# Improving Physical Activity and Health with Information Technology

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**Abstract.** Physical inactivity and overweight/obesity kill 6 million people yearly [1]. Regular physical activity (PA) such as walking, cycling, or participating in sports has significant benefits for health and weight-loss maintenance. It reduces of the risk of diseases, e.g. diabetes, depression, or helps weight controlling. This one year case study explores how daily monitoring of objective PA and weight effects on body mass index (BMI) -value when the target is to achieve globally accepted normal BMI-value. The study aims to learn by cost-effective modelling how improvements in wellbeing and health on an individual level occur with the help of information technology gadgets.

**Keywords:** physical inactivity, activity monitoring, improvements in health and wellbeing

## 1 Introduction

World Health Organization (WHO) has reported physical inactivity as the fourth leading risk factor for global mortality causing an estimated 3.2 million deaths globally. Indeed the number of deaths per year increases to six million when also overweight and obesity are counted together with physical inactivity [1]. This is a tremendous figure - especially - as it is mostly related to our living habits.

Regular physical activity (PA) such as walking, cycling, or participating in sports has significant benefits for health and weight-loss maintenance [2]. Although, the nature between objectively measured of physical activity and abdominal fat distribution has not been well characterized [3], previous studies have firmly shown that PA reduces of the risk of diseases and reduce mortality and extend life expectancy [4, 5]. But the challenge is: How do we change our way of living? How can we be more physical active in modern information society? Indeed, we need to find practical solutions how this is possible to do with the help of ICT gadgets.

To be more active is challenging as at the same time there are several new attractive leisure time thefts such as Angry Birds, Facebook, You Tube, Play Stations, Wiis, and virtual games on internet. As technology devices and services are penetrating the society into deeper levels, the need for studying their usefulness for physical activity and wellness becomes imperative. Modern technology and popularization of internet has brought a variety of applications aiming at promoting personal health and

wellness available for layman, such as pedometers, heart rate monitors, and multidimensional accelometers.

The PA is a well-studied field within healthcare research internationally. We have reviewed literature and found around two hundred research journals where technology have been used for improving the individual ability to get encouraged for achieving recommended levels of exercise and physical activity [6]. However, in most of these research articles the research design and sample is based on treatment of some disease. In order to increase the physical activity of population we need to understand how normal layman use information and communication technology (ICT) devices to support their physical activity and to improve their health and wellbeing.

In this one year case study our focus is on exploring how daily monitoring of PA, physical exercise (PE) and weight (WE) effects on Body Mass Index (BMI) -value. The BMI is commonly used to classify underweight, overweight and obesity in adults. It is a simple index of weight-for-height. The BMI is defined as the weight in kilograms divided by the square of the height in meters (kg/m2). The international classification of adult BMI for normal range is from 18.50 to 24.99. The wellbeing target of the current study is to achieved globally accepted normal BMI (body mass index) -value. The assumption is that with the normal range BMI value the life time expectancy is superior and quality of live is better than with overweight situations: i.e. health and wellbeing of an individual improves when BMI value of overweight/obese decreases.

The primary contribution of the study presents how information and communications devices and the data they provide can be used to improve our everyday health. In our study model we use this data to support achieving normal BMI value. The success of the model is judged based on achieved BMI target.

The structure of the paper is organized as follows. Section two focuses on research background: 1) the use of information and communication technology (ICT) for health and well-being, and 2) global trends behind the study. In section three the research design is described. The results are presented in section four. Conclusions and research limitations as well as the future research directions end the papers.

## 2 Research background

### 2.1. ICT used in or proposed to use for improve health

ICT has been proposed to improve health in many ways and in different levels but there are communication and integration challenges. Analysis of big data on population level is one approach. Electronic health records could improve population health by including better understanding of the level and distribution of disease, function, and well-being within populations [7]. When an individual get access to his or her own data electronic health records it can be called personal health record which enables patients to access their health information and improves care quality by supporting self-care [8]. However, then personal health records need to be integrated with

physicians' electronic health records systems and provide shared access both ways in addition to secure e-mail communication and educational modules [9].

Delivering health related data via internet and establish kiosk and centers have worked very well in developing countries [10, 11]. However, delivering healthcare information totally freely, for example via You Tube, requires to design some kind of interventions to enable consumers to critically assimilate the information with more authoritative information sources to make effective healthcare decisions [12].

