needs are mentioned.

3.1 Social cognition models

When studying health behaviour, one main assumption is of importance: the behavioural patterns that underlie the leading causes of death in industrialised countries can be changed. Social Cognition Models (SCMs) attempt to define the cognitive factors that underlie these 'social' patterns of behaviours. The focus here will be on various theories and models that have been used or described regarding interventions focusing on changing level of physical activity, being the Social Cognitive Theory (SCT), Theory of Planned Behaviour (TPB) and TransTheoretical Model (TTM) (Conner & Norman, 2005).

3.1.1 Social cognitive theory

The SCT (Bandura, 1982) starts from the assumption that motivation and action are influenced by forethought. More specifically, it assumes three types of expectancies: situation outcome expectancy, action outcome expectancy and perceived self-efficacy. The first is concerned with expectancies about what consequences will occur when the subject would not interfere. Susceptibility to a health threat is often used as an example of representing one such situation outcome expectancy. The second, action outcome expectancy, pertains to beliefs about whether certain behaviour will or will not lead to a particular outcome; the belief that quitting smoking reduces the risk of lung cancer is a clear example. The third, self-efficacy, is defined as the belief that the particular behaviour is, or is not, within an individual's control. For example, the belief that one is, or is not, capable of exercising regularly would constitute such a self-efficacy expectancy. In sum, the SCT assumes that personal sense of control makes it possible to change behaviour; if people believe they can take action to accomplish a certain goal, they become more inclined to do so and feel more committed to the decision.

3.1.2 Theory of planned behaviour

According to the TPB (Ajzen, 1991), behaviour is preceded by intentions, that is, motivation or one's plan to exert effort to perform the behaviour. Intentions, in turn, are constituted by attitudes, subjective norms and perceived behavioural control. Attitudes concern the overall evaluation of the behaviour, comprising *behavioural beliefs* about the perceived consequences of the behaviour. Subjective norms are made up based on *normative beliefs*, which represent perceptions of significant others' opinion about whether the individual should, or should not engage in the behaviour. Finally, perceived behavioural control is based on *control beliefs,* concerning whether one has access to the necessary recourses and opportunities to perform the behaviour successfully. It is thought that by influencing the various beliefs, behaviour can be changed (and/or maintained).

3.1.3 Transtheoretical model

The TTM (Prochaska & DiClemente, 1983) assumes that as individuals change behaviour, they move through a number of stages, as depicted in Figure 4, and that different cognitions may be of importance at different stages. The following five stages are defined: precontemplation (no intention to change behaviour within six months), contemplation (intention to change behaviour within the next six months), preparation (intention to take steps to change behaviour within the next month), action (has changed behaviour for less than six months) and maintenance (has changed behaviour for more than six months). It is best described as a circular model, since subjects can enter and exit at any point and relapse to an earlier stage is possible. Next to these stages, the model includes several other constructs: a decisional balance (benefits versus costs), self-efficacy (confidence that one can engage in healthy behaviour; temptation to engage in unhealthy behaviour) and processes of change (activities that people engage in to progress through the stages).

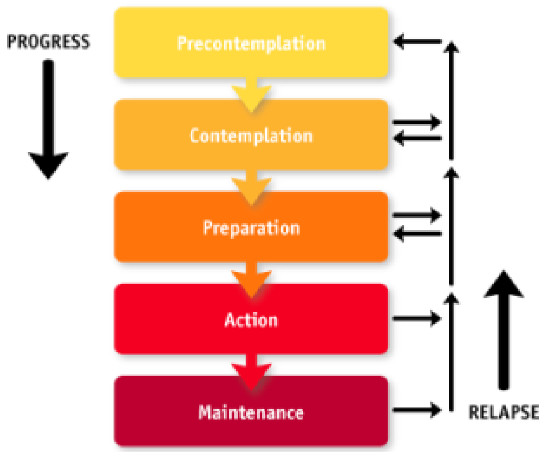

Figure 4. The transtheoretical model.

