HEALTH INFORMATION SYSTEM FOR OBESITY PREVENTION AND TREATMENT OF CHILDREN AND ADOLESCENTS

Prototype

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Abstract

Childhood obesity is becoming an alarming issue with implications affecting the society and the healthcare sector. In response, multi-professional programs with physical activity, nutritional and psychological components have been proposed. Still, due to limited resources only small number of patients can be included in these programs. Health information systems (HIS) have the potential to tackle these challenges. Yet little is known about the design and effects of HIS in the domain of multi-professional obesity programs, in particular those tailored to children and adolescents. In order to address this problem we have built a HIS prototype with a goal to support obesity interventions for children and adolescents. The prototype provides several contributions to theory and practice. First, it fits to the concept of multi-professional obesity interventions not present in most of existing commercial and research-based applications. Second, it provides an instrument that is co-designed by patients, IS researchers, computer scientists and obesity experts, thus tailored to the specific needs of children and adolescents. Third, it provides a possibility to gain evidence-based knowledge about the potentials and the effects of HIS over obesity therapy outcomes through longitudinal field studies in 2014.

Keywords: Health information systems, childhood and adolescent obesity, multi-professional program.
1 Problem Definition

Due to the significantly increasing numbers, childhood obesity is becoming an alarming issue (Sassi, 2010). According to the World Health Organization¹ in 2011 there were more than 40 million overweight children under the age of five with a growth that is taking epidemic proportions. For example, the rate of overweight children and adolescents in Switzerland has doubled between 1997 and 2007 (Aeberli et al., 2010) with predictions that this number will grow up to 20 percent by 2022 (Schneider et al., 2009). This situation has serious implications for the healthcare sector by increasing costs due to obesity-related comorbidities and a lack of health supply (Hänggli et al., 2008).

In order to address these issues, multi-professional programs with physical activity, nutritional and psychological components have been proposed (Sempach et al., 2007). This approach was shown to have positive effect on therapy outcomes, such as body composition (Savoye et al., 2007). Still, due to limited personnel, training and financial resources, only a small number of patients can be included in these programs (Kushner, 1995). Moreover, family-based interventions as an approach towards childhood obesity treatment are facing the challenges of low recruitment and retention rates due to the high demands for parents' involvement (Epstein et al., 2007; Knowlden and Sharma, 2012).

Health information systems (HIS) have potential to improve outcomes and reduce costs of health interventions by providing the possibility for self-monitoring while simultaneously supporting the patients’ decision making through real-time access to relevant information (Spring et al., 2013). Moreover, previous studies show that IS-based health interventions are more effective when they supplement the interaction with the therapists instead of completely replacing it (Mohr et al., 2011; Reed et al., 2012). Yet little is known about the potentials and effects of HIS in the domain of multi-professional obesity programs, in particular with regard to children and adolescents. In addition, the challenges of HIS for children and adolescents are still to be addressed by monitoring the potential side-effects, such as excess use of IT systems.

In order to address these issues we have built a HIS prototype that has a goal of improving obesity therapies and preventing excess body weight of children and adolescents. The prototype complements existing interventions by serving as a coach and providing guidance to the patients in the period between the consultations, based on the prescribed therapy.

2 State-of-the-Art in IT-supported Obesity Interventions for Children

A number of studies have been conducted in order to investigate the potential of HIS to increase the efficiency and quality of obesity interventions (e.g. Arteaga et al., 2010; Knowlden and Sharma, 2012; Spring et al., 2013; Turner-McGrievy and Tate, 2011). In addition, commercial applications exist which support concepts of daily activity tracking and self-monitoring of nutritional intake, such as Jawbone Up², FitBit³, Nike⁺⁴, etc. Yet, reviews indicate that effects of HIS on obesity-related health outcomes remain unclear and where observed to be rather modest and mostly un-sustained (e.g. Reed et al., 2012; Wieland et al., 2012; Williamson et al., 2006). Moreover, in the majority of interventions a multidisciplinary approach based on physical activity, nutrition intake and behavioural/psychological

factors is not available (Spring et al., 2013). In addition, most of the existing IT-supported health interventions are tailored to adults who might have different requirements and preferences compared to children and adolescents (Arteaga et al., 2010). Finally, none of these applications has been evaluated as part of an existing multi-professional obesity intervention for children and adolescents.

