Health & Wellbeing

eit Knowledge & Innovation Community

EIT ICT Labs

Technical Foresight Report

Physical Wellbeing for Active Healthy Ageing

Executive Summary

This report aims at identifying trends, challenges, and recommendations in relation to Physical Wellbeing for Active Healthy Ageing. This foresight will help expose future themes with high innovation and business potential. The purpose is to create a common outlook on the future of ICT and to establish a strong community across EIT ICT Labs nodes and partner organisations.

With the continuing growth of elderly populations, their increasing demand for care and thereby the rising costs and labour requirements, it has become a matter of urgency to look for ways to revise the current healthcare system. Not only by more efficient care solutions, but also mainly changing focus from care to prevention. With better prevention, care costs may be reduced by letting people live independently in their own home for a longer period of time, delaying nursing home admission. This can be done by diagnoses and treatments of disease in early stages. However, a more efficient way is primary prevention: motivating people to become and remain healthy as long as possible and shortening the period that people suffer from (multiple) chronic disease(s) and/or minimising the impact and effect of these (multiple) chronicle diseases.

The mega trend 'Digitization' has already had great impact on our society. Within the area of health and wellbeing, we are witnessing an accelerated pace in digitization: the mass adoption of smart and connected ICT by consumers, professionals, and businesses. In the near future, technologies, networked devices, sensors, and communication will play an important role in this domain.

Due to the upcoming networked devices and sensors (in-home monitoring and wellbeing related personal devices and applications: measuring diet, exercise, fitness, weight loss, and beauty) people are able to monitor their own health. Through remote- and self-monitoring, measurements can be done regularly by an individual, at home. Health status and trends can be derived from the data. Professionals will only be involved when highly required.

Monitoring technology will make emergency and assistive support more effective and efficient. Networked systems will play an important role in injury detection and prevention (like fall detection, kitchen safety, and wandering prevention).

Coaching and persuasive technology will be used to create awareness about activity patterns. Systems will pro-actively promote exercise. Elderly will be persuaded to change behaviour to become (or remain) physically active. Exergames will play an important role. Self-tracking apps and devices provide 24/7 measurements. In combination with context-aware technology, motivating feedback and triggers can make it possible to adjust physical activities better to someone's preferences and

way of living. In this way behaviour change towards a healthier lifestyle will be more sustainable.

The development of the above described technologies will also involve some key issues. One of the main issues will be about privacy and security of data. Recording data related to personal wellbeing should be done in a secure manner.

Another challenge will be standardization. Many devices can be bought independently. The strength of these technologies is the integration of sensors and actuators. However, it is still an unstructured market with a lack of transparency and standards. Moreover, a lot of different sensors exist nowadays, but one should carefully select a set that gives meaningful information about the situations that need to be monitored.

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List of Abbreviations

HWB	Health & Well-Being
EIT	European Institute of Technology
WHO	World Health Organization
ICT	Information and Communication Technology
AA	Active Ageing
AHA	Active Healthy Ageing
PIR	Passive Infrared
BMI	Body Mass Index
POC	Point of Care
CPAP	Continuous Positive Airway Pressure
ECG	Electrocardiogram
CES	Consumer Electronics Show
B2B2C	Business to Business to Consumer
B2C	Business to Consumer
PAN	Personal Area Network
LAN	Local Area Network
COPD	Chronic Obstructive Pulmonary Disease
API	Application Programming Interface

1 Introduction

This technical report is part of the EIT ICT Labs Foresight Study and Innovation Radar within the thematic action line of Health and Wellbeing (HWB).

The report aims to identify key scenarios, trends, challenges and recommendations in regard of HWB. This foresight will help expose future themes with high innovation and business potential. The purpose is to create a common outlook on the future of ICT and to establish a strong community across EIT ICT Labs nodes and partner organizations.

By 2025, about one-third of Europe's population will be aged 60 years and over[1]. Moreover, more than 60 percent will manage more than one chronic condition by 2030 (American Hospital Association, 2007). Due to the ageing society, healthcare related costs will increase tremendously over the next few decades. It is expected that in The Netherlands in 2040, almost 60 per cent of the total health-related costs will be made for people ages 65 and up (now approx. 40 per cent)[2].

The incidence of many chronic illness and disabilities increases with age. Older adults are at high risk for developing chronic illnesses and related disabilities. These chronic conditions include:

- Diabetes mellitus
- (Osteo)arthritis
- Congestive heart failure
- Dementia

From a recent study from the WHO[3], researchers state that the majority of cost of care is spent in the last year of one's life. However, the researchers also state that these costs will drop when people are over 80 years of age.

While currently the major costs – treatments in the last year – will drop, costs for taking care of people that live a longer period of time 'suffering' from (multiple) chronic diseases will tremendously rise.

The potential economic and societal costs of diseases of this type rise sharply with age. Reducing severe disability from disease and health conditions is key to holding

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[1] http://www.healthyageing.eu/sites/www.healthyageing.eu/files/resources/Healthy%20Ageing%20-%20A%20Challenge%20for%20Europe.pdfhttp://www.healthyageing.eu/sites/www.healthyageing.eu/files/resources/Healthy Ageing - A Challenge for Europe.pdf

[2] http://www.zorgkapitaal.nl/trends/13/ (in Dutch)

[3] http://www.nu.nl/economie/3551776/probleem-vergrijzing-nederland-valt-mee.html (in Dutch)

down health and social costs. The longer people can remain mobile and care for themselves, the lower are the costs for long-term care to families and society.

Indeed, in Western industrialized societies, there is a growing incidence of overweight and obesity as well as associated hypokinetic diseases. Excess and insufficient adipose tissue are known to cause health disorders, and are currently the number one cause of death worldwide due to the increased risks for diseases like diabetes mellitus, cardiovascular diseases, stroke, hypertension and certain type of cancers. Similarly, insufficient adipose tissue increases risks for multiple chronic diseases too, like diabetes mellitus, cardiovascular diseases, osteoporosis and organ failure. Furthermore, the intra-abdominal fat (visceral adipose tissue) is directly causal (aetiological) for some of the mentioned diseases and moreover poses one of the 4 diagnostic criteria of the Metabolic Syndrome.

Because many adult and older-age health problems were rooted in early life experiences and living conditions, ensuring good lifestyle in earlier stages of life can yield benefits for older people. With the continuing growth of elderly populations, their increasing demand for care and thereby the rising costs and labour requirements, it has become a matter of urgency to look for ways to maintain and improve the functional abilities of ageing people.

This means that improvements need to be done with respect to prevention and care. The quality of care needs to be more efficient but in such a way that patients will still have a high quality of life. Often this involves one or more informal caregiver (friend or relative) looking after the elderly.

With better prevention, care costs may be reduced by letting people live independently in their own home for a longer period of time, delaying nursing home admission. This can be done by diagnosing and treating diseases in their early stages. However, a more efficient way is primary prevention: shortening the period that people suffer from (multiple) chronic disease(s) and/or minimising the impact and effect of these (multiple) chronicle diseases.