3.1.4 Persuasion principles

Another technique to influence individuals is proposed by Cialdini (2001). Six principles are defined that can be used to persuade others: reciprocity, scarcity, authority, commitment, consensus and liking. First, reciprocity can be interpreted as the general tendency of people to repay what others have provided them with. Second, the scarcity principle pertains to the rule that things are more valuable to us when they are less available. The authority principle states that people are more inclined to obey when information is provided by a subject with authority. Next, commitment refers to the general wish of people to be consistent with what they have already done. Fifth, the consensus principle beholds subjects' tendency to do things they see others doing. Last, the liking principle states that people are persuaded more easily by others whom they like. Kaptein, Markopoulos, Ruyter en Aarts (2009) state that people differ in their susceptibility to the different persuasion strategies and developed a questionnaire to assess an individual's susceptibility to the various principles.

3.2 Cognitive behavioural therapy

CBT (Cooper, Fairburn & Hawker, 2003) is widely applied in clinical settings to overcome disorders such as depression and anxiety disorder; it provides tools for supporting behavioural change. More specifically, it helps individuals identify their problematic behaviour, make small changes in them, and maintain the changes. A central aspect of CBT is self-observation: the subject needs to monitor and record one's actions, emotions, and thoughts. Hereby, the subject learns about his/her behaviour and factors influencing it. A treatment based on CBT is Acceptance and Commitment Therapy (ACT) (Hayes, Strosahl & Wilson, 1999). ACT aims at increasing intrinsic motivation to change behaviour by use of 'value analyses'. These analyses make explicit what constitutes a good life for the individual and what should be done to further promote it. This is specified using behavioural analyses; i.e. determining what factors contribute to the problematic behaviour and which of those factors one can change.

3.3 Tailoring

The need to personalize health information is known as 'tailoring' and is defined as:

> *"…creating communications in which information about a given individual is used to determine what specific content he or she will receive, the context or frames surrounding the content, by whom it will be presented and even through which channels it will be delivered. Overall, tailoring aims to enhance the relevance of the information presented and thus to produce greater desired changes in response to the communications" – Hawkins et al. (2008)*.

An example of this technique, or method of presenting feedback, is providing different information depending on a subject's stage of change. Another example is to provide feedback related to a subject's personally set goal. Hawkins et al. (2008) also define three strategies through which to achieve the goal of enhancing the relevance of the presented information: personalisation, feedback and content matching.

Personalisation increases the subject's attention or motivation to process a message by conveying that it is designed especially for 'you'.

Feedback presents individuals with information about themselves (e.g. obtained during assessment). Three types are distinguished: descriptive (report subjects' attitudes, beliefs, or behaviour), comparative (compare with others or with progress over time) and evaluative feedback (include level of interpretation about a subject's attitudes, beliefs or behaviour).

Finally, content matching refers to providing messages about the individual's status on theoretical determinants of the behaviour of interest, like outcome expectations, normative beliefs and efficacy. Noar, Benac and Harris (2007) showed that interventions that used tailoring on attitudes, self-efficacy, stage of change, social support and processes of change had significantly larger effect sizes than interventions that did not tailor on these concepts. In other words, health behaviour interventions that include tailoring are thought to be more effective than interventions that do not.

3.4 Implications

All things considered, there is considerable overlap between the constructs that the SCMs describe. Intention is typically presented as the strongest predictor of behaviour, as a mediating variable between social cognitive variables and behaviour. Next, self-efficacy is incorporated in almost all models, although occasionally labeled dissimilar, like perceived behavioural control. Finally, the models imply a central role for health education (to change beliefs/expectancies) and the need to personalize or tailor health information (individuals can have different beliefs/attitudes), such that it is relevant to the specific individual. Concepts frequently encountered in research include stage of change, process of change, self-efficacy, behavioural intentions, social norms, attitudes, perceived susceptibility and social support. Tailoring on these constructs can enhance relevance for the individual and thereby increase the impact of the message. The persuasion principles proposed by Cialdini (2001) also have implications for optimal tailoring, since individuals are thought to differ in their susceptibility to the various principles. Finally, CBT (and ACT) indicates self-observation to be of key importance with respect to changing behaviour. Ideally, these aspects need to be incorporated in applications to achieve an as high as possible effect and service users as optimal as possible.

