Towards Individualised Persuasive Technology for Obesity Prevention in Teenagers

Claudio L. Lafortuna[1], Maurizio Caon[2], Sarah A. Tabozzi[1], Stefano Carrino[2], Neil S. Coulson[3], José C. E. Serrano[4], Marco Sacco[5], Omar Abou Khaled[2], Giovanna Rizzo[1] and Elena Mugellini[2]

[1]Istituto di Bioimmagini e Fisiologia Molecolare, Consiglio Nazionale delle Ricerche, via Cervi 93, Segrate Milano, Italy
[2] HumanTech, Haute Ecole Spécialisée de Suisse Occidentale, Bd de Perolles 80, Fribourg, Switzerland
[3]Division of Rehabilitation and Ageing, University of Nottingham, Queen's Medical Centre, Nottingham NG7 2UH, U.K.
[4]NUTREN-Nutrigenomics, Dept Medicinal Experimental, Universidad de Lleida, Montserrat Roig, 2 – 25008 Lleida, Spain
[5]Istituto di Tecnologie Industriali ed Automazione, Consiglio Nazionale delle Ricerche, Via Bassini 15, Milano, Italy

Keywords: Virtual Individual Model, Persuasive Technology, Obesity Prevention.

Abstract: Obesity is a major clinical problem for individuals and health care systems worldwide, alarmingly fuelled by body mass excess in the juvenile age. In spite of its multi-factorial origin, unhealthy lifestyles relative to alimentary behaviours and physical activity habits play a major causative role. Thus, an important preventive action of this condition can be conducted by fostering motivation of young people towards healthy lifestyles through engagement and inclusion. ICT technologies offer a powerful tool to address effectively this serious medical and societal issue by the development of persuasive strategies based on an accurate modelling of individual's characteristics. PEGASO is a technological multidisciplinary project aimed at promoting healthy lifestyles among teenagers, through assistive technology enhancing motivation to healthy lifestyles, empowered by a virtual individual model (VIM) for user characterisation. The VIM intended for the PEGASO project, including functional, physical and psychosocial aspects profiling young individuals' health status and behaviours relevant in alimentary and physical activity domain, will enable the development of an individualised assistive technology expected to leverage motivation to healthy lifestyles through implicit and explicit interaction.

1 INTRODUCTION

Obesity is a major public health challenge at all ages in developed countries. According to the 2007 report of EU Public Health Programme Project "Global Report on the Status of Health in the European Union - EUGLOREH" (EUGLOREH, 2007), across the entire EU, overweight affects almost 1 out of 4 school age children/adolescents, in particular. This number is likely to increase by more than 400,000 children a year.

Moreover, juvenile obesity is associated with a number of serious medical conditions and can lead to increased rates of non-communicable disease in adulthood, such as cerebro-vascular disease, diabetes, certain types of cancer, osteoarthritis, gall bladder, endocrine disorders and premature death, in relation with the high probability for obese children

to become obese adults; it is also recognized that being overweight/obesity in young peole carries within it a range of psycho-social consequences including low self-esteem, depression and social exclusion, all resulting in sizable economic impact on health care and social systems (Speiser et al., 2005) (Dent, 2010) (Trasande and Chatterjee, 2009).

From the literature it emerges that although also for the juvenile age the cause of body mass excess is multifactorial, including for a small portion genetic background and neuroendocrine status, in the greatest majority behavioural aspects related to lifestyle and diet play an important causative role, with a relevant interference of socioeconomic factors (Speiser et al., 2005) (World Health Organization, 2000) (Commission of European Community, 2005). Therefore, in order to undertake an effective action of prevention of the condition of

body mass excess, it is necessary to intervene on adolescents' behaviour, through education and engagement, to enhance motivation towards healthy diet and active lifestyle.