In this report we will focus on trends in technology for physical wellbeing. Being an EIT ICT Labs activity, this report focuses on ICT support for improving physical wellbeing. Improvements to the quality of cure in the medical domain (better treatments) is outside the scope of this document.

2 Objective of Technologies for Healthy Ageing

ICT can enable Active Ageing (AA) in various ways. A classification of the different ways ICT can help comes from the literature of Gerontechnology, an interdisciplinary field devoted to the design of technology and environments for independent living and quality of life of older adults. These four approaches are summarized as *Gerontechnology goals* (Harrington & Harrington 2000). We explore each of them in the following paragraphs, by situating each goal in terms of when and how they improve the ageing process. In the remainder of the report we will see technologies that fit in one or more of these categories.

Prevention. It's the first and foremost goal of Gerontechnology. Successful prevention can make the other three goals redundant. Prevention implementation success may mean saving vast sums of money that can be redirected to other societal needs (Harrington & Harrington, 2000). As we age, prevention helps us to avoid injuries and slow down physical, mental and social decline. Using a machine to stay fit and keep walking, following a physical training plan using videos on YouTube, improving our nutrition with a tool that helps us log and monitor what we eat or stimulating our brain with computer games are examples of IT enabling AA through prevention.

Compensation. When an impairment or disability can no longer be prevented, *compensation* comes into place to either reduce the impact of the declined capability, or to partially and artificially replace a not available capability (inborn or due to injuries or illnesses). Compensation is applied either on the environmental or on the personal level (Harrington & Harrington, 2000). (Geron)technology can be used for these purposes, making up for impairments that people face as they age. IT for compensation is particularly useful to support cognitive deficiencies, but sensors and actuators are increasingly viable as solutions to perform physical actions, such as moving or changing the status of objects (from closing doors to turning lights on and off).

Care. When we cannot prevent nor compensate a problem, and/or we need assistance to recover from an incident or to reduce the impact of a chronic condition, *care* is needed. (Geron)technology provides care directly (e.g., sensors and monitors) or by facilitating the work of the caregivers. The caregiver can either be a formal caregiver (e.g., nurse, physician), an informal caregiver (e.g., family member, friend), or the elderly individual is in charge for his/her own care needs.

Enhancement. (Geron)technology can help to create new opportunities and extent existing capabilities, and help people gain new capabilities. Using IT to keep updated with our interests, to learn new things, to find interesting activities to join, to augment

experiences in which we are already involved, to enable real time access to information or to discover new experiences or work opportunities that we can commit to are examples of IT for enhancement.

3 Technologies for Physical Well-Being

In this chapter we provide a snapshot of the current and upcoming technologies related to physical well-being for active healthy ageing. To create a structured description of the technologies, the chapter is divided into 4 sub-chapters: data collection, emergency technology, assistive technology, coaching and persuasive technology.

3.1 Data Collection - Monitoring

In this section we briefly describe trends in data collection using monitoring technology. For the purpose of this document, we distinguish between sensors used in smart homes (to indicate the status in each and every room of the house) and what we call here 'personal devices', that is, sensors that are used (or worn) by the person being monitored.

Sensors only provide raw data. This data often requires processing to derive meaningful information. The sensor data can be used as a basis for *emergency* solutions (e.g., fall detection), it can be *assistive* (e.g. reminders) or it can be *persuasive* (e.g., exergaming).

Data can but can also be recorded and shared with formal or informal caregivers. For example, if a person takes a blood pressure measurement every day, these measurements can be shared with the general practitioner on a weekly basis – potentially improving care since the general practitioner has more data available to e.g. adjust the medication schedule. When sensor data (or interpreted information) is shared with informal caregivers, they get a quick overview of how well the person is doing, like whether adhering to the medication schedule.

3.1.1 In-home monitoring

Several in-home monitoring solutions exist, both commercially and developed within research projects. An example is that of Passive Infrared (PIR) sensors that are able to **detect motion** in the various rooms in the house, combined with other sensors that can gain insight in what the person (or persons) is doing.

Figure 1: Wireless PIR sensor

Figure 2: Smart plug

Power meters or smart plugs are instead used to measure whether certain appliances are being used. A smart plug is a power meter that can be mounted between the appliance and the wall outlet, providing detailed energy consumption data about a single appliance. Another type of power meter exists, in the form of an optical sensor that can be mounted on the energy meter in the metering cupboard. Such sensors provide insight in the overall **energy consumption** of the house, which in turn may give an indication of what the person is doing in the house.

Occupancy sensors give indication on where the person is (or where the person is sitting or lying on). For example, they can give indication on whether the person is in bed or sitting on the couch.

Open/close sensors on doors and windows can be used to track whether the user has left the house or whether windows are still open, but they can also be mounted on cupboards and drawers in the kitchen to measure specific (meal preparation) activities in the kitchen.

Figure 3: Open/close sensor

Sensors typically provide a form of wireless communication to a central gateway where all the data can be combined and interpreted. Example technologies include Z-wave[4], FS20 and Zigbee[5].

Numerous other sensors can be added to these in-home sensor networks to get an even more detailed overview of the situation in the house: thermometers, ambient light sensors, gas sensors (carbon monoxide, carbon dioxide, oxygen level sensors, natural gas sensor), smoke detectors et cetera. For example, Netatmo[6], a home air quality system, provides temperature, humidity, CO_2 level, pollution as well as noise

[4] http://www.z-wavealliance.org/technology

[5] http://www.zigbee.org/

[6] http://www.netatmo.com/en-US/sitehttp://www.netatmo.com/en-US/site

level information. A similar product is the Canary system[7]: a home security device with an HD video camera and safety sensors track everything from motion, temperature and air quality to vibration, sound, and activity. Lively[8] is a wireless sensor that tracks motion of the people in a house and model their daily routing pattern. Lively includes 6 different sensors for detecting food and drink activity, medications, getting out and, a custom sensor for specific purposes.

3.1.2 Personal devices

In the last few years it has become increasingly common to use *personal* monitoring devices. We see the market of personal devices as divided into four segments, each with a different demand of monitoring focus:

- Sport Enthusiasts, with a focus on heart rate (performance) monitors (Fittest)
- Healthy Adults, with a focus on activity monitors (fit)
- Adults at risk, with a focus on health monitors (fitter)
- Fragile people, with a focus on alerting systems (not fit)

Monitoring devices suitable for use by the end user include, but are not limited to:

- Blood pressure meter – which measures the systolic and diastolic pressure as well as pulse. Modern blood pressure meters have a self-inflating band that needs to be placed around the upper arm or wrist.
- Blood glucose meter –used by diabetics to measure the level of glucose in the blood.
- Weight scale. Modern scales also measure BMI and body fat percentage based on the electrical resistance of the body. It is important to monitor and evaluate insufficient and excess body fat and its location on the body (sub-cutaneous or intra-abdominal) because of its incidence on lifestyle-related diseases.
- Heart rate. There are two types of devices in this area: 1) those doing continuous measurements such as belts or wrist worn (Mio Alpha[9]) but also spot checks, e.g. Withthings[10].
- POC (Point of Care terminal) terminal for blood samples, used for glucose and blood Vit K status
- CPAP breathing monitoring and aid for people suffering from apnoea

[7] http://canary.is/http://canary.is/

[8] http://www.mylively.com/

[9] http://www.mioglobal.com/

[10] http://www.withings.com/http://www.withings.com/

- Movement sensor, Philips Direct Life[11] for activity monitoring.
- SPO2 and ECG – are emerging, an example is Scanadu[12]
- Accelerometers and position. These are used to give an indication of the physical activity level of a person. An accelerometer can be used to measure acceleration along three axes and can be used to derive – after processing – whether a person is e.g. walking or bicycling. GPS sensors in smartphones can be used to track movement. By analysing the movement pattern, assumptions can be made about the modality being used (on foot, by bike, by car).