On the other hand, implementations of new information systems have faced difficulties, especially when it changes dramatically the well-established business models in the field. For example, in Europe implementations of electronic prescriptions have taken more time than expected [13, 14].

On individual level there has been several approached on using technology to health conditions. A systematic literature review of mobile health technologies reveal that they have potential to be used as tools for the prevention and treatment of overweight and obesity, particularly with mobile phones and texting, which are already used daily by most of the population [15]. Based on another systematic review, there is an argument that despite the bold promise of mHealth to improve health care, much remains unknown about whether and how this will be fulfilled [16]. Electronic lifestyle activity monitors are commercially popular and show promise for use in public health interventions and provide feedback via an app in computer or mobile [17].

Using the PA devices provides more precise data than a subjective self-assessment. The use and feasibility of physical activity promoting websites and applications have been studied with encouraging results [18,19]. However, little is known about how objective physical activity assessment on 24/7 basis effects health. In this study, we observe objective PA assessment together with self-reporting PE, WE, and measure the success, i.e. health effects, of the project with the change of the BMI value. The feasibility of high intensity PA value was confirmed with self-assessment dairy of physical exercise. The study aims to model a cost-effective way for improving well-being and health on individual level without any communications or integrations to health professionals.

### 2.2. Global trends in world health

There are convincing evidence that a sedentary and unfit way of living increase the risk of numerous chronic diseases and conditions and even decreases longevity [21]. A physical inactivity has been one of the highest leading global risks for mortality in the world already for some time [21]. Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure. Physical inactivity causes an estimated 3.2 million deaths globally [1].

Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. A crude population measure of obesity is the body mass index (BMI), a person's weight (in kilograms) divided by the square of his or her height (in meters). A person with a BMI of 30 or more is generally considered obese. A person with a BMI equal to or more than 25 is considered overweight. Obesity has

reached epidemic proportions globally, with at least 2.8 million people dying each year as a result of being overweight or obese [1].

The physical inactivity and obesity are modern rising risk factors and they can be found in everywhere, i.e. in high, middle and low income countries. Together they kill about 6 million persons per year. In order to avoid this, WHO has been launching "Global Strategy on Diet, Physical Activity and Health".

Being physically active is a major contributor for both physical and mental wellbeing [22]. PA has many scientifically proven health enhancing effects and the PA is extremely effective in preventing and treating just lifestyle connected diseases. Studies also confirm that long term physical activity e.g. walking is associated with significant better cognitive function and reduced risk of dementia [23, 24]. A major goal for public health is to identify evidence-based interventions to promote PA in populations [25]. This includes research on how ICT could be used to promote PA in our everyday life.

Current global PA guidelines given by WHO for adults accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or at least 75 minutes of vigorous-intensity aerobic PA throughout the week or an equivalent combination of moderate- and vigorous-intensity activity [26]. The duration of PA should be at least 10 minutes per time. And one should involve at least two or more muscle-strengthening activities per week. Globally, around 31% of adults were insufficiently PA in 2008 according to Global Health Observatory of WHO. The lack of PA has effect on public health as there is evidence that inactive individuals have higher risks for many lifestyle diseases such as coronary heart disease, high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon and breast cancer, and depression. These risks could be significantly reduced with preventive behaviors, such as improving nutrition and enhancing in regular PA [27].

In many countries the PA has been promoted by recommendations. The PA recommendations differ from country to country, although the recommendations for adults of WHO are probably most well-known. Many persons want to be more physically active, but achieving sustainable changes in lifestyles can be challenging and behavior determinants differ based on individuals and environments [28]. Despite many benefits of the PA, initiation and maintenance rates in the general population have been rather disappointing [29]. And based on the resent figures we still need methods and implementation of successful PA interventions.

ICT-embedded health and wellness services have suggest empowering people to manage their health [30]. Indeed, research evidence suggests that individuals who exercise are more likely to maintain weight losses [31].

## 3 Monitoring of physical activity and weight during the study

The ICT has penetrated into our lives to a level where it has started to show as an integrated part of our bodies and ways of living. It has reshaped our habits. However, information and communication technology along with effective decision making combining motivational and environmental factors, can definitely improve our health

level. One of the major contributing parts of physical activity is technology tools and services, such as: pedometer, accelerometer, heart rate monitor, social networking, sport gaming and devices, computer based counseling system, global positioning technology, mobile entertainment electronics. In this study, we are more interested in use and awareness of activity monitoring tool.