4 Existing applications

This chapter presents an overview of some of the applications that have been developed to provide people with information about their level of physical activity. The various applications are classified based on what feedback loops are used (Figure 3). For identifying publicly available applications, the iPhone App Store and Android Market was searched using the term “physical activity”. Not all are mentioned, since most have overlapping functionality. Furthermore, four researchers from Roessingh Research and Development who have experience with an activity monitoring system and knowledge about user needs were interviewed. Finally, a literature study was performed to further identify existing applications that intent to measure and/or increase level of physical activity. The purpose of the current chapter is not to provide an exhaustive list of applications, but rather provide inspiration and insight in what has already been developed. From here we aim at identifying gaps or shortcomings. This should lead to needs for an application that differentiates itself from currently available applications, which is discussed in chapter 5.

4.1 Local feedback

- UbiFit: the application runs on a Nokia and uses information from on-body sensors (triaxial accelerometer, among others) to provide real-time information about level of physical activity. The authors did not include aspects of social cognition models, though users were motivated by reward: when physically active, flowers and butterflies appear on the display of their mobile phone. When subjects move little, only grass is displayed. The screen is filled with items based on the type of activities subjects performed during the last four weeks and their goal attainment (Consolvo, Landay & McDonald, 2009).

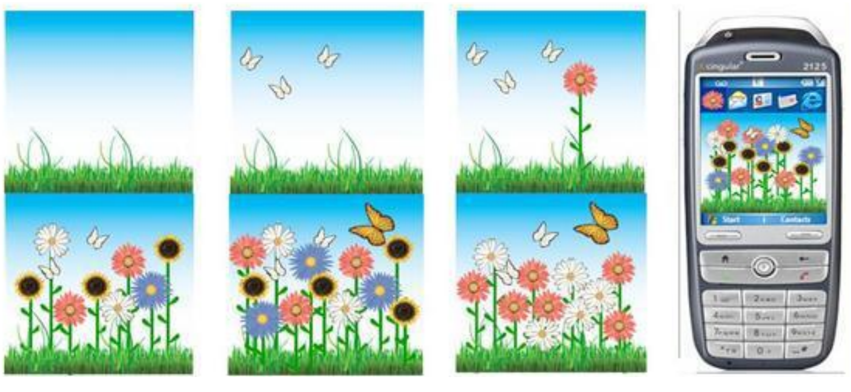

Figure 5. The UbiFit Garden

- StepUp: a Nokia N95 is used to offer subjects a quantitative measure of their level of physical activity, measured in the number of steps per day by a built-in pedometer. Total step count per day is shown. Again, social cognition models are not mentioned. The authors conclude by recommending a sharing option for providing competition which should serve as a source of positive feedback for improving the number of steps. The long term goal of the authors is to increase the subjects’ awareness and understanding of the importance of exercise and facilitate integration of regular exercise into daily life (Khalil & Glal, 2009).

- Office Exercise: made for people with sedentary jobs. The application hints its users to execute specific instruction as not to keep the same posture for too long, for example hold the phone above your face and keep it there for a while (Android market$_a$).

- Mijn activiteit: provides a calendar for both planning and registering sports activities (manually entered). Feedback is provided by graphs and activity summaries (Android market$_b$).

- Routinely: provides reminders of activities and tasks (e.g. walk the dogs, take vitamins) so that users develop healthy habits (all have to be set manually) (Android market$_c$).

- Be Fit, Stay Fit Home Fitness Challenge: records activity entries (manually entered) based on type, intensity level and duration. Every day that an entry is made represents a lottery ticket to win giveaways (Android market$_d$).

- Exercise Booster: the application helps keep a record of exercise sessions (manual entry). Planning and scheduling is possible. Activity per week is displayed in a progress bar (Android market$_e$).

- HealthLog: extensive options to enter data about one's weight, exercise and health condition (Android market$_f$).