Thanks to the large diffusion and development of ICT, time is ripe for a major employment of persuasive technology to cope with healthcare challenges. PEGASO is a technological project aimed at promoting healthy lifestyles among teenagers, through assistive technology fostering motivation, enhanced by a virtual model of individual's characteristics related to health (PEGASO, 2013). The adoption of a Virtual Individual Model (VIM) including functional, physical and psychosocial aspects characterizing individual's health status and relevant behaviours, will lead to a more individualised strategy for the enhancement of motivation to engage in healthy lifestyles, particularly with regards physical exercise and dietary behaviour.

2 STATE OF THE ART

The deeper understanding recently achieved about the biology of human being, introduces the idea of the individual as a unique multiple organ system, overtaking the traditional approach –in force in medical practice- of the human body as a set of independent sections Indeed most of the major diseases affecting world population, one for all obesity, are recognized to have multi-factorial causation, spanning from physical to mental and social factors (World Health Organization, 2000). Thereof derives that in order to efficiently act on complex health conditions it is necessary to analyse the interaction of all the factors involved in that phenomenon, with in mind that the more information is provided, the more personalised and exact the intended actions will be.

These premises led to the outline of the Virtual Physiological Human (VPH), a methodological and technological framework for integrated modelling of a living human body (Fenner et al., 2008). Funded by European Commission, the initiative hosted the development of several projects in the recent years, focused on the modelling of different human body functions incorporating cross-disciplinary knowledge from biochemistry, biophysics and anatomy of cells, tissues and organs.

The models allowed by this framework collect the results of multiple observations on organism's functionalities, disseminate them among experts from multiple scientific disciplines to build a

collaborative analysis and develop systemic hypotheses, and finally interconnect integrated data in models that consolidate the original hypotheses.

The models so far realised in the context of VPH concern different functional specialisms, including projects in the cardiovascular, respiratory, neurological, immunological and oncological domains, which exploit the current knowledge about physiological and pathological mechanisms finalised to medical practice and/or tutorial simulation.

The many projects stemming from the framework of VPH are substantially aimed at describing the interaction of all the physiological components of individuals - referred to as Physiome -, from molecular to apparatus level. This systemic approach inherent in VPH modelling conforms to the holistic approach in the study of body function, supplying the view of the body as a single multi organ system.

However, such a holistic architecture of the many projects, modelling physiology and pathology of the different body functions to converge into the Physiome solution, substantially describes the human being from the perspective of biological relations without accounting for the behavioural and social externalities, which may interfere with and determine the biological balance of functions in health and disease.

By contrast, the PEGASO VIM aims to include in individual's characterisation, both biological specifications and relevantly related behaviour factors spanning from the physical domain of body structure to physiological description of functional interaction, and psychosocial determinants of health specifically involved in alimentary and physical activity behaviours in young people.

VIM could be used as a robust support for tailoring the computer-based multi-level persuasive interventions. From this point of view in computer science, research communities in the persuasive technology domain have taken the first steps towards exploiting mobile and wearable technologies, which can gather data about the user's activity and behaviour in a real-time and long-term fashion, for the purposes of developing tailored systems in order to deal with obesity as a significant health-related issue (Arteaga et al. 2009). In addition, based on their wearability, these devices can be used for active encouragement towards a healthier lifestyle (Valentin and Howard, 2013). Several studies demonstrate that a crucial aspect in the realization of such a system is to design appealing applications for the final users (Read et al., 2011), in this case young people.
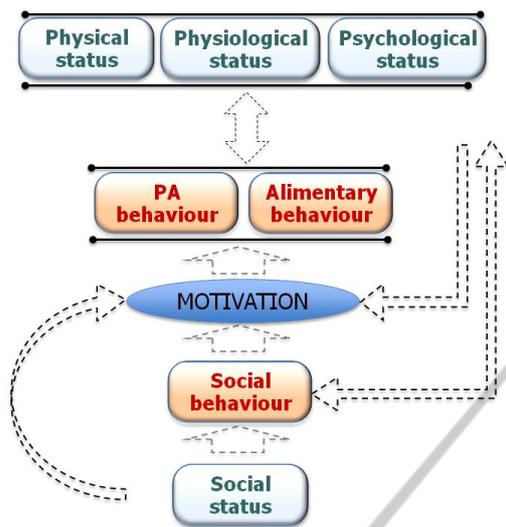
Figure 1 - The PEGASO virtual individual model assumes that health status is primarily settled on elements of physical status, physiological status and psychological status. Body structure and functionality are influenced by the individual's behaviours in the domains of alimentation and physical activity (PA), which are driven by relevant aspects of motivation. Social status, social behaviour and psychological status (i.e. the psychosocial factors) are considered as important determinants of motivation to engage in healthy lifestyle behaviours. Stippled arrows denote the presumptive relations among the model's element which will be defined in the project.