While different personal devices have different functionalities, there seems to be clear trends:

- From fixed (weight scale) to portable (mobile phone) to wearable (movement sensors)
- From point measurement to continuous measurement
- From download of data to instantaneous access of (processed) data.
- From single function to multifunction
- From disconnected/offline to connected.

3.2 Emergency technology

Alerting systems notify a care service in case of perceived emergencies. Their sensing is typically not focused on vital signs, but on detecting traumas such as falls. Emergency technology relies heavily on monitoring technology, but puts additional demands of latency, robustness, and quality of service. The latency and robustness requirements are ultimately determined by the “Golden Hour” of treatment, or, the time it takes for effective aid to reach the subject.

In some conditions the Golden hour is truly a matter of minutes, and fatal or serious medical consequences arise if the treatment is not immediate. In such cases, the emergency services must be complemented with resources in loco, such as the case of cardiac arrest, which is the reason cardiac arrest aids are widely deployed. In addition to "active alarms" there are also "passive alarms" (sometimes called a "safety clock"), following the principle of a so-called dead man's switch. On the base station there is a button that the user is supposed to activate several times a day; this confirms that the user is well. If this confirmation goes lacking for a longer period (usually around 12 hours), a telephone call is placed or someone is sent to check whether everything is in order at the residence.[13]

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[11] http://www.directlife.philips.com/http://www.directlife.philips.com/

[12] http://www.scanadu.com/http://www.scanadu.com/

[13] http://en.wikipedia.org/wiki/Medical_alarmhttp://en.wikipedia.org/wiki/Medical_alarm

Prevention	Compensation	Care	Enhancement
Prevention of injury, e.g. by turning off the natural gas supply in case of leakage	N/A	Emergency handling: informing formal or informal caregiver / emergency services	N/A

3.2.1 Wandering detection or prevention

In the more severe stages of dementia, people tend to lose awareness of time, causing them for example to go outside at night. Technology can be used to detect – and in some case prevent – this behaviour. A simple sensor on the outside door can give a good indication that someone is trying the leave the house at night. PIRs and cameras can also be used to detect wandering incidents and to inform caregivers of problems.

3.2.2 Fall detection

For elderly, fall detection is becoming increasingly important. A fall detection solution (typically) uses data from an accelerometer and/or an air pressure sensor to detect that a user has fallen and then informs either a formal or informal caregiver about the event. The raw acceleration values from the accelerometer have to be processed and filtered to extract this event.

Depending on the system being used, an audio or video connection may be established with the home of the user to further assess the situation, before sending someone over to assist the elderly.

As a failsafe measure, the fall detection sensor is also equipped with an emergency button that the patient can press to indicate that he is in need of help. The Medical Alert Service with AutoAlert Option[14] from Philips detects more than 95% of falls and automatically calls for help if it detects a fall.

3.2.3 (Kitchen) safety

(Kitchen) safety features are aimed at preventing injuries or accidents due to natural gas leakage, high carbon dioxide or carbon monoxide levels, water overflow or fire. These solutions typically consist of multiple sensors and one or more actuators to

[14] http://www.lifelinesys.com/content/home

turn off the gas, water or to sound an alarm indicating to the person that he needs to leave the premises. Emergency services or informal caregivers may be notified automatically.

Burns are a major threat to the health of the general population, and for the less robust elderly population they a major source of traumatic injury in the home. Kitchen equipment is a source of danger to the elderly if they are not conscious of the danger of hot surfaces.

Kitchen safety can be improved by better use of low heat energy sources, such a microwave ovens, or conventional ovens with better loading and unloading systems.

Design of oven systems and other heating systems such as toasters could be significant improved by new certification processes to ensure that notification of the temperature of solids and liquids is properly reported by the equipment.

One simple example is hot taps that indicate the temperature of tap water via LED lights. However, this example could be extended to other kitchen appliances that handle hot solids or liquids.

3.2.4 Personal alarm services

Personal alarm services provide people with a 24/7 system for contacting professional help in case of emergency. We discussed earlier the example of fall detection, but there are several other solutions in this category. In recent projects, such as the European Florence project[15], a robot has been used to assess the situation in case of an emergency. Care personnel at the alarm centre could establish a video connection with the person via a camera mounted on the robot. Using a keyboard, they could control the robot to look around the house, driving to the location of the emergency.

The ethics of video surveillance of the elderly, however, needs to be addressed by studies on the social barriers attached to invasive monitoring of the home, and on how to exploit video analysis to reduce the ethical objections to video methods.

3.3 Assistive Technology

Assistive technologies include products, systems and services that assist people in performing a task that, because of disabilities or limitations, they would otherwise be unable to do. A wide variety of assistive technology is available to help people keep their independence for longer.

Assistive technologies can help older people in the social domain (e.g. suggestions

[15] http://www.florence-project.eu/

to call or visit a family member or friend), the mental domain (e.g. medication reminders) or in the physical domain (e.g. reminders for doing some physical exercise). We'll focus on systems and devices that will help people in the physical domain.

Assistive technology can be both supportive as well as preventive.

Prevention	Compensation	Care	Enhancement
Movement-activated nightlights to avoid falls	In case of mental decline, technology can help people to start or resume daily activities, such as giving suggestions to go outside for a walk.	N/A	N/A

3.3.1 Reminders

With sensors installed in home or sensors in personal devices (e.g. smartphones), it is possible to monitor a person's activity in their own home over a period of time. Based on these daily activities, a system can give feedback and help people to start or resume interrupted activities.

ClarisCompanion[16] is an example of assistive technologies that help the elderly people to stay in touch with their loved ones from their homes. The device is user friendly and highly customizable. Family members can configure the device and remotely set reminders, configure email and alerting system and also track the user activity.

The device can also be programmed to beep with reminders to take medicine, and it also provides reminders for an exercise routine and for calendar events. For example, if sensors in home have measured that the elderly have only watched television during the last three hours, and the system has checked the weather forecast, it could give the elderly a suggestion to go outside for a walk.

Reminders could be based on both a calendar (planned reminders) as well as on sensor input (spontaneous reminders).