To address these issues, the proposed HIS prototype supports the recommended multi-professional approach (e.g. Sempach et al., 2007). This approach is important for growing children, since the therapy goals are not only related to weight loss, but also to improvement of life-style habits (Epstein et al 2007). The prototype was collaboratively developed by obesity experts, children and adolescents, IS researchers and computer scientists by applying a situation-based design science methodology (Hevner et al., 2004) in combination with the Rapid Application Development principles (Beynon-Davies et al., 1999). The prototype will be evaluated through longitudinal field studies with children and adolescents as a part of existing obesity therapy and prevention programs in 2014.

3 Prototype Description

This prototype follows the recommended multi-professional approach by supporting the goal of improvement of nutrition, activity, mood and relaxation (Epstein et al 2007). For each of these components a dedicated service was developed. In addition, the concept of goal setting, which was shown to be an important part of the behavioural treatment leading to improved therapy outcomes (Story 1999), was added to the system. As such, the goal setting service serves as an umbrella concept and can be used in combination with all of the previously mentioned services.

The HIS prototype is implemented as a client-server application: the client side is a native Android application developed for tablet-PCs, while the server side is a web application (PHP, MySQL) used for synchronization with client usage data. Tablet-PC was chosen due to its portability and dimensions to provide optimal support during the consultations by showing greater level of details compared to smart phones.

The users of the HIS prototype are both patients, for self-monitoring, and therapists, acting as behavioural coaches through configuration and monitoring. These two roles will be distinguished in continuation while describing the main services.

3.1 The Timeline

To integrate different services and to enable the possibility to get insights into the potential correlation between individual components of intervention, a concept of timeline was introduced. The timeline represents a chronological visualization of all activities undertaken by the users and all events which are automatically triggered by the system, such as a reward assigned upon goal completion (see Section 3.4 for details on goals and rewards). Each record in the timeline is represented through an icon which corresponds to the event or action type, a content part which might contain text and/or photo, and a timestamp. The system enables filtering of the events over two dimensions: time period (1 week, 2 weeks, 1 month or custom) and record type (nutrition, activity, mood, relaxation or goal). In the latter case, multiple-choice selection is supported. For example, the nutrition expert could filter out only those events that are relevant for him in the period since the last consultation.

Apart from providing an aggregated view of activities to the patients, the timeline also enables the therapists to get an overview of patients’ behaviour and compliance with the prescribed therapy over the period of time between the consultations. It therefore serves as a basis for discussion during the consultations. As such, the timeline plays an important role for both patients and therapists and is therefore placed on the landing screen of the application (see Figure 5 in the Appendix).
3.2 Physical Activity Service

Physical activity therapy is more effective, when its level is increased in everyday life, compared to participation in time-limited sport programs (Epstein et al. 1985). In order to achieve this goal, the physical activity service is integrated with the FitBit platform. The selection of FitBit Flex as activity tracking device was based on the good acceptance by the patients due to its modern appeal and ease of use of the FitBit Flex activity tracking device. Among other features FitBit enables tracking of the number of steps per day (spd). Synchronization with the device is done as a background process but can also be initiated by the patient. The results are presented in the timeline on a daily basis along with a motivational feedback.

An overview of the obtained results is presented on a dedicated screen. For each day a feedback is provided by ranking the activity level on a scale from bad to excellent and which is visually distinguished through a colour scheme. The rules for different levels are initially set to predefined values by physical activity experts: bad - up to 5'000spd, average - up to 10'000spd, good - up to 15'000spd and excellent – more than 15'000spd. These values can be changed by the therapists to address differences among patients.

The system also supports a concept of achievements with a goal of increasing the motivation of the patients. Activity badges are automatically assigned by the system if a certain threshold is reached on a daily and weekly basis. Each time a badge is assigned, a timeline record is created.

