CoviHealth: Novel approach of a mobile application for nutrition and physical activity management for teenagers

María Vanessa Villasana
maria.vanessa.villasana.abreu@ubi.pt
Faculty of Health Sciences
Universidade da Beira Interior
Covilhã, Portugal

Ivan Miguel Pires
impires@it.ubi.pt
Instituto de Telecomunicações
Universidade da Beira Interior
Covilhã, Portugal

Juliana Sá
julianasa@fcsaude.ubi.pt
Faculty of Health Sciences
Universidade da Beira Interior
Covilhã, Portugal Hospital Center of Cova da Beira
Covilhã, Portugal

Nuno M. Garcia
ngarcia@di.ubi.pt
Instituto de Telecomunicações
Universidade da Beira Interior
Covilhã, Portugal

Nuno Pombo
ngpombo@di.ubi.pt
Instituto de Telecomunicações
Universidade da Beira Interior
Covilhã, Portugal

Eftim Zdravevski
eftim.zdravevski@finki.ukim.mk
Faculty of Computer Science and Engineering
Ss Cyril and Methodius University
Skopje, North Macedonia

Ivan Chorbev
ivan.chorbev@finki.ukim.mk
Faculty of Computer Science and Engineering
Ss Cyril and Methodius University
Skopje, North Macedonia

ABSTRACT

The increasing number of teenagers with obesity and sedentary lifestyle is related to the poor habits of diet and physical activity. There is a large diversity of mobile applications related to diet control and physical activity, mainly directed to adults and without any medical control. *CoviHealth* project consists of the implementation of a mobile application for young people to promote healthy dietary habits and physical activity based on anthropometric parameters control and gamification. The main contribution of this paper is a detailed specification of an integrated mobile for promoting healthy habits for young people. Additionally, it leverages the effects of the gamification and medical control on stimulating education with healthy habits. Even though other mobile applications have some features that the proposed application has, to the best of our knowledge, a standardized specification for the integration of activity recognition, healthy habits and food intake for teenagers lacks.

GoodTechs '19, September 25–27, 2019, Valencia, Spain

ACM ISBN 978-1-4503-6261-0/19/09…$15.00
https://doi.org/10.1145/3342428.3342657

CCS CONCEPTS

• **Mathematics of computing** → *Statistical graphics*; • **Computing methodologies** → *Neural networks*; • **Applied computing** → *Computer-aided design*; *Health informatics*; *Bioinformatics*.

KEYWORDS

Nutrition, Physical activity, Mobile applications, Teenagers, Health.

ACM Reference Format:
María Vanessa Villasana, Ivan Miguel Pires, Juliana Sá, Nuno M. Garcia, Nuno Pombo, Eftim Zdravevski, and Ivan Chorbev. 2019. CoviHealth: Novel approach of a mobile application for nutrition and physical activity management for teenagers. In *EAI International Conference on Smart Objects and Technologies for Social Good (GoodTechs '19), September 25–27, 2019, Valencia, Spain.* ACM, Valencia, Spain, 6 pages. https://doi.org/10.1145/3342428.3342657

1 INTRODUCTION

To date and to the best of our knowledge, the use of the technology by teenagers in secondary schools exploits the existence of new healthcare problems related to the childhood obesity and the sedentary lifestyles [20, 21].

The main objective of CoviHealth project consists in the use of the devices that promote the sedentary and lonely lifestyles to stimulate an increased level of physical and socialization. In order to achieve this goal, the development of a mobile application for Android devices is proposed. The development of this type of mobile applications is related to the Ambient Assisted Living (AAL) subject, assisting and motivating the young people to adopt healthy diet habits and promote physical activity [5, 9, 10, 26].

The existing mobile applications in the market are mainly related to diet and nutrition, including the measurement of the energy expenditure, the calories intake, the calories needed, and a food database [6, 7, 22–24, 26].

Currently, the mobile applications related to physical activity and diet control existent in the online application stores are majority prepared to adults. There is a lack of mobile applications explicitly prepared for young people, acknowledging their unique needs, promote their use, including gamification to motivate learning, medical control, among others.