[16] http://www.clariscompanion.com/

3.3.2 Lighting

There are also technologies to improve someone's safety. Falls are the leading cause of hospital visits and the primary cause of accidental deaths in persons over the age of 65 years.

To avoid falls in the dark caused by objects on the floor or doorsteps, movement-activated nightlights can be installed between the bedroom and the toilet to assist movement and recognition.

The elderly are frequently victim of scams and other trickery to gain access to the home, and allow the perpetrators steal or set up effective frauds, which can cause both financial damage and stress to the elderly. Lighting of doors and hallways to a residence is an important aid to protecting the elderly from such criminal perpetrators. Door can also be provided with sensors to detect forces and voice communication that indicated the dialogue with the elderly is not safe, or that a third person should be informed on the state of the dialogue to help in communication or warn security services.

In France the concept of Police3.0 is gaining interest as a topic to aid security services, while in the UK, the police are already offering RESTful APIs is gain access to data on criminal activities. Smart lighting and the associated sensing for control of lighting system in public and semi-public places have much potential to improve the safety of the elderly, if the information gathered of the lighting system can be shared with those responsible for alerting to other dangers in the home.

3.3.3 Guidance

The value of being outdoors has been shown to lead to increased well-being and enhanced quality of life[17]. However, spending time outdoors independently may demand some support. Outdoor alarms are available for the purpose of supporting people with dementia. Due to symptoms accompanying the disease, e.g., memory loss these people need support to find their way back home. Other purposes of outdoor alarms are focused on elderly who want to be able to feel safe enough to leave their home, but always want to be able to call for support and can be found if needed.

Technology can be applied to assist people with memory limitations (e.g. mild dementia), because they often have troubles by finding their way back home. To compensate for this and creating the ability for the elderly to go outside without the direct help of a (in)formal caregiver, solutions are developed which will give guidance in case they get lost. This increases the freedom of people with a mental decline.

[17] http://www.diva-portal.org/smash/get/diva2:611678/SUMMARY01.pdf

An example of this technology has been developed in a research project, 'TalkMeHome'[18]. The TalkMeHome service is developed for elderly with (mild) dementia. In case the elderly cannot find their way back home, they can easily press a button to get connected to a caregiver. The caregiver receives the position of the elderly via GPS and can explain how the elderly could get home again via a voice call, or call for help.

3.3.4 Aids for daily living

Assistive technology for daily living is a huge area with devices and services supporting everyday life of (among others) elderly. Daily living aid increases, maintains, or improves the functional capabilities of people with disabilities.

Aids for daily living include, but are not limited to:

- *Clothing and dressing aids*: e.g. button helpers and zipper pullers are dressing aids that enable people with arthritic hands in fastening their shirts, shorts and pants
- *Food preparation and eating aids*: e.g. carving knives, gripping aids, scissors, forks with either special grips or blades for people with weak grip or limited range of motion.
- *Toileting and bathing aids*: e.g. self-wipe bathroom toilet aids, shower massagers, fog-less mirrors, specialty toilet seats, a wide variety of bathroom cleaning aids, and weight scales.
- *Reaching and mobility aids*: e.g. grab rails, ramps, walking sticks and host of others, all designed to help those with limited personal mobility.

3.4 Coaching and Persuasive Technology

One of the key to active healthy ageing is to exercise regularly (Singh, 2002). Technology helps older adults in training, but in the past attempts to support regular training has seen very high attrition rates (Donkin et al., 2011). Indeed, with the increasing age, there is a progressive physical decline in older people leading to problems such as postural instability and falls. Physical exercise has been proven to be the most effective intervention to improve balance and reduce fall risk on older people. However, regular physical exercise has been perceived as boring and not motivating (Schneider et al., 2003).

[18] http://www.talkmehome.nl/

Prevention	Compensation	Care	Enhancement
Prevention by getting motivated to do physical exercise regularly	Include social influences to avoid loneliness	Using exergames in rehabilitation	Enhancing communication skills by providing intergenerational communication technologies

For this reason, technology today aims at developing solutions that are not only highly usable but that also include a persuasive aspect. The research area that covers the use of technology to persuade people in changing their behaviour has been labelled *persuasive technology* by Fogg. (2002). Fogg makes a distinction between intrinsic and extrinsic strategies that can be used to persuade people into a behaviour change. Individual motivation is based on triggering the intrinsic drive of the individual, e.g., by setting goals, creating awareness, or by conditioning through positive reinforcement. Extrinsic strategies build on social psychology; other people can be the source of motivation, e.g., through competition, cooperation or comparison.

3.4.1 Exergames

One of the most common persuasive technology methods is to use *game elements*. The use of video games in physical training, also known as 'exergaming', has a positive impact on delivering exercise programs with higher levels of motivation and enjoyment for the elderly (Brox et al., 2011). Exergaming is a portmanteau of 'exercise' and 'gaming' and is a term used for video games that are also a form of exercise. Exergaming platforms are designed to track body motion or body reactions and provide both fun and exercise for game players[27]. Numerous video game console companies have designed exergaming interfaces that are becoming very popular. Three of the major players are: Sony PlayStation Move[19], Nintendo Wii[20], and Microsoft Xbox 360 Kinect[21]. Most exergames are designed to prevent physical decline by motivating people to do physical activities and to help the elderly to maintain and even improve physical abilities such as muscle strength and balance. A famous example of exergaming for elderly is Silver Balance (Gerling et al., 2010),

[19] http://us.playstation.com/ps3/playstation-move/

[20] http://www.nintendo.com/wii/what-is-wii/

[21] http://www.xbox.com/en-US/kinect

SilverBalance is an exertion game prototype which runs on Nintendo Wii Balance Board. It offers simple and intuitive interaction paradigms which are easy and fun for the elderly users. Exergames such as silverBalance can improve specific physical abilities while being fun and competitive. Exergames are not only used as a preventive tool, they have also has proven to be effective in rehabilitation sessions (e.g., SilverBalance[31]). The engaging nature of videogames is a patient-centred approach to engage patients in otherwise boring and repetitive rehabilitation exercise. For example, Corehab[22] provides customized exergames for rehabilitation after an injury. A physical therapist prescribes the rehabilitation plan using configurable games. Patients wear motion sensors that detect movement, and with their movement they control an avatar that plays a game. The game is designed in such a way that correct moves for rehab lead to success in the game. Corehab comes with more than 50 game-exercises for knee, ankle, hip and, balance control and a monitoring interface for the physiotherapist.

Another way to stimulate the elderly in increasing their exercise levels and so to prevent age-related health issues is by using context-aware technology (Yen & Chen, 2011). Here, activity patterns can be monitored, elderly people can be made aware of their activity patterns, and a system can pro-actively promote exercise. A number of chronic diseases of the elderly can be assisted by intensive coaching. For example, the care of COPD (Chronic Obstructive Pulmonary Disease) patients with GOLD IV (Very Severe COPD[23]) is strongly influenced by intensive coaching to resort mobility and reduce dependency on lifestyle habits that have very strong influence on the function of the lungs and heart, smoking secession, effective sleeping, and rigid attention to diet. However, such coaching is very costly, and usually only used after an incident has drastically reduced the health of the individual.

