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A Smart Wearable Sensors System for Counter-Fighting Overweight in Teenagers

Carlo Emilio Standoli [1,*], Maria Renata Guarneri [1], Paolo Perego [1], Marco Mazzola [2], Alessandra Mazzola [1], and Giuseppe Andreoni [1]

[1] Politecnico di Milano, Dipartimento di Design, via Giovanni Durando, 38/A, 20158 Milano, Italy; E-Mails: mariarenata.guarneri@polimi.it (M.R.G.); paolo.perego@polimi.it (P.P.); alessandra.mazzola@polimi.it (A.M.); giuseppe.andreoni@polimi.it (G.A.)

[2] Neosperience S.p.a, Corso Indipendenza 5, 20125 Milano, Italy; E-Mail: marco.mazzola@neosperience.com

* Author to whom correspondence should be addressed; E-Mail: carloemilio.standoli@polimi.it; Tel.: +39-022399-5917.

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Abstract: Obesity and other lifestyle-related illness are among the top healthcare challenges in Europe. Overweight in younger age is an alarming predictor for obesity in adulthood, but also entails short-term health complications in juvenile age along with greater risk of social and psychological problems. Knowing how to stay healthy is not enough to motivate individuals to adopt healthy lifestyles, but relevant progress can be achieved through the use of incentives delivered through a combination of behaviour change processes and mobile technologies. The PEGASO system framework has been designed to address prevention, by offering to teenagers three main functionalities: (a) Monitoring: The dimension covers the behavioural and physiological analysis of young users through a monitoring platform including wearable sensors and mobile phone for the acquisition of physical, behavioural and emotional attitude of adolescent; (b) Feedback: This function provides feedback in terms of required actions to undertake and will propose personalized modification of the lifestyle (e.g., in terms of healthy food habits and/or physical activity), thus promoting the active involvement of adolescents in changing their behavior; (c) Social: In this dimension users can share experiences with a community of peers concerning e.g., physical activity, food consumptions and everyday habits through different gaming strategies. This paper presents the intermediate results of PEGASO sensor platform's development. The platform is based on the combination of wearables and app

running on a smart-phone. The development was performed in a co-design approach with high-school's students in Italy, UK and Spain.

Keywords: wearables; lifestyle monitoring; teenagers; behaviour change; co-design

1. Introduction

1.1. Problem Statement: The "Obesity" Epidemic

The rapidly increasing prevalence of overweight and obesity among children and adolescents reflects a global 'epidemic' worldwide. Due to the associated serious medical conditions, it is estimated that obesity already accounts for up to 7% of healthcare costs in the EU, as well as costs to the wider economy associated with lower productivity, lost output and premature death. Obesity in younger age groups has been recognized as an alarming key predictor for obesity in adulthood, but also entails a number of short term health complications in juvenile age [1].

Obesity and overweight do not affect only the health dimension. They also have an economic, a social dimension and an environmental dimension. Obesity and overweight implies "direct" and "indirect" costs. The firsts are connected with the personal health care, the hospital health care, the health services and the drugs, whereas the second category of costs is mainly related with a reduced productivity of the obese workers. At social level, it has been studied that the obese person often has a very low self-esteem, is depressed and tends to stay on his/her own: he/she is most of the time mocked by his/her peers. As a consequence, the overweight people may have serious relationship problems, often they begin to smoke and to consume alcohol very early. Environment has a significant impact on the development of obesity. Many factors contribute in the sedentary lifestyle of young and adults. As an example the urbanization trend, the rise in the number of vehicles and the lack of cycle paths discourage parents to let their children walk or cycle to school.

This situation is no more sustainable: it is urgent to begin with prevention programmes. Placing preventive care at the heart of health systems is of paramount importance. Advances in understanding of health risk factors and design of effective interventions to prevent ill health are the way forward. Measuring and evaluating the quality of prevention strategies is important in order to gain a better understanding of their mechanisms of action and potential benefits and risks; to measure their impact and appropriateness; and to monitor their relevance in terms of tackling health inequalities [2].

In consideration of the above, PEGASO [3] is an FP7 project funded by the EU that tackles prevention focusing on obesity and related co-morbidities, in which lifestyle coaching could play a very important prevention role, such as by developing a platform that - leveraging mobile and ICT technologies and through wearable sensors platforms - supports young people to become aware of risks and motivated them in a behaviour change path towards healthy lifestyles.

1.2. Pegaso Fit for Future: Goals and Approach

The aim of PEGASO Fit for Future is to develop a multi-dimensional and cross-disciplinary ICT system – the PEGASO Behaviour Change Platform - that includes game mechanics to influence

behaviours in order to fight and prevent overweight and obesity in the younger population by encouraging them to become co-producers of their wellness and take an active role in improving it.