The proposed mobile application includes monitoring of lifestyles with an educational component for nutrition and physical activity, medical control, and registration of anthropometric values. These components are expected to motivate teenagers to use this type of mobile applications. The inclusion of a gamification component is expected to motivate young people to use this mobile application.

This paragraph finishes the introductory section. A summary of the literature review is presented in section 2. Section 3 presents the study design, the architecture of the system and the statistical methods that will be used for the statistical analysis of the data collected. The results are presented in section 4, including the features of the mobile application and its benefits. In the end, section 5 presents the discussion and conclusions.

2 RELATED WORK

Reviewing scientific articles in a domain involves systematic but time consuming steps, and in order to improve the process and find relevant articles more quickly, we utilised the NLP-based toolkit described in [29].

Currently, mobile devices are commonly used for everyday activities, and they can be used for nutrition and physical activity purposes [3, 4, 18, 28]. According to the research performed in Google Play Store [15], which included 250 mobile applications, we analyzed the features of 82 mobile applications, verifying that all mobile application in this research are very similar, and they are mainly based in the monitoring of the diet, weight and Body Mass Index (BMI).

Based on the analysis performed, only 24% of the mobile applications (20 of 82) are presented in some scientific studies. The major part of the mobile applications are related to "Health" (55%), 20% of the mobile applications are related to "Diet and Nutrition", 15% of the mobile applications are related to "Education", and, finally, the remaining 10% of the mobile application included in scientific studies are related to "Physical activity". However, the major part of these mobile applications is only referred to in the study or its features are presented with further analysis and validation.

Furthermore, the major part of the mobile applications analyzed is related to "Diet and Nutrition" (51%), being the remaining mobile applications categorized as "Health" (22%), "Education" (14%) and "Physical activity" (13%).

The next step was to analyze in detail the applications, extracting the features of the mobile applications. The essential features available in the mobile application are presented in Table 1. Additionally, we verified that the significant part of these mobile applications is related to diet control, *e.g.*, calories needed and intake, food database with the indication of calories, diet diary and diet plan, and anthropometric parameters, *e.g.*, weight, height and calculation of the Body Mass Index (BMI). However, other essential features were highlighted in the mobile applications analyzed, including the registration of goals, physical activity level and an educational component. Regarding the mobile application included in "Physical activity", the major part of these mobile applications is related to the registration of the physical activity and the calculation of the calories burned.

In addition, only 25% of the mobile application included efficacy analyses in research studies. As the effect on health is the most critical for the use of this mobile application, the depth studies found were mainly related to the mobile applications classified as "Health", including *Lifesum - Diet Plan, Macro Calculator & Food Diary* [14], *Calorie Counter- MyFitnessPal* [11], *Samsung Health* [16], *Calorie Counter – MyNetDiary* [12], and *Calorie Counter by FatSecret* [13].

Table 1: Summary of the most relevant features on each category.

Features	Number of mobile applications
Diet	
Diet diary	28
Calories needed calculate	28
Food database with calories	27
Calories Intake	26
Diet plan	22
Macronutrients intake	19
Recipes	19
Anthropometric parameters	
Weight/Height	52
Age	42
Genre	42
BMI	23
Social	
Goals	35
Education	25
Physical activity level	25
Reminders	16
Physical activity	
Calories Burned	26
Exercise diary	19
Training plan	16
Medical parameters	
Medication diary	2
Diabetic registration	2
Allergies registration	2
Vital parameters	
Blood pressure	2
Pulse	2

Lifesum - Diet Plan, Macro Calculator & Food Diary was analyzed by the authors of [17], revealing that exists a correlation between the body fat of the individual and the body fat measured by the mobile application.

In [8], *Calorie Counter – MyFitnessPal* was analyzed, concluding that the information provided to the user was very complicated for the everyday use of this mobile application.

An early attempt at designing personalized healthcare systems is proposed in [19], where authors describe a novel recommendation algorithm for healthcare based on data collected from a mobile sports application – *SportyPal*.

Samsung Health was analyzed in [1], comparing the mobile application in two different models of mobile devices and placed in distinct parts of the subject's body, being that, in all devices, the best results were achieved with the mobile device in the arm, reporting a Root Mean Square Error between 3.6% and 5.4%.