3.4.2 Social interactions and sharing

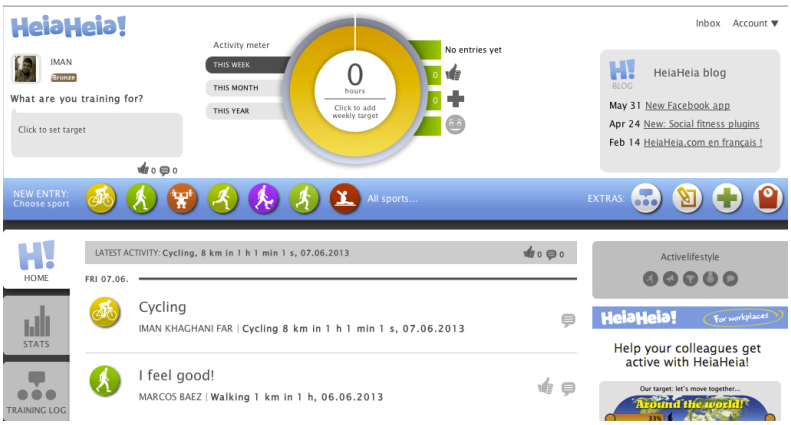
Another powerful motivation factor is social sharing. Participating in regular training sessions outside their homes can be challenging for the elderly, and it is hard to motivate oneself to exercise regularly alone at home. In addition, many elderly with physical and cognitive declines suffer from loneliness (Chang & Yang, 1999), making social interaction very important. There are several types of social influences that can promote behaviour changes. Persuasive techniques that are used are e.g. competition (applications where people have to compete in an activity) and cooperation (applications where people have to collaborate in an activity). In many applications it is possible to share data, such as achievements and points, with other people, and this motivates people to do more physical exercise (Silveira et al., 2013).

[22] http://www.corehab.com/

[23] http://www.webmd.com/lung/copd/gold-criteria-for-copd

Virtual social Gym[24] is a Tablet application that provides a virtual environment for the independently living elderly at home to perform physical exercises with friends and acquaintances. The platform allows healthcare experts to create customized training plan for a group of elders. Later, the elderly user can join a club, invite others to the club, and follow different training sessions while she is accompanied with her friends. The main persuasion is in the peer-pressure that a group of people would have on each other. Users will be inviting each other to clubs, ask other club members to join them in a training session. While training, users will be able to see each other activities, like they are all together in a real gym. Consequently, they don't feel alone while exercising; they can get a tap from a friend, or encourage their gym-mate to do better. This is critical for singled out elders who are not leaving their home regularly.

Virtual Social Gym prototype



Heihaheiha Dashboard

[24] http://Socialgym.org

Heihaheiha[25] is another example of a web platform that let the user track and share their workouts. Heihaheiha allow the users to create training plans and groups and share it with their friends. Users will be able to communicate with each other, participate in each other's training plan and share, comment and like their friends' activities. In addition, adding more friends and login more sport activity will increase the level of the user. This will create a persuasive mechanism for the users to improve their social interaction along with sport activities.

3.4.3 Fitness devices and apps

In recent years, various monitoring devices have found their way to the consumer market. These devices and applications can be divided into three main categories, each focused on a different market segment: heart rate monitors for the enthusiastic adults, activity monitors for the Healthy Adults, and health monitors for the Adults at risk.

Heart rate monitors

There is a wide range of sensors for heart rate monitoring and performance measurement, many of them also offering APIs, thereby making it possible to integrate them into 3rd party applications. Examples include Fitbit[26] and Bodymedia[27]. A complete and up to date list can be found on programmableweb.com.

The business model is B2C via sales of a device, while the apps and web services are free, with a few exceptions such as Nike that can charge for premium services.

The key trend here is to remove the need for the chest strap by using either:

- Heart-rate sensors in earphones, or headband, or a second arm-band.
- Wrist-worn monitors at CES, this market was covered by OMRON[28] and MIO Alpha[29]. New:
- Video, such as in Philips VitalSigns[30] application.

[25] https://www.heiaheia.com/

[26] http://www.fitbit.com/

[27] http://www.bodymedia.com/

[28] http://www.omron-healthcare.com/eu/en

[29] http://www.mioglobal.com/

[30] http://www.vitalsignscamera.com/

Activity Monitors

These sensors and systems monitor the overall daily activity, some of them extending into nutrition management and sleep monitors. This area sees a mix of "traditional" players (such as LG and Philips) and of more or less new companies, from FitBit to Withings. A very large number of small companies, especially from China, are entering the market, so that the landscape is becoming very competitive. The key trend as demonstrated in recent conferences and trade shows (such as the Consumer Electronics Show) was to offer a variety of wearing positions for the sensors, a variety of designs, and a variety of pricings (all with impact on precision) therefore aiming at different target groups.

Fitbit[31] is one of the leading examples of off-the-shelf self-tracking devices. Fitbit is coming on different wearable and wireless activity tracking (i.e., Flex, zip, One) and a smart "balance" for reporting on the user's weight. In addition, Fitbit provides a comprehensive web and mobile interface for the user to be able to track her activities in addition to schedule and moderate her future activities. The entire Fitbit package is regularly monitoring the user daily activities (e.g. sleeping, walking, sit, stand). These devices can typically be connected to a PC to view and/or upload the data to a (paid) remote storage facility. The supplied software (or web portal) offers views and analyses of the data and allows the user to track progress with respect to goals.

Other examples of these systems include the Nike+ Fuelband[32], the Jawbone UP[33] and Philips' DirectLife[34]. However, these devices are focused on adults, not on the needs and abilities of the elderly.

Smartphones also contain sensors, such as accelerometer, camera and GPS. In recent years, the number of applications that make use of these sensors to monitor someone's physical activity is booming. The data of most of the apps can easily be share via social media. Examples of such applications include, Runkeeper[35], Endomondo[36] and Nike+ Running[37]. Once again, these apps are not focussed on the needs and abilities of elderly.

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[31] http://www.fitbit.com/

[32] http://www.nike.com/us/en_us/c/nikeplus-fuelband

[33] https://jawbone.com/up

[34] http://www.directlife.philips.com/

[35] http://runkeeper.com

[36] http://www.endomondo.com

[37] http://nikeplus.nike.com/plus/products/gps_app/

Another example of self-tracking is Runtastic[38]. Runtastic provides tracking application for major smartphones (IPhone, Android, windows phone) and uses the device built-in features such as accelerometer and geolocation to track the user daily activity. Runtastic is used to optimize mainly the user workout and let the user to compare it with her past workout activities.

The application is coming with different packages, each providing tracking for a different sport (i.e. walking, jogging, mountain biking, winter-sports).