4.2 Local feedback including feedback through a database

- Nexercise: iPhone application that monitors physical activity using a built-in accelerometer. The user earns points for various activities (select cycling, running, or walking) and can win prizes (from $5 to $250 gift cards). Users can choose to compare their activity score with their friends and the application will notify the user when a friend surpassed them (iPhone app store).

- Runkeeper: user has to choose activity to perform (e.g. walking, running, cycling, skiing, etc.), after which the application will utilize built-in GPS technology to track the user. Feedback includes distance, time, pace, calories burned, heart rate (entered manually) and the path travelled. Users can also view their activities on the internet (Android market$_g$).

Figure 6. Runkeeper

4.3 Local feedback including feedback through a database and healthcare professionals

- P4Well / Wellness Diary: the authors describe the development and testing of the "Pervasive Personal and PsychoPhysiological management of WELLness" system. It comprises a mobile phone application and a web based portal which display information from a wrist worn accelerometer (for sleep quantity and quality) and heart rate monitor (physical activity). The Trans Theoretical Model (see section 3.1.3) was utilized for designing the application's menu. The tools are organized under five menus according to five phases: information (precontemplation), appraisal (contemplation), planning (preparation), action (action), and follow-up of success (maintenance). Users are encouraged to follow the five phases, but one may start at any of them. The program cannot detect the user's stage of change. Aspects of Computerized Cognitive-Behaviour Therapy (CCBT) methods are included. Individuals actively observe and record actions/emotions/thoughts/other health related parameters (weight/sleep habits). Based on these observations one is able to learn about behaviour and factors influencing it (Happonen, Mattila, Kinnunen, Ikonen, Myllymäki, Kaipainen, et al., 2009).

The intervention also comprised three face to face group sessions (1st: informative/motivating, 2nd: completing questionnaires, receiving feedback from professional, 3rd: completing final questionnaires, receiving feedback from professional). Preliminary results show that 1) attitude towards the mobile phone application (Wellness Diary) was more positive than attitude towards the internet portal, 2) face-to-face contact with, as well as consultation through the web based portal from (psychology and physiology) professionals were regarded as being very important for this kind of service, and 3) peer-group support was not perceived as an effective approach in the wellness service domain (Happonen, Kaipainen, Väätänen, Kinnunen, Myllymäki, Lappalainen, et al., 2009).

Wellness Diary: one of the studies in the P4Well program focused on usage and usability of the Wellness Diary (WD) application (Figure 7). Subjects were volunteers who were participating in a work-related rehabilitation program and who had elevated burnout scores. All participants received a mobile phone running the application, pedometers, blood pressure meters, personal scales and other devices including a heart rate monitor, wrist-worn activity monitor, pressure sensitive sheet under the mattress, and a sensor box monitoring environmental variables such as temperature and lighting. Subjects had to measure their blood pressure twice a day, their weight every morning and wear pedometers every day. Results had to be entered manually. The program concluded with an individual face-to-face feedback session based on

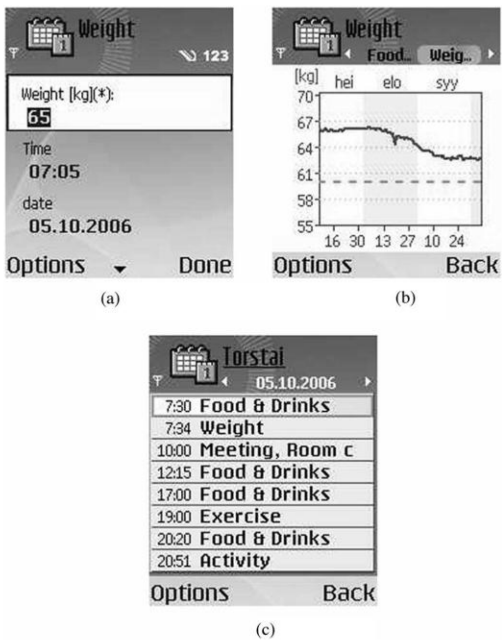

Figure 7. The Wellness Diary application

the subject's measurements. The authors conclude with statements about good usage and usability; the study lasted for three months during which the number of entries subjects made maintained stable (good long term adherence). Furthermore, self-observation is indicated to be a key element in ICT-based wellness programs, where the objective is to learn subjects about their behaviour and change it. The role of feedback is to help maintain motivation by showing the long term progress. In addition, it is concluded that simplicity and ease of use are always important (Matilla, Pärkä, Hermersdorf, Kaasinen, Vainio, Samposalo, et al., 2008).