Illustration of the physical activity service and the settings screen which supports FitBit integration and activity level customization are shown on Figure 1.

Figure 1. Physical activity screen illustrating the level of activity over the last week and a badge for daily achievement in the top right corner (left), and the Settings screen (right).
3.3 Nutrition-related Services

The goal of nutritional therapy is to influence the eating behaviour of the patients by providing support for healthy ingredients selection through self-monitoring (Burke et al., 2011). In addition, concepts such as eating without hunger and speed of eating as factors which influence obesity should be taken in consideration (Carnell and Wardle, 2007). Based on these insights, the prototype provides two services as a part of the nutritional therapy: food diary and speed of eating (illustrated on Figure 2).

![Food diary and speed of eating screen](image)

**Figure 2.** Food diary service illustrating auto-complete function for ingredients entry (left) and speed of eating screen (right).

The food diary service enables tracking of food and water intake. In order to provide nutritional information while taking in consideration cultural differences, integration with the Swiss Food Composition Database\(^5\) was made. Once initiated, the food diary service guides the patients through several steps: (1) selection of the intake type (food or water), selection of the meal (breakfast, morning snack, lunch, afternoon snack, dinner or anytime) and entry of each ingredient by providing (a) the name of the ingredient – supported by the auto-complete function, and (b) quantity. Optionally, a photo of the meal can be added. Upon completion, a timeline record is created which shows the calories for each ingredient, as well as the total number of calories for the meal and the day. Similarly, in case of water intake, the entered quantity will be displayed in the timeline along with the daily

water intake. An overview of the obtained results in terms of average calories and water intake is presented on a dedicated screen. In addition, a line chart illustrates fluctuations in daily food and water intake over time. Finally, to stimulate the diversity of nutritional intake, a list of ingredients is shown, sorted by (1) the frequency of intake and (2) calories.

The speed of eating service has a goal to raise the awareness regarding the speed of eating and to address the correlation between the speed of eating and the feeling of satiety. Once the patient initiates the process, the system starts counting the time. In addition, the patient is asked to enter the current degree of hunger (from not hungry to very hungry) and make a photo of the plate before eating. The same steps are repeated when the patient has eaten half of the plate, three quarters of the plate and the full plate. In case satiety is reached before finishing the meal, the patient can indicate this by choosing the not hungry answer. In order to motivate the patient to stop eating at this point, an additional question is shown: “Do you still want to eat?” which can stop the timer if the answer was no. Upon completion, a timeline record will be created that shows the time needed to complete the meal ingestion, as well as the taken photos. The average degree of hunger and speed of eating (in seconds) as well as the fluctuations over time at each step of the meal are presented on a dedicated screen.

3.4 Psychological and Behavioural Services

Stress and mood disorders in childhood are found to be related to childhood and adult depression and obesity (Pine et al, 2001). To address this issue, obesity treatments include psychological treatments in a form of behavioural and cognitive behavioural therapies, such as stimulus control, goal setting, self-monitoring, rewards, etc. (Sempach et al., 2007; Spring et al., 2013). To provide support for this component the following services are added to the HIS prototype: mood monitoring service, relaxation exercise service and goal setting service (including rewards for successfully achieved goals).

The mood monitoring service enables tracking of the emotional state of the patients. It is based on the established, picture-based scale, known as Self-Assessment Manikin (SAM) (Bradley and Lang, 1994) which is suitable for children since it overcomes the linguistic challenges. SAM distinguishes between three dimensions of the emotional state: pleasure, arousal and dominance. In addition, in order to gain insights into the potential correlation between the emotional state and the feeling of satiety, an additional measure is added which corresponds to the degree of hunger scale used in the speed of eating module (see Figure 6 in the Appendix for illustration). After entering the mood and hunger-level values, optionally the patient can also enter a reason for his mood. Upon completion, a timeline record will be created containing the entered values and the overall mood score represented through colour scheme of the icon. An overview of the mood state over time, as well as the average values over different dimensions are presented on a dedicated screen.