In [25], *Calorie Counter – MyNetDiary* was analyzed, where it returned satisfactory results and 60% of the participants in the study considered this mobile application is better than others.

Finally, the mobile application named as *Calorie Counter by FatSecret* was analyzed in the study [2], concluding that the measurement of the calories intake by this mobile application does not correspond to the real values, i.e., the measured value of the calories intake is 14% higher than the real value.

3 METHODS

3.1 Study design

This study consists in the implementation of a mobile application for the Android platform because it is the most used platform in the market [27]. The developed mobile application will be distributed to at least 356 volunteered students from a secondary school aged between 13 and 18 years old, where the population selected will be mainly teenagers.

The mobile application will allow the control of the monitoring of the anthropometric parameters, diet plan and training plan by the healthcare professionals. In addition, this study includes some training sessions in the selected school to educate teenagers about nutrition and physical activity.

In order to monitor the effects of the use of the mobile application, we will use questionnaires about the current lifestyle during the time of the study regularly for two months.

3.2 System Architecture

The system proposed named as *CoviHealth* is based in a three-tier layer model (see Figure 1), which it is composed by a mobile application for the registration of the different data, and a Web platform mainly used for the management and healthcare providers. According to EU General Data Protection Regulation (GDPR), the connections between the clients (*i.e.*, desktops and mobile devices) and the remote server are performed by connection with Secure Sockets Layer (SSL), in order to reduce the problems with the privacy of the data acquired. The data will always be accessible to the users of the different platforms, where the management, including the deletion of the data, will be allowed.

As users with different privileges access this system, the users' data is available in the Web Platform for all registered doctors, but the data cannot be changed without the consent of the user. The editor will only manage the contents in the Web Platform, and the administrator can manage the permission in the Web Platform. The user can register his/her data in all components of the system, where the privileges are the same between the Web Platform and the mobile application.

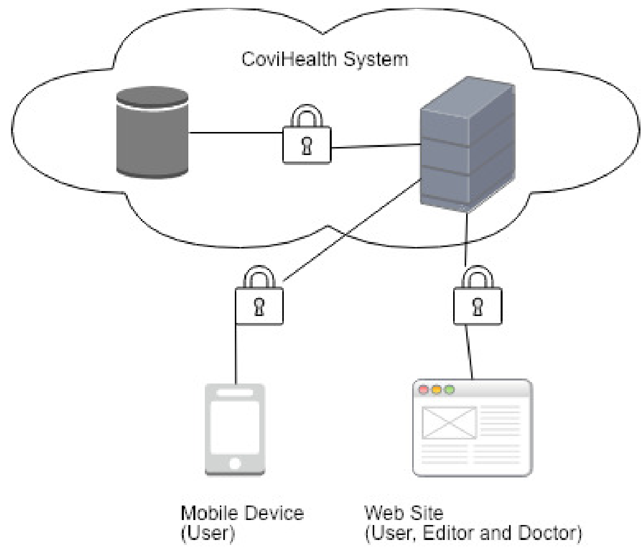

Figure 1: Architecture of the system proposed.

3.3 Hypothesis for Data Analysis

The data will be acquired from the individuals that are selected and classified as a Gauss distribution, where the data will be acquired with the questionnaires filled before and after the time of the study. The number of individuals needed to obtain significant results was calculated to the *t-Student* test.

According to the responses provided in the questionnaires, the acceptance of the proposed mobile application will be evaluated to verify the acceptance of the mobile application by young people, promoting healthy lifestyles.

4 RESULTS

4.1 System Proposed

Regarding the related work in this subject, the system proposed named as *CoviHealth* includes two components, these are a Web Platform and a Mobile Application. This system has different types of users with different levels of permissions, including standard user, administrator, doctor and editor, where the user is the unique type of user that has permissions to use the mobile application and the remaining types of users only perform the management in the Web Platform.