Health Monitors

This category of applications is targeted at people with specific risks or concerns in terms of health, i.e., beyond the need to remain fit. Because the needs are so diverse, the range of application and sensors here is also very diverse. For example, there are applications and sensors to monitor glucose level in the blood (such as the iBGStar blood glucose meter[39]), blood pressure monitors, (such as Whithings[40]), injury monitors (such as the concussion monitors from Shockbox[41])

The business model is still for the majority B2C via the sales of the device, with only few exceptions (such as the Health Buddy of Bosch, which is subscription based).

The large majority of these sensors come with smartphone applications that are relatively usable, and the design of the sensor themselves is clearly picking up in importance with respect to (only) functionality.

Again, as for the previous example, while some of these applications clearly have the elderly in their potential target market, there appear to be no special attention for these classes of users. Indeed, while applications are easy to use, they are not at the level that is amenable to many older adults, at least not without assistance. Many of them seem also to assume that health per se is a motivation and do not provide specific persuasion methods, besides trying to achieve a cool design.

4 Trends

In this section we discuss key trends in active healthy ageing. Although we take a worldwide perspective when possible, we focus specifically on trends that apply to Europe.

[38] http://www.runtastic.com/

[39] http://www.bgstar.com/

[40] http://www.whithings.com

[41] https://www.theshockbox.com

4.1 Societal trends

1. **Ageing population** – Between 2008 and 2013, there is a projected worldwide increase in the 65-plus population. In 2008, 7.5% of the population was in the 65-plus age group. In 2013, the percentage rises to 8.1%, which is an increase of 66 million people to a total of 574 million. This will have a dramatic effect on all aspects of society, especially healthcare. (BCC)
2. **Dramatic increase in average life expectancy** – We soon will have older people than children and more people at extreme old age than ever before. Nowadays, life expectancy at birth is over 80 years of age in high income countries[42].
3. **Severe shortage of (informal) caregivers** – Because of the demographic changes, there will be a gap between the number of people who need help and care and the people who can provide those help and care. Therefore, there is a need for better information and tools to ensure the well-being of the growing number of elderly.
4. **Healthcare costs** – Higher demand for more efficient drugs and medical devices for pain treatment will continue to drive the pain management market. As a result healthcare costs will continue to increase
5. **A change of lifestyle** – People are more and more active compared to many years ago. They wish to travel the world, are active in sports and life has become more and more demanding. As a result this more stressful life brings more common pains like back pain and repetitive strain injuries.
6. **Single households** – The number of single-person households has been on the rise, driven by changes in culture and lifestyles, and rapid population ageing. Lonely elderly people who often have no family to fall back on will place a strain on social welfare budget.
7. **More intense communication** – Due to the digitalisation, elderly are able to have more intense and more rapid communications with their relatives.
8. **Increasing consumer awareness** – Consumers become more aware and educated about the negative effects of pills and drugs to either treat their diseases or to improve their condition. As a result,
    a. **Drug-free solutions** – Consumers are looking more and more for drug-free solutions to avoid any side effects of medication.
    b. **Alternative medicine** – Whilst many patients have tried off-the-shelf drugs and medicines, they are much more inclined to an alternative to drugs. There is also a trend to try herbal remedies, which are not considered hazardous as medicines can be. Massages and acupuncture are also more often considered as alternatives.

[42] http://www.who.int/gho/mortality_burden_disease/life_tables/situation_trends_text/en/

c. **Medical devices** – The market is fuelled by the availability of highly efficient medical devices that do not cause any side effects. The medical devices market is well documented for treating pains that do not respond to drugs. A higher demand for medical devices given the double digit CAGR growth trends across the globe (Global Alliances, 2011)
d. **Telemedicine** – For cost reduction purposes and to make it easier for patient to get a consult (when movement is a problem).
e. **Non-invasive technology** - Patients do not want pain or disease to dominate their lives. Modern technology can enable them to run their lives without limitations on when and where they need to get their treatment. They can be treated when needed, without adjusting to treatment appointments. As a result we can see various trends on a product level based on this core need: Preference for non-invasive options. Future growth will be highly influenced by increased awareness of non-invasive devices for treatment and rehabilitation, re-imbursement policy in the US for surgical procedures and growth of the At Home care segment.

4.2 Digitization Trends

By the year 2020, an entire generation will have grown up in a primarily digital world. Their familiarity with technology, reliance on mobile communications, and desire to remain in contact using large networks will transform how we work and how we consume. The phenomenon of digitization is reaching an inflection point. The effects of an increasingly digitized world are now reaching into every corner of our lives because three forces are powerfully reinforcing one another:

1. **Consumer Pull** – Consumers, and particularly Generation C, are already fully adapted to the digital environment. They naturally expect to be always connected, are willing to share personal data, and are more likely to trust referrals from their closest friends than well-known brands.
2. **Technology Push** – Digital technology continues to expand its influence. The infrastructure backbone of the digital world is bringing affordable broadband to billions of consumers. In parallel, low-cost connected devices are being deployed in every industry, and cloud computing, and the information-processing machinery it requires, is developing quickly.
3. **Economic Benefits** – The economic benefits to be captured through digitization are real. A wave of capital has poured into the new digitization technologies and companies, and the public markets reward early movers with unprecedented valuations.

4.3 Trends on Data Collection

1. **Increased accuracy and reproducibility of the sensors and measurement methods:** accuracy is an important aspect for monitoring purposed. For example blood pressure, weight, body fat % using BIA (Bio Impedance) scales are very dependent on the activity level, the measurement method, the hydration level of the user. Any non-reproducibility might create some distrust in the product and sometime demotivation in a lifestyle change process (where (improved health) results may not show on the monitoring tool).
2. **Networked devices and sensors** - internet connected home monitoring systems, no gateway just direct upload of data to the cloud. There are also many devices that can be used at home for taking a lot of measurements and connect via Bluetooth to your smartphone to upload the data to the cloud.
3. **Integration of multiple devices** – each company tries to offer a complete set of devices: Withthings – scale with air quality, activity monitor with heart rate and blood pressure meter. Also the apps offer alarms and some type of intelligence relative to being within healthy boundaries.
4. **Monitoring and Mobile Health** – Advanced sensor technologies (e.g. Smart Homes) coupled with mobile devices and services (e.g. smartphones, blood pressure meters), will make it possible to measure valuable data about someone's physical state. The data can be used as a basis for multiple purposes, such as coaching, assistance, emergency.
5. **Self-tracking** – There are millions of mobile applications including thousands of apps related in some way to health and well-being – diet, exercise, fitness, weight loss and beauty. None will get much traction until the business model of healthcare creates the necessary incentives for consumers (and providers) to engage and until wearing devices is something that makes people feel well emotionally, not "just" something that promotes health.
6. **Cost-effective secondary prevention** – Through remote- and self-monitoring, measurements can be done regularly by an individual him-/herself at home. Trends can be derived from the data. Only in case of negative signs or other problems, professional caregivers will (automatically) be involved, much of this can also be done virtually. In this way, care professionals can serve more patients in less time.
7. **Smart Textiles** - a possible new trend is integrating technology in clothing.
8. **Quantified self:** users want to monitor and control themselves their health. Only use the professional when highly required.