In order to achieve this, PEGASO Fit for Future is centred on three lines of actions: (1) the generation of self-awareness and acknowledgement of risks associated to unhealthy behaviours; (2) enhancing and sustaining motivation to take care of health with a short/medium and long-term perspective; and (3) changing behaviour towards a healthy lifestyle based on healthy diet and adequate physical activity.

PEGASO gives guidance towards developing good habits and provides a social platform to stimulate young people's willingness to engage actively in their health management.

Indeed, lifestyle monitoring solutions [4] and their integration into smart clothing and wearable accessories have emerged as ICT solutions, able to capitalize on the latest advances in sensing, signal analysis and communications. This has generated a number of commercial products and experimental prototypes, demonstrating the important advances achieved in the underlying enabling ICT technologies. Nowadays wearable sensors and smart textile becomes key elements of lifestyle coaching service in an ecologic monitoring setting for a single user responsive system. Nevertheless, the available commercial products offer limited functionality and accuracy to represent reliable monitoring solutions, while experimental prototypes are obstructive, conspicuous, requiring skilled users, or only applying to specific populations. In both cases a step forward has to be done to fulfil the mobility and ergonomic requirements crucial for their public acceptation and commercial exploitation.

This paper provides the result of the first phase of experimental activities conducted with teenagers, focusing on the results and feedback gathered with regard to the use of wearable sensors systems. The challenge of PEGASO, adopting a User Centred Methodology [5], is to ensure that the system meets the requirements of the users. The approach is useful to motivate and engage users, which is an essential requirement for systems' acceptance and efficacy rather than forcing to accommodate technologies, products, or services. It should be underlined that PEGASO, as tool for prevention is addressed also to healthy people. Recruitment of teenagers will be done through schools, focusing on fostering communities of interest (i.e. all students in a class), rather than students with identified risk factors.

2. Experimental Section

2.1. Pegaso Goals and Approach

Individual monitoring represents a crucial point for PEGASO success. Wearable Sensors will be used to collect data about teenagers' physical and behavioural habits. The aim of the project is to allow users to be more and more independent and self-conscious in monitoring their activities and put them into relationship with their lifestyles, in terms of increasing their attitude to movement and correct nutrition.

A Wearable Device, such as a bracelet or a shirt embedding smart textiles, allows a continuous monitoring of the physiological parameters in an unobtrusive and comfortable way. Sensors usually measure movements (by means of 3-axial accelerometers) and physiological parameters (e.g., hearth rate, respiration rate, temperature and oxygen in blood).

Some statistics affirm that there is a lack of utilization of these products, specially sports and activity monitors, close to six month of use. For this particular reason, a point scheduled to be developed in PEGASO is to strengthen acceptance and continuous use of the wearable devices by the users. That is important to make healthy habits inducted by the use of the devices durable. This acceptance could be

reached involving the users since the beginning of the devices development, using a User Centred Approach. To enhance the acceptance of new devices, combined with the healthy habits that PEGASO Project promotes, we cooperated with potential users in the design and development of devices and technologies, pointing out on the features and functional advantages that the system offers.

2.2. Methods

The PEGASO User Centred approach is aimed at involving the end–user in the early stage of development of the entire platform. The use of a co-design activity represents an important step in this approach because by making the final user actively participate into the design process the final acceptance and compliance of the system have more success and value.

Since the beginning of PEGASO Project, teens were involved through several focus groups, to elicit and understand their opinion about health, the importance of healthy and active lifestyle, the use of mobile and social media for health purposes and the monitoring of their activities and physiological parameters through wearable devices. These focus groups were conducted in Italy, Spain, and UK.

Table 1. Focus Group participants in each country.

	Participants (Male and Female Aged Between 13 and 17)		
	Italy	**Spain**	**United Kingdom**
Phase 1	75	28	45
Phase 2	27	30	14
Phase 3	66	28	94

Focus Groups were methodologically organized into three phases. During the First Phase of Focus group, PEGASO Project has been presented to teens, investigating their awareness about its main topics, e.g. the use of technology for health purposes.

The Second Phase was addressed to the exploration of sensors and wearable technologies for health management. Each participant tested one Life tracker for one week.

Figure 1. Sample of PEGASO Smart Garments: on the left, the Visible Sensor line, on the left, the Hidden Sensor line.

The goal of this focus was to collect participants' opinions about the use of wearable sensors and their features. In addition, some design samples of PEGASO Garments (two sport t-shirt and two sport bras) were provided, to investigate the most important features that the teenagers consider relevant to improve the wearables acceptance. Two different samples of garments were presented: one characterized by visible sensors, the other one by hidden sensors. The "Visible Sensor Line" was made of "Kinetech Woven", in order to be comfortable and guarantee the skin perspiration. "Kinetech Woven" is a patented technic woven, used for professional sport activities. The "Hidden Sensor Line" was made of jersey cotton, in order to look like everyday garments. The device was hidden thanks to a pocket placed on the chest. Two textiles electrodes are embedded in both the Smart Garments Lines, to record I-lead ECG signal, respiration and movements. These electrodes are made of silver based yarn, and placed on the chest. The Smart Garments are connected with the electronic wearable device by means of two snap buttons.