The relaxation service takes a proactive approach by providing relaxation content to the patients as a list of predefined music, photos and videos. Among others, photos of food are added to address the concept of stimulus control since the concept of confrontation with individual food type was found to be able to reduce the consumption of this food in a stressful situation (Stephan, 2012). Proprietary content can also be uploaded to the system. In addition, therapists have the possibility to determine which content will be visible to the patient. Each time a patient initiates a relaxation service a relaxation session is started which can last up to three minutes. During this time, a control button will appear on random time intervals which should be pressed by the patient to ensure that the he is looking at the presented stimulus. Based on the number of hits, an attention score is measured. In addition, movement of the device is measured to determine the relaxation state of the patient. Mood monitoring service is triggered automatically before and after the relaxation session to estimate its effect.

Results of the relaxation sessions are presented on a dedicated overview screen which shows the mood values before and after the relaxation, as well as the session duration, attention score and movement. Figure 3 illustrates the main functionalities of the relaxation service.
The goal setting service is one of the key components of the system. The system supports creation of goals for each of the above mentioned services, i.e. physical activity, nutrition, mood monitoring, relaxation and a generic type, i.e. other (see Figure 7 in the Appendix). Each time a goal is created it is added to the list of active goals where its progress can be tracked. For each goal type several possibilities for completion are offered: manually, through photo documentation or automatically. For example, for nutrition related goals, the automatic goal tracking can be achieved each time the food diary or speed of eating service is used. In case of manual tracking, the patient has to indicate the goal completion by pressing the done button which appears next to the goal in the list of active goals and on the daily agenda on the landing screen. Each goal is bounded by a set of rules which determine under which conditions the goal is finished: (1) duration of the goal - defined through starting and ending date, and (2) completion frequency - defined by rule type (max or min based goals), number of repetitions, and measurement interval (per day, per week, per month), e.g. the rule could be formulated as min 3 times per week. A goal is marked as finished if (1) the objective is met – for max-based goals, or (2) the end date is reached – for min-based goals. Once the goal is finished, it is moved to the list of finished goals where it is categorized as successful or unsuccessful.

To increase the motivation of the patients, a reward system was added to the goal setting service. Each time a goal is completed, points are assigned to the patient for the particular goal type. The number of points depends on the difficulty level assigned to the goal (easy - 100, medium - 250 or difficult - 500 points). Based on the number of points, medals and trophies are assigned to the patient. Figure 4 illustrates the goal setting service including the rewards screen.
Figure 4. List of active goals showing the progress for each goal (left) and rewards screen with activity achievements - on top, and points/medals/trophies over different goal categories - on bottom (right).

4 Contribution

The HIS prototype presented above provides several contributions to theory and practice. First, it supports the concept of a multi-professional approach not present in most of existing commercial and research-based applications. Second, it provides an instrument that is co-designed by patients, obesity experts, IS researchers, computer scientists and, thus tailored to the specific needs of children and adolescents. Third, it intends to improve therapy adherence by the incorporation of goal setting, mood monitoring and relaxation training. Fourth, it enables to gain evidence-based knowledge on the potentials and effects of HIS to improve outcomes of obesity therapy. Namely, a longitudinal study in duration of one year will be conducted as a part of an existing multi-professional obesity intervention for children and adolescents. Fifth, it provides the possibility to evaluate the long-term effect of the HIS-support to the therapy compliance. Finally, it provides the possibility to gain insights into the potential side-effects of IT-supported therapy through monitoring of the overall usage of the tablet-PC.

5 Presentation of the Prototype

The HIS prototype will be shown on a tablet-PC. In addition, for each service, a video will be available which provides a detailed explanation of the usage.
References


Randomized Controlled Trial Using Mobile Technology. Archives of Internal Medicine, 172 (10), 789-796.
Appendix: Screen shoots

Figure 5. The landing screen containing the daily agenda with the next goals (on the top), the pop-up menu with shortcuts to main services (top right) and the timeline.
Figure 6. Mood monitoring screen enabling entry of three mood dimensions (according to SAM scale) and a degree of hunger.
Figure 7. Goal creation screen providing possibility to choose: a goal type, goal tracking mode, difficulty level, frequency of completion and goal duration.