4.4 Trends on Emergency Technology

1. **Prevention of injury** – Emergency technology relies heavily on monitoring technology. As soon as a dangerous situation arises, this kind of technology

either notifies the person of the risk (e.g. wandering detection and prevention) or mitigates the risk automatically (e.g. automatically turn off the gas).

2. **Effective fall detection** – A fall detection solution (typically) uses data from an accelerometer to detect that a user has fallen or the person can press the emergency button. Either a formal or informal caregiver will be informed about the event. A video connection may be established with the home of the user to further assess the situation, and to make sure to send the right assistance to the elderly.

4.5 Trends on Assistive Technology

1. **Engagement technology** – With sensors installed in home or sensors in personal devices (e.g. smartphones), it is possible to monitor a person's activity in their own home over a period of time. Based on these daily activities, a system can promote people to start (or resume interrupted) activities, like going outside for a walk when some has watched television for the last couple of hours.
2. **Safety and assistance technology** – Refers to technology that will assist the user e.g. to avoid falls in the dark caused by objects on the floor or doorsteps, movement-activated nightlights can be installed between the bedroom and the toilet to assist movement and recognition.
3. **Portable self-treatment electronic devices for domestic usage** – Domestic usage of devices allow consumers to e.g. rehabilitate without taking medicines or going to a health professional or a doctor.
4. **All-day-wear therapy electronic devices** – Wearable miniaturized medical devices for non-invasive treatments, delivering continuous treatment or even restore damaged cells.

4.6 Trends on Coaching and Persuasive Technology

1. **Exergames** – To get technology accepted and to persuade people to change behaviour (e.g. do more physical exercise), it has to be intuitive, easy and fun to use. Most exergames are designed to prevent physical decline by motivating people to do physical activities. Moreover it could help elderly to maintain and even improve physical abilities such as muscle strength and balance.
2. **Context-aware technology** – By using context-aware technology, activity patterns can be monitored, elderly people can be made aware of their activity patterns, and a system can pro-actively promote exercise. In this way elderly can become or remain physically active. We expect in the coming years a focus on applications that hit the usability and motivational requirements of the older segment of the population, something that has not yet happened to a large extent, although we see growing interest in this space.
3. **Social data sharing** – The desire to share and the interest in what our fellow

beings are up to does not change with age. What changes is only our ability to interact and our sense of pride, or perception on whether we have interesting stories to tell. There seems to be a consistent trend here towards enabling elders to share and interact, although the key will be whether applications will manage to offer interaction metaphors that make elders sufficiently able and proud to share aspects of their current life.

4. **Fitness and self-tracking apps and devices** – In recent years, various activity monitoring devices have found their way to the consumer market. Aimed at people that would like to remain active and fit without going to the gym three times a week, these devices typically use an accelerometer embedded in some kind of waterproof casing. These devices are meant to be worn by users 24/7, with batteries typically lasting up to two weeks. Some devices provide a subtle form of feedback towards the user to indicate whether the user has reached their daily goal. Target groups are mainly youngsters and adults, not (yet) elderly.

5 Challenges

5.1 Overall Challenges

- **Privacy and security of data** – recording data related to personal wellbeing should be done in a secure manner. And nobody has got the real solution yet (several leakage of personal data are occurring).
- **Standardization** – Many devices can be bought independently. The strength of assistive technology is that sensors and actuators can be combined to create a valuable solution. However, it is still an unstructured market with lack of transparency and standards.
- **Engaging (elderly) people in a preventive manner** – without any bad health diagnose yet and making them acquires and uses supporting products.

5.2 Challenges in Data Collection

- **What to monitor** – a lot of different sensors exist, but one should carefully select a set that gives meaningful information about the situations that need to be monitored.
- **Accuracy and reproducibility** – it is important to provide accurate measurements to the users (to have a proper health evaluation), but it is even more important to have highly reproducible results - to be able to monitor (daily or weekly) small progress to keep people motivated and increase the chance of adherence to a program. E.g. in body composition or blood pressure.
- **Meaningful processing** – even if all the inputs are perfect, it might be quite

hard to detect certain situations. For example, one could derive from events in the kitchen that a meal is being prepared, but what really counts is if the person actually consumed the meal. Processing should be able to deal with missing, or conflicting, sensor events.

- **Maintenance** – for easy installation, battery-operated wireless sensors can be used. However, for the monitoring functionality to work, it is essential that all battery-operated components have sufficient power, and that batteries are replaced when needed – especially since the person being monitored might not realize when batteries run empty.

5.3 Challenges in Emergency Technology

- **Reducing false positives** – for emergency technology to work, it is important that all emergencies are detected and that the number of false positives (cases where an emergency is reported but no actual emergency has taken place) is low. If the number of false positives is high, care personnel may not respond adequately to actual emergencies, expecting it to be a non-emergency.
- **Privacy** – when an audio or video connection can be established with the house/patient in case of an emergency, safeguards have to be made that these connections cannot be activated remotely in case there is no emergency reported – it should not be possible for care personnel to 'eavesdrop' on the patient without the patient knowing.
- **Lack of robust and secured home gateway** – No guarantee of service beyond gateway: 911 problem for all services.
- **Zero maintenance system** – Service and support staff for the elderly .

5.4 Challenges in Assistive Technology

- **Independent Training** – Current training application designs and tools are often made rich in functionality but are rarely usable by older adults without some kind of assistance. The challenge is to design applications that can be used independently, without requiring help from others, as this is a powerful motivator for training
- **Adaptive training applications** – "Older adults" is a term that spans a very wide group of people with different skills. Furthermore, people (including older adults) do have the ability to learn and improve. Consequently, a challenge is how to create solutions that enable users to learn more sophisticated (and efficient, effective) ways to interact with the applications to get more done while maintaining the ability of using the device independently.

5.5 Challenges in Coaching and Persuasive Technology

- **Capturing the social dimension** – The social aspect is a very strong motivator for training in young adults, both for the social interactions during training as well as for the effect of a training (slimmer body) in social context. The need for interaction and recognition stays as we age, the challenge here is how to satisfy this need.
- **Contributions to society** – Motivation to train and stay healthy may also come from a sense of purpose in life. Therefore, persuasion technologies must find ways to facilitate older adults in contributing to society and/or in enabling persons to learn and grow, somehow "improve".

6 Recommendations

This section makes recommendations for future technology development in relation to Physical Wellbeing for Active Healthy Ageing.

6.1 General Recommendations

Privacy and ethics – As technology continues to improve, the eHealth industry will have great impact on the health care system. eHealth will become a major factor in the infrastructure of healthcare. However, policies and procedures are needed to guarantee privacy and security, while enabling sharing of information with authorized parties. Because we target ageing, it is particularly important to ensure that the adopters of the technology are clearly made aware of which information is exposed, to whom, and for what purpose, in a manner which is understandable to them.

Link to network of medical professionals – to increase the chance of success of any supporting (preventive) technology, it is important to have a strong link with specialized medical professionals and interaction designers, as they know what the challenges of the ageing population are to stay healthy and what are the interaction paradigms they are comfortable with. Furthermore, involving them at an earlier development stage and getting their endorsement will facilitate the trust for the user in the technology developed.