Activity monitors provide a means to examine the intensity, frequency, and duration of PA. The knowledge of daily activity may motivate some of us to be more active. The purpose of this study is to analyze and compare the change of PA per day by using Polar Active [32] activity monitor for one year study period. Polar Active was chosen for this study because of its features. For example, it measures activity 24/7, it divides activity to different zones, and it contains daily activity target feature. The technology for the target calculations was the most important feature for selecting Polar Active. Primary, Polar Active has been developed for Physical Education purposes of students: The tacit educational aspect is, indeed, one of the issues in this study context: Are we able to change our living habits with the help of technology? Are we able to improve our wellbeing or health by using technology daily to support our change of living habits?

Polar activity technology detects and filters activity intensity, and calculates it to MET (Metabolic Equivalent of Task, or simply metabolic equivalent, a physiological measure expressing the energy cost of physical activities) values. In Polar activity technology METs are used to accumulate time in the five different activity zones: very easy (1-2 MET), easy (2-3.5 MET), moderate (3.5-5 MET), vigorous (5-8 MET), and vigorous+ (>8 MET) (Table 1).

| ZONE | MET | ACTIVE TIME |
|---|---|---|
| Vigorous+ | >8 | x |
| Vigorous | 5-8 | x |
| Moderate | 3.5-8 | x |
| Easy | 2-3.5 | |
| Very easy | 1-2 | |

Table 1. Activity zones, MET values, and zones that add up active time in Polar Active.

The calculation of active time (≥3.5 MET) has been patented by Polar. Active time is the sum of the times spent in the 3 upper zones. In this case study, we are interested in this MET over 3.5 values per day. Indeed, the data can be downloaded to appropriate Polar web service where the activity zones and also sleeping time will be visualized. In the web service, also sleeping time or more accurately time in bed can be calculated.

In Polar activity monitors (Polar Active, FA20, AW200), one dimensional (1D) acceleration is measured. When comparing 1D to 3D measurement in accelerometers in general, it has been shown that 3D does not significantly improve the prediction of energy expenditure compared to 1D [32]. In Polar devices, 1D also provides longer battery lifetime.

The data is analyzed in 30 s epochs, and all epochs above 3.5 MET accumulate active time. Typical activity for moderate 3.5-5 MET zone is brisk walking. For vigorous 5-8 MET zone typical is playing and games e.g. playground games and rope jumping. Basketball, football and soccer usually are 7-8 METs. Typical vigorous+ activity is running fast. Sedentary activities (e.g. screen time) accumulate very easy zone. All the features and calculations of the monitor apply to all age groups from children to adolescents to adults.

Activity is counted in METs that express energy expenditure and are multiples of resting metabolic rate (1 MET=BMR). Calories are expressed as total kilocalories summing the daily activity calories and the user's basic metabolic rate through day and night. Steps are accumulated when activity is detected when cadence exceeds 70 steps per minute.

The acceleration based measurement does not measure accurately all activity modes. For example cycling, indoor cycling, weight training (gym) and 'light' aerobics do not give accurate METs, calories or steps.

Plus the activity values given by Polar activity monitor, the daily physical activity or actually physical exercise (PE) was also traced by minutes with watch. They daily weight was measured with Omron Body Composition Monitor BF500 at the same time of day with the same clothing, i.e. every morning before breakfast.

All the daily values were collected to the metadata file for further analyses from one year trim down case study of overweight middle-aged blue-collar woman. Data is gathered and analyzed based on daily PA (>3.5 MET, Polar Active) and physical exercise (PE) in minutes, and morning weight (kg). The PA and PE counselling was similar: avoid two successive days of non-PA/PE. The day was non-PA if the value was below 60 minutes. The trim down target was set to -1 kg/month.

## 4 Results

In 87 days PA was below one hour in two or more successive days (24 %). In 96 days there was no PE in two or more successive days (26 %). In 60 days both these values were below the target (16 %). In 115 days the morning weight was not measured because of work or holiday (32 %). The correlation between the change of weight and PA (-0.0343857) was higher than the correlation between the change of weight and PE (-0.01237). BMI-value decreased (29.0 -> 26.7), but is still 1.8 above normal value. Trim down project was 50 % successful (-6kg/12kg). Figure 1 shows daily PE and PA. Figure 2 shows change of weight during the study time.