Coupling of multi-domain VIM and persuasive technology should represent a successful approach to the user, for adolescents' engagement in behaviours preventing overweight and obesity (such as healthy food and active life), starting from the quantitative description of relevant individual's aspects.

3 VIRTUAL INDIVIDUAL MODEL

The PEGASO VIM depicted in **Figure 1** points to integrating biological aspects of human functioning with lifestyle behaviours and psychosocial externalities that are relevant for the
development of overweight and obesity conditions, especially in young people. PEGASO VIM is based on the concept of the human body as a single complex system, which already empowers the several projects referring to VPH, funded by the European Commission in the recent years (Fenner et al., 2008).
As shown in **Figure 1**, PEGASO VIM considers

an individual's health as resulting from the balance between physical, mental and social well-being, according to the World Health Organisation founding definition (World Health Organization, 1948), so that Health Status in the model is the product of Physical, Functional and Psychological Status. The elements characterising Physical Status will be identified among the indicators of body adiposity and risk factors for the development of the disease conditions related to overweight and obesity, as interpreted on the basis of standard reference values (Dulloo et al., 2010). Similarly, parameters relevant for the profiling of Functional Status will be identified from evidence based literature accounting for the metabolic derangements, which derive from body mass excess (Zhu et al., 2003). Factors determining the individual's exercise capacity which are influenced by body mass excess and associated conditions will be accounted as well (Lafortuna, 2013).

According to collective views of international groups of experts (World Health Organization, 2000) (Commission of European Community, 2005), the role of lifestyles as determinants of conditions such as overweight and obesity has been thoroughly evidenced, with particular focus to juvenile age. Studies using motion sensors have shown that children who spend less time in physical activity are at higher risk of becoming obese during childhood and adolescence. Television and video games have contributed to more sedentary leisure activities and are associated with the consumption of energy-dense snacks and beverages, as well as encouraging inappropriate food choices which are attributable to television advertising. There is, in fact, a positive correlation between hours of television viewing and being overweight, especially in older children and adolescents, regardless of their levels of physical activity (Rey-Lopez et al., 2011). In fact, the findings from the 2009/2010 survey in EU countries from Health Behaviour in School-aged Children (HBSC) international report indicate that young people who are overweight/obese are more likely to exhibit unhealthy alimentary patterns, are less physically active and watch television more, an increased prevalence of being overweight/obesity is also significantly associated with low family affluence (Currie et al., 2012). Therefore, the PEAGASO VIM will identify parameters permitting the characterisation of Alimentary and Physical Activity Behaviours expected to have a direct influence on both Physical and Functional Status.