Identified shortcomings with respect to the WD are that it does not prompt users to exercise or provide motivational features such as alarms, rewards, or analysis of behaviour. It also does not provide immediate feedback and highlight success, which is thought to increase sense of challenge and thereby has a positive effect on long term adherence. Other shortcomings regarding long term adherence include the lack of a social support feature, an algorithm for detecting relapse and a reward system (Matilla, Korhonen, Salminen, Ahtinen, Koskinen, Särelä, et al., 2010).

- <u>TuneWalk:</u> a mobile phone application that helps patients in a cardiac rehabilitation program during exercise, using heart rate and physical activity analysis (data from accelerometer). It stores long term information about the subjects' progress during the weeks of the rehabilitation program. Data can be viewed on a mobile phone as well as on a web based portal, which, in turn, can also be accessed by a healthcare professional. This personal mentor can view past performances, checks up on the patient and intervenes when needed (e.g. when training too hard). Consultation takes place through phone or video calls and text messaging. The authors conclude with statements about their success in developing a mobile exercise tool for home-based cardiac rehabilitation (Mattila, Ding, Mattila & Särelä, 2009).

- <u>Mobile Phone Application:</u> the authors describe a telehealth application that improves self-management of patients with Type I Diabetes Mellitus. The application is developed so that patients can get an overview of food/drink intake, level of physical activity, insulin intake, blood glucose level and blood pressure (all have to be entered manually). This information is shown on the patients' smart-phone and also sent to a database ('patient management unit'). This database can be accessed by a physician using a laptop or smart-phone in order to receive the most up-to-date data about a patient. When necessary (e.g. when the patient's glucose level is too high) the physician can edit or update the patient's treatment displayed on the portal or communicate with the patient by sending e-mails (Mougiakakou, Kouris, Iliopoulou, Vazeou & Koutsouris, 2009).

- <u>Philips DirectLife:</u> this product comprises a triaxial accelerometer equipped with nine LED-lights that are used as a scale to indicate progress towards one's goal and a web-based portal where users can access a personal page. This page provides an overview of the level of physical activity (per hour, day, week, month or year) and allows for personal goal setting (based on the number of calories one wants to burn per day). In addition, the web based portal is equipped with a built-

Figure 8. Philips DirectLife

in message service to contact a coach for individual advice. A blog about activity coaching can be accessed and e-mails about performance are sent to the user (http://www.DirectLife.Philips.com).

- <u>Roessingh Research and Development activity monitor:</u> the application, running on a mobile phone, gathers data from a triaxial accelerometer worn on the hip, to assess the subject's level of physical activity. The mobile phone shows a graph (x-axis: time, y-axis: cumulative level of physical activity) with a reference line, which represents the average level of physical activity of a group of healthy control subjects. The subject's own level of physical activity is drawn as another line, so that one can compare one's own level of physical activity to the average of the population. In addition, the percentage of deviation from the average is displayed on the screen. Based on this deviation, the subject receives a prompt to be more physically active in order to reach the targeted level of physical activity at the end of the day, or take a short break as not to spend too much energy in the morning and save some for the evening. The application can be linked to a remote database which in turn can be accessed by the user and healthcare professionals (Weering, 2011).

Figure 9. RRD activity monitor

5 Conclusion and future directions

This chapter provides an overview of this document and summarizes key points that are of importance to our goal of increasing well-being. We firstly provide a scenario based description of the end-product or service that we envision in section 5.1. This enables us to identify the needs that we want to address, which are provided in section 5.2. Next, the current state of the art and available tools with respect to the needs are described in section 5.3. Finally, in section 5.4 we conclude with comparing our desired scenario with the available tools to identify gaps and directions for future research.