The mobile application should encourage the improvement of the diet and nutrition of users, including different features to increase the use of the mobile application. These are:

- User management
  - Registration;
  - Login;
  - View/Edit user details;
- Physical activity management
  - Goals registration and validation;

  - Physical activity monitoring with a pedometer (see Figure 2);
  - Goals registration and validation;
  - Location monitoring for the challenges;
  - Summary of the daily, week and month physical activity;
- Nutrition
  - Diet plan with calendar;
  - Training plan with calendar;
- Questionnaires
  - Initial questionnaire related to the physical, diet, nutrition and personal data of the user;
  - Monthly questionnaire to evaluate the user;
- Anthropometric parameters management
  - Body fat and muscle mass registered with an image that the user customize an image with his/her body;
  - BMI calculation;
- Home
  - Curiosities;
  - Tips;
- Gamification
  - Gain points and allows the generation of a QR code in order to get discounts in shops;
  - The points are gained:
    * With the use of the mobile application, *e.g.*, opening the different sections;
    * Each time that the user opens the mobile application;
    * With the performance of each quiz;
    * With the performance of challenges;
  - Challenges:
    * Challenges per week
    * Group challenges;
- Medical
  - Medication diary;
  - Biometric parameters registration;
- Social
  - Integration with social networks;
  - Reminders.

On the other hand, the Web Platform, which allows the authentication of the different types of users, includes different features for the customization of the mobile application and management. These are:

- General
  - Login;
  - View/Edit user details;
  - View dashboard (see 3);
- Administrator
  - User management
    * View list of users;
    * View user details;
    * Edit the user details;
    * Add/remove/block users;
    * View list of users;
- Common user
  - Dashboard;
  - Access vouchers;
  - Generate vouchers;

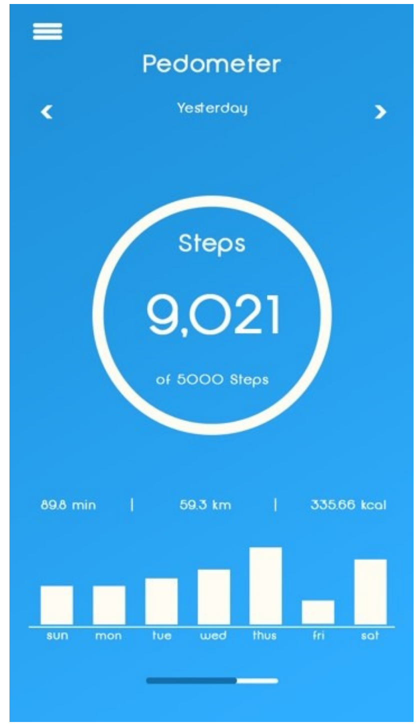

Figure 2: Prototype of Mobile Application (Pedometer).

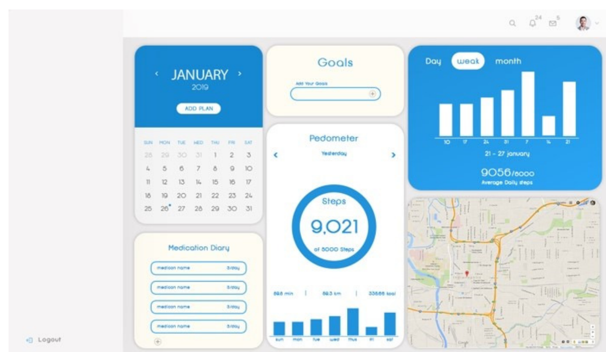

Figure 3: Prototype of Dashboard for a Web Platform (User).

- Doctor
  - User management
    * View list of users;
    * View user details;
    * Edit the user details;
    * Define training plan of the user;
    * Define the diet plan of the user;
- Editor
  - Challenges registration;
  - Quiz registration;
  - Tips registration;
  - Curiosities registration;
  - Personalization of the Home.

Table 2: Features implemented in the mobile application.

Features	Number of mobile applications
User management	82
Age	42
Gender	42
Diet diary	28
Diet plan	22
Questionnaire	2
Physical activity monitoring	10
Exercise diary	19
Challenges	7
Training Plan	16
Medication diary	2
Education	25
Reminders	16
Tips	0
Curiosities	0
Weight	52
Height	2
BMI	23
Body fat	9
Lean body mass	1
Goals	35
Body structure	1
Points	1
Medical control	0
Gamification	0

4.2 Benefits of the system proposed

Based on the features described in section 4.1 and the features of mobile applications previously analyzed, the features that will be implemented in the *CoviHealth* project, they are ranked in Table 2. As the primary goal of the proposed mobile application is to motivate the teenagers to use the mobile application and to be educated about nutrition and physical activity, the highlighted features will captivate the teenagers to use the mobile application with curiosities, tips, medical control and gamification.