A central issue in the development of VIM will concern the specification of the psychosocial factors
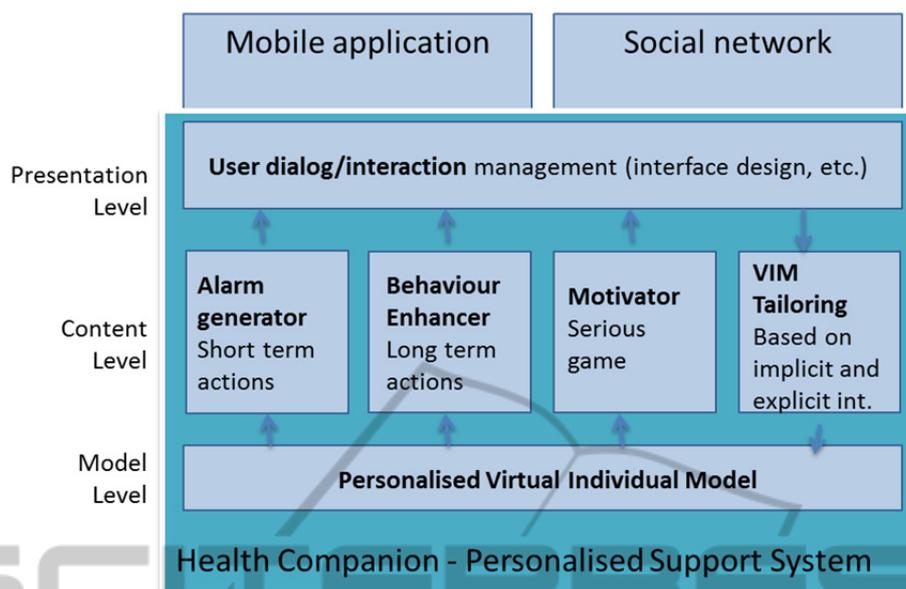
Figure 2 - Automatic system architecture.

impacting upon young people's motivation to engage in healthy alimentary behaviour and active lifestyles, which are a major determinant of the Health Status. These factors have been shown to be significantly associated with biomedical factors in the genesis of body mass excess especially in children and adolescents (Currie et al., 2012) (Mikolajczyk and Richter, 2008) and obesity carries with it a number of important psychosocial consequences (Dent, 2010) (Trasande and Chatterjee, 2009) (Gortmaker et al., 1993). For example, body mass excess in children/adolescents is associated with low self-esteem, depression and social exclusion, with immediate consequences in the psychological and social domain, possibly leading also to concurrent or subsequent psychiatric pathology. Specifically, social exclusion in childhood has been associated with reduced psychological functioning in adulthood, with an expectation of lower educational attainment, less money earning, experiencing higher rates of poverty and having a lower likelihood of marriage (Gortmaker et al., 1993). Thus, profiling of Social Status and Social Behaviour along with Psychological Status will be an important task in VIM building during PEGASO project, in view of the critical role played by these elements for the characterisation of motivation to healthy behaviours. Addressing the psychosocial determinants and influences on these behaviours from a range of domains (including cognitive, interpersonal, familial, environmental) will in fact provide the conceptual background for the development of the assistive technology expected to foster lifestyles preventing body mass excess in younger people.

4 AUTOMATIC SYSTEM BASED ON PERSUASIVE TECHNOLOGY

The multi-parametric PEGASO VIM is integrated in an automatic system that helps experts in monitoring users' behaviour, and in tailoring system functionalities. Smartphones and wearable devices are responsible for interacting with the teenagers.

4.1 Architecture

The main components and their mutual relations forming the automatic system architecture are presented in **Figure 2**. The architecture is structured in three levels: model, content and presentation.

1. *Model level:* is the base of the whole system and contains the contribution brought by VIM, translated into ontological form. The information about the user, collected through the explicit and implicit interaction of the individual with the system, is entered into the generic VIM, and processed to structure the Personalised Virtual Individual Model (PVIM).

2. *Content level:* couples the user information contained in PVIM with the system's content, for

shaping the intervention. It is also the means by which the PVIM is updated. It contains four blocks

- the **alarm generator block** provides instant suggestions for short-term actions (e.g., "*walk until the next bus station while going to school*");
- the **behaviour enhancer block** aims at encouraging long term changes in the user behaviour, such as practicing physical activity more regularly;
- the **motivator block** processes PVIM information to adapt the task presented to the user in the context of a serious game;
- finally, the **VIM tailoring block** analyses the feedback resulting from implicit and explicit interaction of the user with the system to continuously adapt the PVIM (see section 5 for a detailed explanation).