5.1 Scenario

Figure 1 provides a continuum spanning different stages of health. The service we envision could be used in any stage. However, in the following scenario we describe a day in the life of a chronically ill patient. Examples of chronic diseases include cardiovascular diseases, cancers, diabetes and Alzheimer's disease. The patient in our scenario, Peter, suffers from COPD.

Peter is 40 years old. He was recently diagnosed with Chronic Obstructive Pulmonary Disease (COPD). This means that his lung capacity is smaller than normal and as a consequence, his already low level of physical activity decreased even further; he takes the elevator more often, does not ride his bike anymore and only walks his dog for five minutes. Peter thinks the reason for this is that when he is more physically active, he gets tired fast and needs to rest. What he does not know is that this causes him to end up in a vicious circle: when resting, he does not feel tired and this leads him to engage in physical activity even less, which in turn causes his health condition to deteriorate even further, which makes him feel tired even faster, etcetera. Peter needs help with setting up goals for increasing his level of physical activity.

When visiting his doctor, the need to maintain a sufficient level of physical activity is explained and Peter is advised to start using an activity coach. This coach consists of an activity monitoring and feedback system, including a web based portal thereby remotely coached by the local physiotherapist. Peter decides to do so. His physiotherapist provides him with the necessary equipment (triaxial accelerometer, mobile phone running an application to provide feedback based on data from accelerometer) and, although Peter is reasonably known with ICT and internet, he also receives a brochure with information about how to use the various components. This folder also mentions Peter's personal log-in code for the web based portal.

When Peter visits the portal for the first time, he is prompted with a few short questionnaires to attain a baseline measure of his stage of change, susceptibility to the various persuasion principles and level of self-efficacy with respect to physical activity. This determines the nature of the feedback he receives on his mobile phone (confronting, complimenting or stimulating). In other words, feedback is tailored on Peter's stage of change, susceptibility to persuasion principles and level of self-efficacy.

The next day, Peter wears the accelerometer for the first time. He does not receive feedback for a week, since a baseline measure of his level of physical activity needs to be attained. After this first week, he starts receiving time and event related feedback about his level of physical activity and whether he needs to become more active or take a short break. The system is also able to identify the intensity of physical activity; low, moderate or high. Through this, the system can stimulate Peter to engage in activities that have a moderate or high intensity, as to improve Peter's level of cardiovascular fitness. Every once in a while, Peter is required to answer a short questionnaire (on his mobile phone) as to keep the feedback aligned with his stage of change and level of self-efficacy. In addition, he is frequently asked a short question about how he is feeling (e.g. rate how tired he is).

Peter needs to wear the accelerometer all day and keep it in close range with the mobile phone. Additionally, he wears a heart rate monitor and the mobile phone is also equipped with GPS-technology that tracks speed and is able to identify activities such as cycling. The total cumulative level of physical activity is provided on the display of Peter's mobile phone, which also shows an average cumulative line measured during a baseline measurement week.

The web based portal is used so that Peter can view his past level of physical activity per day, week and month. Furthermore, the portal is used so that the physiotherapist can help Peter to set up the goals Peter needs to achieve with respect to level of physical activity, and contact Peter when necessary or when scheduled. At least once every two weeks there is contact between peter and his therapist. In between the therapist can also access the portal and provide additional tips and intervene when it seems that Peter does not achieve his goals. Peter can also contact his doctor by sending messages through the portal. Optionally, Peter indicates he wants to share his data with other users.

After using the system for a while, Peter starts to notice the beneficial effects of a higher level of physical activity on his well-being and fitness. In addition, he is now able to set his own goals and needs less feedback from the mobile phone, but also from his doctor. His doctor compliments him for achieving this self-management status and proposes to meet only once per month; if it turns out he still needs help he can use the dedicated message service on the portal. Several months later Peter is still happily using the system as he keeps setting higher goals as to keep increasing his physical fitness.