In the Third Phase, we provided users with a co-design template, asking them to sketch the new PEGASO Smart Garments. We gave some guidelines and suggestions, related to materials or colours to be used or to the sensors' positioning, to let them design t-shirts, bras or vests.

Figure 2. PEGASO Co-Design Template – "The rules of the game".

3. Results and Discussion

All the participants demonstrated a great interest in wearable sensors, considering them comfortable and useful for the monitoring of their lifestyle. Some of them said that they would prefer to use these garments only during exercise, not during the entire day in place of their clothes (*"If I wanted something in my clothes I would rather wear a wristband that is more discrete).* They demonstrated interest for garments' price, their availability on the market, and information about design, materials and colors. They were very interested on collected data, detected using these garments, especially during their sport activity, to detect their improvement. Another strong point was represented by the comfort in use of the garments, compared with bracelets. This is due to the embedded smart textile. Users said they will be allowed to use these garments playing sports (e.g., during the volleyball training sessions they can't wear anything like bracelets or necklaces but they are allowed to wear smart garments).

As result of the third Focus Group, teens gave feedbacks on the garments' features and some sketches. They had to choose among some templates of t-shirts, bras and vests and to design their favorite one. As the previous phases, there were no unanimity on the sensor placement: some of them preferred the visible one, the others the hidden one. They would prefer light and technical fabrics, like

the ones already used for sport clothes. Users were very interested in the monitoring features but they take the garments' design into highly consideration, recommending us to collaborate with fashion designers. Aesthetics of PEGASO system drives its acceptability.

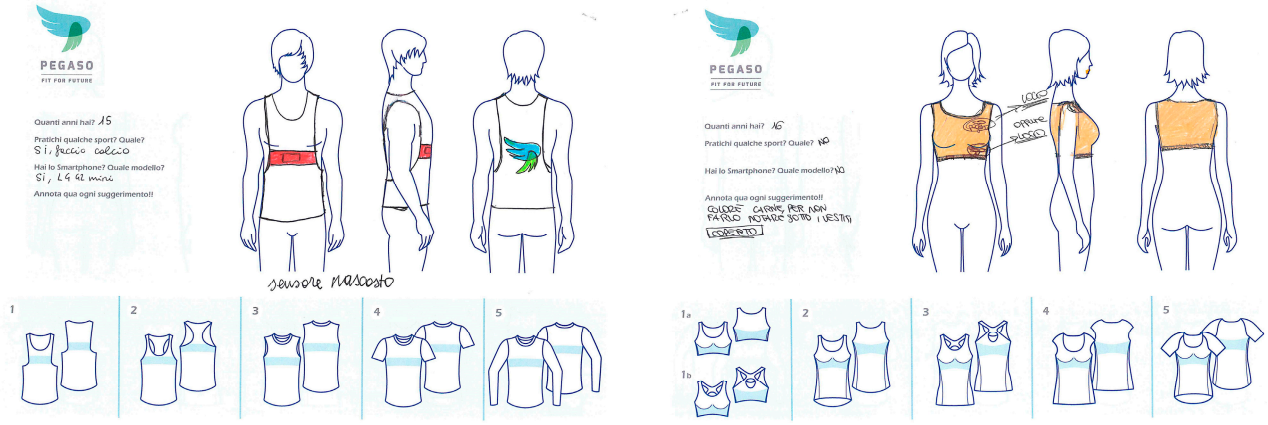

Figure 3. PEGASO Co-Design Template – Samples of Users' sketches.

4. Conclusions

Activity trackers life's shortness is a common topic in literature and, in particular, the phenomenon is particularly widespread among teens. As a matter of fact, teens revealed to be interested in monitoring oneself activity and in wearing smart clothes: so the importance to foster design by involving the category in the process. Designing devices answering their desiderata really is the challenge, and the afore-mentioned involvement is the key.

The PEGASO framework will be validated by secondary school students. Four validation studies will be carried out in Italy (Lombardy), Spain (Catalonia) and United Kingdom (England/Scotland), involving about 400 students. The validation of the PEGASO platform will assess the following factors:

System and Technology acceptance, usability and long-term use: these will be also a secondary assessment of motivation and engagement;

Reliability in assessing the teen-agers lifestyles and their changes (with focus on the eating habits and on physical activities) related efficacy on the sensors' network system;

Efficacy of the system in encouraging lifestyle change.

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Conflicts of Interest

The authors declare no conflict of interest.

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