3. *Presentation level:* represents the system interface to the user and manages dialogue and interaction tasks.

One of the main advantages offered by the inclusion of VIM in this architecture is the possibility to personalize the model based on the individual behaviour and behavioural changes: on one hand, based on the VIM as fundamental element of its architecture, the system provides different types of information to the user: alarms, games, long terms actions, etc.; on the other hand, information acquired from the user is continuously used to update the PVIM.

4.2 Tailoring

Tailoring is the process by which the automatic system dynamically tracks the changes in user parameters and, through the use of reinforcement learning algorithms, allows the detection of users' preferences concerning the favourite and most effective intervention strategies.

Indeed, VIM tailoring has, as direct outcome, the modification in the execution of actions planned in the *content level* (alarm generator, behaviour enhancer, and motivator blocks).

The tailoring is taken into account along different axes and with different approaches:
- Personal axis
- Sociocultural axis
- Temporal axis

The **personal axis** uses the three aspects of the VIM (functional, physical and psychosocial) to understand and adapt the therein knowledge to the user. For example, a PVIM describing a user performing physical activity in an irregular fashion can encourage the user to regularize his/her activity; in contrast, users scarcely inclined to physical exercise might be compensatively encouraged to healthy eating. The previous simple scenarios show how the PVIM can affect the type of feedback provided to the user.

The European dimension of our study will allow us to take into account also the different ethnological specificities impacting on adolescents' lifestyle. This will open the possibility to define the **socio-cultural axis** of our tailoring approach. During the PEGASO project, three pilots in different countries will take place (Italy, Spain and United Kingdom). These pilots will allow us to examine the cultural differences that may impact on teenagers' lifestyle and to adapt the VIM accordingly. Unlike the personal axis, the socio-cultural tailoring is a static process.

Finally, the **temporal axis** will take into account the evolution of the user behaviour over time. The goal of this analysis is twofold. *Firstly*, it will be possible to associate particular events to the teenager lifestyle. For example, we can associate eating habits and stressful events (such as those related with demanding school duties) or to a specific period of the year (summer or winter vacations). Combining this information with the personal axis will also allow us to explore how the social life of the user influences such habits. For example, the system should be able to understand if the user engages in healthier dietary practices when eating alone or with peers. *Secondly*, the temporal axes will allow analysing the response of the user to the system clues.

The temporal and the personal axes will evolve with the system and the continuous interaction with the user. The adaptation of the PVIM is, therefore, performed dynamically. Machine learning approaches will use the dynamical information about the user to adapt such model. Such valued information is provided by mobile and wearable technologies as presented in the next paragraph.

4.3 Mobile and Wearable Technologies

Nowadays, smartphones and other wearable devices have promising sensing and processing capabilities, also based on the integration of different sensors with mobile functionalities.

The wearability of sensor devices permits us to gather data about the user's activity and behaviour in a real-time, long-term fashion (Martín, et al., 2013).

If compared with classical approaches, based on sporadic clinical testing, our approach has well defined advantages. In particular, while real-time information can be exploited to conceive instant feedback to the user, long-term data can be integrated with conventional information more sporadically acquired in a clinical setting thus leading to a more precise estimation of the overall trends concerning physical and functional conditions, as well as about changes in behaviour liable to influence the health status.

In addition, due to the intrinsic possibility to be always-on and always-connected, smartphones have the potentiality to become the most appropriate technological companion (Siewiorek, 2012). Wearable and mobile technologies allow also developing pervasive applications, such as pervasive games, which "are no longer confined to the virtual domain of the computer, but integrate the physical and social aspects of the real world" (Magerkurth et al. 2005). That means that users can interact and play while moving freely in the real world, thus fostering physical activity. This concept created a rift with the traditional concept of playing games that usually confined the players on their chairs in their rooms.