5.2 Needs

To summarize, our goal is to develop an application that can help to improve an individual's level of well-being. Research shows that a higher level of physical activity has a significant positive effect on health condition and prevention of several mental en physical chronic diseases, which is the reason we focused on attempting to increase the individual's level of physical activity to achieve our goal.

To realize this, we need an accurate and objective tool to gather data about an individual's physical activity during the day. This data should be sent to a local device, like a smart-phone. Since effort is known to have a negative effect on long term motivation and adherence, automated data entry and visualization is desirable. Applications and their associated technology should be as unobtrusive as possible, which also means that data should be recorded automatically as much as possible. This data, in turn, should be presented on a display that continually shows (cumulative) level of physical activity as to provide information about the individual's current status. The system needs to be able to provide feedback based on the percentage of deviation from a reference line and to classify activities into low, moderate or high intensity. Furthermore, this data needs to be available via an internet portal, where users can view their past performance and progress towards personally set goals. A third party, like a health care professional, should also be able to access this portal to provide professional feedback. In addition, we want to provide users with an option for peer-group contact/support to be toggled on and off. Finally, we do not want users to stop using the application/service after only a few weeks. We explicitly intent to develop a product which will be used for extended periods of time. For this, questionnaires are needed for assessing stage of change, susceptibility to persuasion principles and level of self-efficacy.

5.3 Available tools

The current state-of-the-art indicates several available options for measuring physical activity through modern day technology. All options have their own advantages and disadvantages. However, for the purpose of measuring daily level of physical activity, accelerometers seem to be best suited. In the most optimal situation, these meters are combined with heart rate monitors and/or GPS technology; GPS can identify activities such as cycling and accelerometers are able to measure indoor physical activity.

The majority of publicly available applications run on mobile phones and provide a means of getting an overview of exercise, instead of being a tool for assessing daily level of physical activity. In addition, many ask for manual data entry, although some do automatically register exercise and calculate number of calories burned. With respect to feedback loops, local feedback is used most frequently in publicly available applications. Most interventions that focus on increasing physical activity also include access to a remote database and feedback from a professional.

For achieving long term adherence and high motivation to use the application/service, theories and models from behavioural sciences are discussed. Social Cognition Models are frequently employed in health behaviour interventions and it is assumed that behavioural change is achieved by progressing through several stages. In addition, self-efficacy and attitudes (beliefs) are thought to be of central importance. Tailoring can be applied to increase message impact. Finally, questionnaires are available for assessing stage of change, susceptibility to persuasion principles and level of self-efficacy.

5.4 Gaps

When comparing our desired scenario to currently available applications and previous research, several gaps can be identified. The most important seems to be the lack of aspects of social cognition models, persuasion principles and cognitive behavioural therapy. The only intervention that does explicitly mention the use of the TTM and CBT is the P4Well system/Wellness Diary. However, this system lacks automated data entry. Although no statements are made about effectiveness, users were enthusiastic about the application, which is of particular importance regarding long term adherence. When taking into account the research on health behaviour interventions, this lack of influence from social cognitions models seems illogical: higher adherence and possibly even larger effect sizes of interventions can be achieved when implementing aspects of these models into applications that aim at increasing level of physical activity. Future applications and interventions with respect to increasing level of physical activity should indeed include (aspects of) SCM and CBT and be based on data from an accelerometer in combination with GPS and/or a heart rate monitor. This last addition poses a new point of interest: data from the different technologies should be combined in such a way that it still provides the user with a clear indication of one's level of physical activity. Furthermore, algorithms to classify physical activity into low, moderate or high intensity need to be developed.

Furthermore, not only applications aiming at increasing physical activity have to be integrated, but also applications for managing work and preventing stress situations to increase the "in control" feeling. This integrated functionality has to be adaptive and cope with varying needs and situations in work and home situations. In addition, the system has to cope with uncertainty in measurements and interpretation of data, while pursuing effective actions in the real world, like coaching, automated handling of tasks, etcetera. Finally, at all times, the system needs to prevent potential harmful actions, which could be the result of incorrect interpretation.

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