6.2 Recommendations in Data Collection

Sensor integration and battery life – Sensors have been an important addition to smartphones ever since accelerometers were first used to determine screen orientation. Nowadays a wide variety of sensors are found in many other devices, such as watches, and glasses. Further development should be done on 24/7 measuring, measuring with a higher sample rate, and integration and combination of sensors in personal devices to serve multiple purposes. As a result, this causes

significant battery drain. Therefore, there is a need for improvement in smart energy use and better battery life. Within the medical (e.g. hearing aids) and military field there are already examples of efficient energy use. However, these are mostly very expensive. Thus, there should be made a translation from those markets towards more affordable solutions.

New metabolic measurements – The BMI is currently the most frequently used method to assign individuals into one of the four categories: underweight, normal weight, overweight and obese. However, the health prognostic value of the BMI scale is very limited, especially in the intermediate BMI ranges, in men and in the elderly. This is due to the fact that it is not able to discriminate between fat- and fat free mass and therefore fails to represent the body's proportional composition. Next to this, it fails to provide appropriate feedback for people undergoing a fitness regime and or fitness-diet program, since these interventions can very well lead to significant and beneficial changes in body composition without a change in body weight. This can lead to demotivation and non-adherence to the program.

Body fat can be measured via a wide range of technologies ranging from highly accurate, but labour and cost intensive and bulky technologies like MRI, CT and underwater weighing, to rather easy to use, quick and cheaper methods like bioelectrical impedance analysis and skin fold measurements. The highly accurate methods are not accessible to the majority of the people, while these cheaper methods provide less (or too low) accuracy and reproducibility or require a proper training level to be applied correctly.

Ultrasound (U/S) is also a technique widely used for non-invasive imaging and clinical diagnostic purposes. This technique is able to directly visualize the different tissue layers, like skin, adipose and muscle tissue. Some initial investigations have been carried out at Philips and showed good potential of this technology for accurate body composition measurement for semi-professional or possibly home usage[43].

6.3 Recommendations in Assistive Technology

Medication control – Compliance is very important in a lot of drug regimes, and it can be very difficult to get patients to accept and remind of the drug regime. The developments in microelectronics might enable doctors to contemplate the day when they will be able to monitor and treat their patients with medical implants that use wireless technology. The latest development in this area is a medical implant controlled by wireless commands to release drugs at regular intervals within the

[43] http://patentscope.wipo.int/search/en/detail.jsf?docId=WO2012093317&recNum=8&docAn=IB2011055959&queryString=%22koninklijke%20philips%22&maxRec=25391

body of a patient

Patients with chronic diseases, regular pain-management needs or other conditions that require frequent or daily medication intake, could benefit from technology: the miniaturization of wireless devices and the ability to place them inside a patient where they perform a new kind of "telemedicine" – medical treatment from a distance.

Simplified professional technologies – Self-diagnosis is another aspect that could make the health care system more efficient. However, professional diagnosis tools and instruments are often expensive and complex. There is a need for inexpensive, but high quality diagnosis tools.

Self-tracking data for medical purposes – Once used only by elite athletes, self-tracking is becoming more accessible to the mainstream. Instead of single-use pedometers, devices such as Fitbit, Jawbone UP, Nike+ FuelBand and others can monitor much more, such as heart rate, calculate calories and count the number of stairs you climb or the quality of your sleep.

Health professionals, however, remain guarded about self-tracking. Professionals are taking notice of the boom in apps and other technology to help collecting bio data, but there is a lot of discussion about the quality of the data and how this data could be used. Monitoring devices have the potential for reducing the pressure on the health care system. However, integration and acceptance in the health care system needs to be established.

6.4 Recommendations in Coaching and Persuasive Technology

Persuading to maintain an active lifestyle – Developing an easy, accurate and adequate (able to determine health risks) monitoring system coupled with an adequately motivating social and medical circle throughout one's life seems a good way forward for preventive health. Defining these elements will be dependent on the available technologies and a highly personalized approach (depending on the user age, country, (medical and social) culture and personality, and many more parameters to be found). Research here should focus on usability on the one side and on persuasion techniques on the other, to provide motivational aspects for being active and healthy and for maintaining interactions with society. We have been shown over and over that technology and functionality is not enough and they do not work unless packaged and used within a context that provides motivation, opportunity and joy in using the technology.

References

American Hospital Association. (2007) When I'm 64: how boomers will change health care. Chicago; 2007 Jul. http://www.aha.org/aha/content/2007/pdf/070508-boomer- report.pdf.

Bodenheimer, T., Lorig, K., Holman, H., & Grumbach, K. (2002). Patient self-management of chronic disease in primary care. *Jama*, *288*(19), 2469-2475.

Brox, E., Luque, L. F., Evertsen, G. J., & Hernández, J. E. G. (2011, May). Exergames for elderly: Social exergames to persuade seniors to increase physical activity. In *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2011 5th International Conference on* (pp. 546-549). IEEE.

Chang, S. H., & Yang, M. S. (1999). [The relationships between the elderly loneliness and its factors of personal attributes, perceived health status and social support]. *The Kaohsiung journal of medical sciences*, *15*(6), 337-347.

Donkin, L., Christensen, H., Naismith, S. L., Neal, B., Hickie, I. B., & Glozier, N. (2011). A systematic review of the impact of adherence on the effectiveness of e-therapies. *Journal of medical Internet research*, *13*(3).

Fogg, B. J. (2002). Persuasive technology: using computers to change what we think and do. *Ubiquity*, *2002*(December), 5.

Gerling, K. M., Schild, J., & Masuch, M. (2010, November). Exergame design for elderly users: the case study of SilverBalance. In *Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology*(pp. 66-69). ACM.

Harrington, T. L., & Harrington, M. K. (2000). *Gerontechnology: Why and how*. Shaker, Herman Bouma Foundation for Gerontechnology.

Silveira, P., van de Langenberg, R., van het Reve, E., Daniel, F., Casati, F., & de Bruin, E. D. (2013). Tablet-Based Strength-Balance Training to Motivate and Improve Adherence to Exercise in Independently Living Older People: A Phase II Preclinical Exploratory Trial. *Journal of medical Internet research*, *15*(8).

Schneider, J. K., Eveker, A., Bronder, D. R., Meiner, S. E., & Binder, E. F. (2003). Exercise training program for older adults. Incentives and disincentives for participation. *Journal of gerontological nursing*, *29*(9), 21-31.

Singh, M. A. F. (2002). Exercise comes of age rationale and recommendations for a geriatric exercise prescription. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *57*(5), M262-M282.

Yen, Y. C., Lu, C. H., Cheng, Y. C., Chen, J. S., & Fu, L. C. (2011). Towards an evidence-based and context-aware elderly caring system using persuasive engagement. In *Universal Access in Human-Computer Interaction. Context Diversity* (pp. 240-249). Springer Berlin Heidelberg.

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