The gamification is the main feature that may motivate the use of the mobile application, where the user gains points that can be converted as discounts in different shops. The integration with social networks to share the values of the physical activity, diet and nutrition are very common in modern mobile applications and it will contribute to the motivation of the users. The medical control is another most central feature because it provides reliable information to teenagers with a personal captivation of the users. Even though recognizing the physical activity with teenagers on the field is a challenging task [31], some machine learning approaches, such as [30], could be utilized to better recognize and the exact physical activity, even on mobile devices.

4.3 Expected results

The mobile application proposed in this study will be evaluated to verify the satisfaction of the users with the mobile application as well as its utility. It is expected that the inclusion of the gamification increases the use of the mobile application because the main population will be teenagers.

It is also expected that the inclusion of medical control increases the acceptance and reliability of the mobile application. The trustworthy and personalized health monitoring of the mobile application allows teenagers to obtain better results with the implementation of healthy habits.

In conclusion, this mobile application will present dynamic content, *i.e.*, tips, curiosities and challenges, to motivate the use of it, increasing the acceptance of the mobile application by the teenagers. In the end, it may motivate performing physical activities.

5 DISCUSSION AND CONCLUSIONS

Healthy living habits are essential for improving the quality of life in order to reduce the rate of future pathologies related to poor eating habits and sedentary lifestyle.

CoviHealth is a multidisciplinary project that includes the development of a mobile application for nutrition and physical activity in order to evaluate and improve the habits of young people. This project will be developed in cooperation between professionals from computer science engineering and medicine from the *Universidade da Beira Interior*, Covilhã, Portugal.

The main functionalities of the proposed mobile application will be the monitoring of physical activity, reminders, possibility to define the training plan, medication diary, medical control, where the innovation of this mobile application is focused on the inclusion of medical control, tips, curiosities and gamification.

In the future, the proposed mobile application will be implemented and a group of young people from a secondary school will be selected for the tests in order to verify if the innovation proposed stimulates the interest in the mobile applications related to nutrition and physical activity.

6 ACKNOWLEDGMENTS

This work is funded by FCT/MEC through national funds and when applicable co-funded by FEDER – PT2020 partnership agreement under the project **UID/EEA/50008/2019** (*Este trabalho é financiado pela FCT/MEC através de fundos nacionais e quando aplicável cofinanciado pelo FEDER, no âmbito do Acordo de Parceria PT2020 no âmbito do projeto UID/EEA/50008/2019*).

This article is based upon work from COST Action IC1303 - AAPELE - Architectures, Algorithms and Protocols for Enhanced Living Environments and COST Action CA16226 - SHELD-ON - Indoor living space improvement: Smart Habitat for the Elderly, supported by COST (European Cooperation in Science and Technology). More information in www.cost.eu.

REFERENCES

[1] Vicente J. Beltrán-Carrillo, Alejandro Jiménez-Loaisa, Miriam Alarcón-López, and Jose L.L. Elvira. 2018. Validity of the "Samsung Health" application to measure steps: A study with two different samsung smartphones. *Journal of Sports Sciences* 00, 00 (2018), 1–7. https://doi.org/10.1080/02640414.2018.1527199

[2] Juliana Chen, Janet E Cade, and Margaret Allman-Farinelli. 2015. The Most Popular Smartphone Apps for Weight Loss: A Quality Assessment. *JMIR mHealth and uHealth* 3, 4 (2015), e104. https://doi.org/10.2196/mhealth.4334