Moreover, such devices can also be used to anonymously gather information about the everyday life context of the users (such as social habits, meal frequency, exercise volume and modality). By gathering these apparently independent data, it is also possible to obtain information about the relationship between different parameters of the VIM model, (e.g., to evaluate if and how the social context interferes with the user's alimentary habits or physical activity behaviours)

However, sensors are not the only source of information in the PEGASO system. In particular, a direct interaction of the user with the system will gain further information to better refine PVIM as explained in the next section.

5 INTERACTION

In the traditional approaches of human-computer interaction research, user modelling was a well-known approach for the design of a usable interface (Fischer, 2001). In PEGASO, the automatic system will integrate a VIM that does not aim at only improving the usability but that will enable the system to choose the best motivational mechanisms for an effective intervention on the users' life style. The system aims at providing personalised interventions that take into account the user's individual characteristics in order to obtain the greatest effectiveness. The VIM characterizes the user's nutritional habits, physiological status, and socio-psychological status to provide personalised motivational mechanisms to help the adoption of a healthy life-style. Obviously, the interaction between the system and the user plays a crucial role in the tailoring process described in the previous section. In fact, the reinforcement learning algorithm needs the user's feedback in order to provide the best personalised motivational mechanisms. Two kinds of user's feedback exist: implicit and explicit.

5.1 Implicit Interaction

Albrecht Schmidt formalised the concept of implicit interaction and provided its definition: the implicit human-computer interaction is "an action performed by the user that is not primarily aimed to interact with a computerised system but which such a system understands as input" (Schmidt, 2000). The mobile and wearable technologies can sense the user's activity in an unobtrusive way. The sensors that will be integrated in mobile devices and in clothes will collect information while the user is wearing them. The user can be monitored during his/her everyday activity and the personal parameters present in the VIM can be dynamically updated in order to adapt the system also when the user's habits change. The sensed data are used to interpret the user's activities and personal behavioural trends, especially about the nutritional habits and physical exercise.

The implicit interaction is based on the activity recognition and context-awareness (Lukowicz et al., 2010). In fact, not only the activity is important but also the context where it is performed acquires a very important value for choice of the opportune motivational mechanism. Knowing that a user is not doing his/her regular physical exercise in the fixed time should trigger a memorandum message on the user's mobile; but if the GPS localizes the user in another city or country, the system can interpret this as the user being on holidays and can avoid the message since it could be perceived as annoying. Moreover, the behavioural trends recognition allows the system to recognize whether the selected mechanisms actually influenced the user's behaviour.

5.2 Explicit Interaction

Users perceive smartphones as personal life companions (Siewiorek, 2012). For this reason, the

PEGASO system will focus the explicit interaction through the smartphone. The explicit interaction is the conscious command and information that the user gives to the system. This is important for many reasons. For example, when the system provides a message to the user, he/she has also the possibility to communicate directly with his/her companion; in particular, the user can show to the companion whether the message and its content have been appreciated or not. The explicit interaction can be performed through gestures. One gesture expresses the appreciation of the feedback (like caressing the smartphone), another one the dislike (like tapping it twice). In this way the system can learn how to provide the best personal message possible thanks to the context information and the monitored activity. In this way, the system can adapt not only the content of the message, but it can choose the best moment and the best modality thanks to a context aware reasoning engine.

The feedback provided by the user is important for the modelling of tailored interventions and to make the information personally relevant. In fact, research has demonstrated that computer-tailored health education is more effective in motivating people to make dietary changes (Brug et al., 2003) and to promote physical exercise (den Akker et al., 2011). The motivational mechanisms will be of different types. For example, there will be interventions for short-term efficacy as alarm messages proposed by the companion when the user is eating something unhealthy or forget to take physical exercise. Other long-term mechanisms aim at changing the user behaviour through serious gaming and the implication of the social community, e.g., friends and family (Johnston et al. 2011).