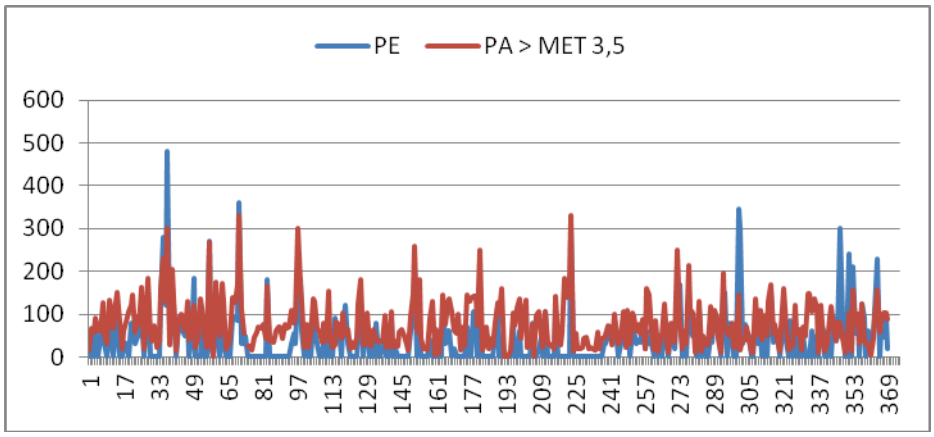


Figure 1. Daily PE and PA

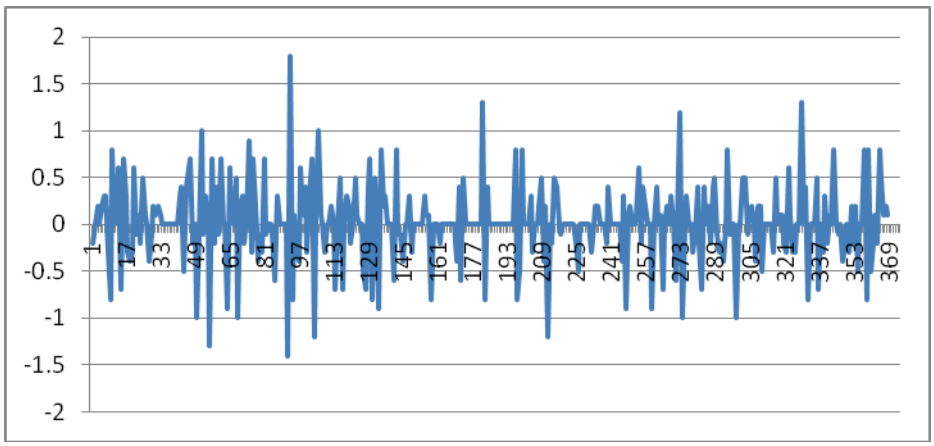


Figure 2 Change in weight (kg/day)

Monitoring daily PA, PE and morning weight do have positive effects on BMI trim down project. Daily feed-back such as PA value keeps trim down project going on. A moderate target as trim down one kilogram per month is challenging when it is based on only changes in PA. But we need simply models to increase PA and decrease BMI worldwide.

## 5 Conclusions, research limitations and future research directions

Physical inactivity and obesity are leading global risks for mortality in the world. One of the major contributors for increasing the physical activity and decreasing obesity could be information and communication technology tools and services. This case

study tried to develop an easy and implementable but effective ICT supported counselling interaction program for PA supported weight controlling program. This is important both for society and individuals. We all need urgently new approaches and tools to reshape our habits or create new ones in a rapidly changing world. Actually, we need different kind of solutions for keeping our daily PA on recommended level. In some cases we need education and training to understand what the PA recommendations are and how they are reached or how to use ICT tools to improve our health and fitness.

For investigating and understanding this phenomenon we have created a Step-Shape –project. This case study is one part of the project where we try to understand and learn the effects of IT use on health and fitness goals. This is a concreate, practical context and individual depending knowledge and therefore case study approach suits for it by giving us a possibility to learn something new.

The study was successful in a way that at least partially health and wellbeing improvements were achieved. However we may always ask whether it was the commitment to the program that provided improvements in the results, not the use of IT. But on the other hand we can also ask vice versa, whether it was the use of IT that provides improvements in the results, not the commitment for the projects. Therefore, we plan to continue the Step Shape project and this longitudinal case study and try to explore whether there are any sustainable changes in living habits.

However, whether the results of this particular case study can be transferred to similar situations are open. It is the reader, not the researcher, who determines what can apply to his or her context.

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