[3] David E. Conroy, Chih-Hsiang Yang, and Jaclyn P. Maher. 2014. Behavior Change Techniques in Top-Ranked Mobile Apps for Physical Activity. *American Journal*

of Preventive Medicine 46, 6 (Jun 2014), 649–652. https://doi.org/10.1016/J.AMEPRE.2014.01.010
[4] Sunny Consolvo, Katherine Everitt, Ian Smith, and James A. Landay. 2006. Design requirements for technologies that encourage physical activity. In *Proceedings of the SIGCHI conference on Human Factors in computing systems - CHI '06*. ACM Press, Montréal, Québec, Canada, 457. https://doi.org/10.1145/1124772.1124840
[5] Ciprian Dobre, Constandinos x Mavromoustakis, Nuno Garcia, Rossitza Ivanova Goleva, and George Mastorakis. 2016. *Ambient Assisted Living and Enhanced Living Environments: Principles, Technologies and Control*. Butterworth-Heinemann, Butterworth-Heinemann.
[6] Virginie Felizardo, Pedro Dinis Gaspar, Nuno M Garcia, and Victor Reis. 2011. Acquisition of Multiple Physiological Parameters During Physical Exercise. *International Journal of E-Health and Medical Communications* 2, 4 (2011), 37–49. https://doi.org/10.4018/jehmc.2011100103
[7] Virginie dos Santos Felizardo. 2010. *Validação do acelerómetro xyzPlux para estimação do Gasto Energético com aquisição de diversos parâmetros fisiológicos*. Ph.D. Dissertation. Universidade da Beira Interior.
[8] S De Francisco, F S H Freijser, I C Van Der Lee, M Van Sinderen, S Verburg, and J Yao. 2013. MyFitnessPal iPhone app usability test ' Add Entry ' the first step to control your diet. , 7 pages. https://doi.org/10.1210/jcem.84.5.5645
[9] Nuno M Garcia. 2016. A Roadmap to the Design of a Personal Digital Life Coach. In *ICT Innovations 2015*, Suzana Loshkovska and SasoEditors Koceski (Eds.). Springer Cham, Ohrid, Macedonia, 21–27.
[10] Nuno M Garcia and Joel Jose P C Rodrigues. 2015. *Ambient assisted living*. CRC Press, Boca Ratom, FL.
[11] Google. 2018. Calorie Counter - MyFitnessPal - Apps on Google Play 2018. https://play.google.com/store/apps/details?id=com.myfitnesspal.android
[12] Google. 2018. Calorie Counter - MyNetDiary, Food Diary Tracker - Apps on Google Play 2018. https://play.google.com/store/apps/details?id=com.fourtechnologies.mynetdiary.ad
[13] Google. 2018. Calorie Counter by FatSecret – Apps on Google Play. https://play.google.com/store/apps/details?id=com.fatsecret.android
[14] Google. 2018. Lifesum - Diet Plan, Macro Calculator & Food Diary - Apps on Google Play 2018. https://play.google.com/store/apps/details?id=com.sillens.shapeupclub&hl=e
[15] Google. 2018. (Nutrition OR diet OR calories OR health OR exercise OR weight) - Android Apps on Google Play 2018. https://play.google.com/store/search?q=(NutritionORdietORcaloriesORhealthORexerciseORweight)&c=apps&hl=en
[16] Google. 2018. Samsung Health - Apps on Google Play 2018. https://play.google.com/store/apps/details?id=com.sec.android.app.shealth
[17] Carly Griffiths, Lisa Harnack, and Mark A. Pereira. 2018. Assessment of the accuracy of nutrient calculations of five popular nutrition tracking applications. *Public Health Nutrition* 21, 8 (2018), 1495–1502. https://doi.org/10.1017/S1368980018000393
[18] Lana Hebden, Amelia Cook, Hidde P van der Ploeg, and Margaret Allman-Farinelli. 2012. Development of smartphone applications for nutrition and physical activity behavior change. *JMIR research protocols* 1, 2 (Aug 2012), e9. https://doi.org/10.2196/resprot.2205
[19] Igor Kulev, Elena Vlahu-Gjorgievska, Vladimir Trajkovik, and Saso Koceski. 2013. Development of a novel recommendation algorithm for collaborative health: Care system model. *Computer Science and Information Systems* 10, 3 (2013), 1455–1471. https://doi.org/10.2298/CSIS120921057K