6 CONCLUSIONS

In this paper, we presented the concept of PEGASO Virtual Individual Model designed for individualised persuasive technology for obesity prevention in teenagers.

The adoption of a Virtual Individual Model (VIM) including functional, physical and psychosocial aspects allows the development of a more individualised strategy for the enhancement of healthy lifestyles through increasing motivation. The PEGASO VIM considers an individual's health as resulting from the balance among physical, mental and social well-being.

For the twofold goal of encouraging and monitoring the teenager activity, we chose to adopt

mobile and wearable technologies. PEGASO aims at increasing the encouragement of healthier behaviours through the use of a tailored ensemble of alerts, serious games applications developed following a gamification approach.

The presented automatic system will interact with the user providing implicit and explicit interactions. The first approach, which is activity-driven, does not require an active participation facilitating the gathering of significant quantity of data over a long period of time since it does not annoy the user. The second approach takes into account the direct, conscious interaction between the user and the system. On the one hand, explicit interaction allows retrieving information that is not possible to interpret through the mere sensing; on the other hand, it allows a direct connection with the user that, thanks to a tailored interaction, can establish an emotional relationship with the companion.

ACKNOWLEDGEMENTS

REFERENCES

Arteaga, S., M., Kudeki M, and Woodworth, A.. 2009. Combating obesity trends in teenagers through persuasive mobile technology. *SIGACCESS Access. Comput.* 94 (June 2009), 17-25.

Brug, J., Oenema, A., and Campbell, M., 2003. Past, present, and future of computer-tailored nutrition education.. *Am. J. Clin. Nutr., vol. 77, no. 4 Suppl, p. 1028S–1034S.*

Commission of European Community, 2005. Green Paper - Promoting healthy diets and physical activity: a European dimension for the prevention of overweight, obesity and chronic diseases. COM(2005) 637, Brussels, December 2005.

Currie, C., Zanotti, C., Morgan, A., Currie, D., de Looze, M., Roberts, C., Samdal, O., Smith, O.R.F., Barnekow, V., 2012. Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: international report from the 2009/2010 survey. *Copenhagen, WHO Regional Office for Europe, 2012 (Health Policy for Children and Adolescents, No. 6).*

den Akker, H.O., Moualed, L.S., Jones, V.M., and Hermens, H.J., 2011. A self- learning personalized feedback agent for motivating physical activity," *In Proc. 4th Int. Symp. Appl. Sci. Biomed. Commun. Technol. - ISABEL '11, pp. 1– 5.*

Dent, M., 2010. The economic burden of obesity. Oxford: National Obesity Observatory.

Dulloo, A.G., Jacquet, J., Solinas, G., Montani, J.P., Schutz, Y., 2010. Body composition phenotypes in pathways to obesity and the metabolic syndrome. *Int J Obes (Lond). 2010; 34 Suppl 2: S4-17.*

EUGLOREH 2007 project The Status of Health in the European Union: Towards a Healthier Europe, available at: http://euglorehcd.eulogos.it.

Fenner, J.W., Brook, B., Clapworthy, G., Convey, P.V., Feipel, V., Gregersen, H., Hose, D.R., Khol, P., Lawford, P., McCormack, K.M., Pinney, D., Thomas, S.R., Van Sint Jan, S., Waters, S., Viceconti, M., 2008. *The EuroPhysiome, STEP and a roadmap for the virtual physiological human. Phil Trans R Soc A. 2008; 366: 2979–2999.*

Fischer, G., 2001. User modeling in human–computer interaction. *User modeling and user-adapted interaction 11, no. 1-2: 65-86.*

Gortmaker, S.L., Must, A., Perrin, J.M., Sobol, A.M., Dietz, W.H., 1993. Social and economic consequences of overweight in adolescence and young adulthood. *N Engl J Med. 1993; 329: 1008-1012.*

Johnston, H., Whitehead, A., Pose presentation for a dance-based massively multiplayer online exergame. In: *Entertainment Computing*, Volume 2, Issue 2, 2011, Pages 89-96, ISSN 1875-9521.