[20] Nan Li, Pei Zhao, Chengming Diao, Yijuan Qiao, Peter T. Katzmarzyk, Jean-Philippe Chaput, Mikael Fogelholm, Rebecca Kuriyan, Anura Kurpad, Estelle V. Lambert, and et al. 2019. Joint associations between weekday and weekend physical activity or sedentary time and childhood obesity. *International Journal of Obesity* 43 (Jan 2019), 691–700. https://doi.org/10.1038/s41366-019-0329-9
[21] Andreia Oliveira, Joana Araújo, Milton Severo, Daniela Correia, Elisabete Ramos, Duarte Torres, and Carla Lopes. 2018. Prevalence of general and abdominal obesity in Portugal: comprehensive results from the National Food, nutrition and physical activity survey 2015–2016. *BMC Public Health* 18, 1 (Dec 2018), 614. https://doi.org/10.1186/s12889-018-5480-z
[22] Ivan Miguel Pires, Virginie Felizardo, Nuno Pombo, Mario Drobics, Nuno M. Garcia, and Francisco Flórez-Revuelta. 2018. Validation of a method for the estimation of energy expenditure during physical activity using a mobile device accelerometer. *Journal of Ambient Intelligence and Smart Environments* 10, 4 (Aug 2018), 315–326. https://doi.org/10.3233/AIS-180494
[23] Ivan Miguel Pires, Nuno M Garcia, Nuno Pombo, and Francisco Flórez-revuelta. 2018. Limitations of the Use of Mobile Devices and Smart Environments for the Monitoring of Ageing People. *HSP* 1, Ict4awe (2018), 269–275.
[24] Ivan Miguel Serrano Pires. 2012. *Aplicação móvel e plataforma Web para suporte à estimação do gasto energético em atividade física*. Ph.D. Dissertation. Universidade da Beira Interior.
[25] M Sanrujan. 2018. *A mobile application to influence and self-manage the lifestyle of type two diabetes patient*. Master's thesis. Cardiff School of Technologies. https://repository.cardiffmet.ac.uk/handle/10369/10080
[26] P S Sousa, D Sabugueiro, V Felizardo, R Couto, I Pires, and N M Garcia. 2015. *mHealth Sensors and Applications for Personal Aid BT - Mobile Health: A Technology Road Map*. Springer International Publishing, Switzerland, 265–281. https://doi.org/10.1007/978-3-319-12817-7_12
[27] StatCounter Global Stats. 2018. Mobile Operating System Market Share Worldwide | StatCounter Global Stats. http://gs.statcounter.com/osmarket-share/mobile/worldwide
[28] Corneel Vandelanotte, Andre M. Müller, Camille E. Short, Melanie Hingle, Nicole Nathan, Susan L. Williams, Michael L. Lopez, Sanjoti Parekh, and Carol A. Maher. 2016. Past, Present, and Future of eHealth and mHealth Research to Improve Physical Activity and Dietary Behaviors. *Journal of Nutrition Education and Behavior* 48, 3 (Mar 2016), 219–228.e1. https://doi.org/10.1016/J.JNEB.2015.12.006
[29] Eftim Zdravevski, Petre Lameski, Vladimir Trajkovik, Ivan Chorbev, Rossitza Goleva, Nuno Pombo, and Nuno M. Garcia. 2019. *Automation in Systematic, Scoping and Rapid Reviews by an NLP Toolkit: A Case Study in Enhanced Living Environments*. Springer International Publishing, Cham, 1–18. https://doi.org/10.1007/978-3-030-10752-9_1
[30] E. Zdravevski, P. Lameski, V. Trajkovik, A. Kulakov, I. Chorbev, R. Goleva, N. Pombo, and N. Garcia. 2017. Improving Activity Recognition Accuracy in Ambient-Assisted Living Systems by Automated Feature Engineering. *IEEE Access* 5 (2017), 5262–5280. https://doi.org/10.1109/ACCESS.2017.2684913
[31] Eftim Zdravevski, Biljana Risteska Stojkoska, Marie Standl, and Holger Schulz. 2017. Automatic machine-learning based identification of jogging periods from accelerometer measurements of adolescents under field conditions. *PLOS ONE* 12, 9 (09 2017), 1–28. https://doi.org/10.1371/journal.pone.0184216