Lafortuna, C.L., 2013. Physiological Bases of Physical Limitations During Exercise. *In: Disabling Obesity - From Determinants to Health Care Models, Capodaglio P, Faintuch J, Liuzzi A, eds., Springer-Verlag, Heidelberg, 2013, pp. 21-38.*

Lukowicz, P., Amft, O., Roggen, D., and Cheng, J., 2010. On-Body Sensing: From Gesture-Based Input to Activity-Driven Interaction. *Computer, vol. 43, no. 10, pp. 92–96.*

Magerkurth, C., Cheok, A. D., Mandryk, R. L. and Nilsen, T., 2005. Pervasive games. Computers in Entertainment, vol. 3, no. 3, p. 4.

Martín, H., Bernardos, A.M., Iglesias, J., Casar, J.R. 2013. Activity logging using lightweight classification techniques in mobile devices. *Personal Ubiquitous Comput.* 17, 4 (April 2013), 675-695.

Mikolajczyk, R.T., Richter, M., 2008. Associations of behavioural, psychosocial and socioeconomic factors with over- and underweight among German adolescents. *Int J Public Health. 2008; 53: 214-220.*

PEGASO - PErsonalised GuidAnce Services for Optimising lifestyle management in teenagers through awareness, motivation and engagement, FP7-ICT-2013-10, Grant Agreement 610727.

Read, J., Fitton, D., Cowan, B., Beale, R., Guo, Y., and Horton, M. 2011. Understanding and designing cool technologies for teenagers. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems*

(CHI EA '11). ACM, New York, NY, USA, 1567-1572.

Rey-López, J.P., Vicente-Rodríguez, G., Répásy, J., Mesana, M.I., Ruiz, J.R., Ortega, F.B., Kafatos, A., Huybrechts, I., Cuenca-García, M., León, J.F., González-Gross, M., Sjöström, M., de Bourdeaudhuij, I., Moreno, L.A., 2011. Food and drink intake during television viewing in adolescents: the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Public Health Nutr. 2011; 14: 1563-1569.*

Schmidt, A., 2000. Implicit human computer interaction through context. *Pers. Technol., vol. 4, no. 2–3, pp. 191–199.*

Siewiorek, D., 2012. Generation smartphone. *IEEE Spectr., vol. 49, no. 9, pp. 54–58.*

Speiser, P.W., Rudolf, M.C.J., Anhalt, H., Camacho-Hubner, C., Chiarelli, F., Eliakim, A., et al., 2005. Consensus statement: childhood obesity. *J Clin Endocrinol Metab*; 90:1871-87.

Trasande, L., Chatterjee, S., 2009. The impact of obesity on health service utilization and costs in childhood. Obesity. (Silver Spring). 2009; 17: 1749-1754.

Valentin, G.; Howard, A.M., 2013, Dealing with childhood obesity: Passive versus active activity monitoring approaches for engaging individuals in exercise, *Biosignals and Biorobotics Conference (BRC), 2013 ISSNIP* , vol., no., pp.1,5, 18-20 Feb. 2013.

World Health Organization, 1948. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.

World Health Organization, 2000. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation. WHO Technical Report Series no. 894. WHO: Geneva, 2000.

Zhu, S., Wang, Z., Shen, W., Heymsfield, S.B., Heshka, S., 2003. Percentage body fat ranges associated with metabolic syndrome risk: results based on the third National Health and Nutrition Examination Survey (1988-1994). *Am J Clin Nutr. 2003; 78: 228-235.*