Treatment of children obesity and diabetes through gamification: a case of study

Nazaret Gómez del Río
GRIAL Research Group
University of Salamanca
Salamanca, Spain
ngomrio@usal.es

Carina S. González-González
University of La Laguna/
Open Univeristy of Catalunya
La Laguna, Tenerife, Spain
carina.gonzalez@ieee.org

Raquel Martín-González
University of La Laguna
La Laguna, Tenerife, Spain
rmarting@ull.edu.es

Vicente Navarro-Adelantado
University of La Laguna
La Laguna, Tenerife, Spain
vnavarro@ull.edu.es

Pedro Toledo-Delgado
University of La Laguna
La Laguna, Tenerife, Spain
petode@ull.edu.es

Norberto Marrero-Gordillo
University Hospital of Canarias
La Laguna, Tenerife, Spain
nmarrero@ull.edu.es

Yeray del Cristo Barrios-Fleitas
University of Twente
Enschede, The Nertherlands
y.d.c.barriosfleitas@utwente.nl

Honorio Armas-Ramos
University Hospital of Canarias
La Laguna, Tenerife, Spain
harmas@ull.es

Francisco Gacía-Peñalvo
GRIAL Research Group
University of Salamanca
Salamanca, Spain
frangp@usal.es

ABSTRACT

Childhood obesity is nowadays a global epidemic. This illness sometimes comes with another associated problem, like Diabetes type II. In this paper we present a case of study about the results of the application of a gamified educational program. A 3-year longitudinal and prospective study was conducted a patient with obesity and diabetes. Different assessments regarding the health state of the patient have been developed (family background, physical/medical, emotional state and physical activity). Using Positive outcomes have been obtained in their medical registers and also, in their health habits. Thus, the application of gamification strategies in the educational program has positive impact in the health.

KEYWORDS

Obesity, Diabetes, Gamification, Technology

1 Introduction

Childhood is the stage where the habits that will be consolidated throughout our life begin to develop. Educating children in healthy habits from an early age is the most effective preventive measure to improve their health and quality of life.

In 1998, the WHO (World Health Organization) [1] warned in its annual report on the incidence of obesity as an emerging public health problem, and in 2004, it declared it a global epidemic, since, progressively, Obesity has affected countries around the world. According to this organization more than 41 million children under the age of five were overweight or obese were obese [2].

Childhood obesity is alarmed not only by the increase in the prevalence of the disease in populations around the world, but by the multiple health consequences in the short, medium and long term such as the increase in risk factors for the development of cardiovascular and metabolic diseases; psychological and social problems derived from the teasing and comments of his peers; and in the long term the persistence of obesity; increase in disabilities; or premature death. All these health problems entail serious

health and economic repercussions for those affected, their families and society as a whole.

The Spanish Society for the Study of Obesity (SEEDO) [3], confirms that 44.5% of Spanish boys and girls suffer from excess weight, this means that practically one in two children is overweight with respect to the growth patterns established by the WHO. Only Italy and Cyprus exceed these figures at European level, according to the IDEFICS study (Identification and prevention of Dietary- and lifestyle-induced health Effects in Children and Infants) [3, 4]. The ALADINO study of 2011 [5] specifies that the infant population between the ages of 6 and 9 years had a prevalence of 26.2% of overweight and 18.3% of obesity. In the Canary Islands, the results were 28.4% and 21.2% respectively, being the Spanish autonomous community with the highest rate of childhood obesity, together with Andalusia.

In its latest report of 2015 [6], the results are encouraging for the Canary Islands, which found that the prevalence of overweight / obesity is five percentage points less than in the previous report. However, the figures are still very high (overweight of 24.3% and obesity of 19.9%). Already in 2016, the WHO issued a report of the Commission to end childhood obesity [7] which includes six recommendations for governments to reverse this global trend, where one is to offer weight-control services to the obese pediatric population based on family and lifestyle and with multiple components. Also, the WHO and other international organizations (such as the World Heart Federation, the International Diabetes Federation, among others) have developed various strategies in an effort to contain high levels of obesity and physical inactivity [8].

Individual personal motivation is especially important for adherence to change, because despite knowing that a change in lifestyle is the most effective method for weight control in the long term, adherence to exercise and physical activity are usually difficult to maintain [9, 10]. In children, the reasons for leaving physical activity are mainly related to the difficulty to adapt to the schedules, the refusal to follow the routine, the dissatisfaction with the results, etc. Therefore, it is necessary to work not only with people affected by obesity, but also to educate their families, since it is in the family environment where lifestyles are acquired and perpetuated. The technology also provides very useful tools to support children in their games and education. There are different studies on educational programs that demonstrate the efficacy of caloric expenditure associated with the use of exergames [12, 13, 14], as well as the effectiveness of the use of technologies and gamification with boys and girls for the promotion of healthy habits in the short term. term [15]. Taking into account previous studies, PROVITAO developed an educational program based on motor games, active video games and virtual learning environments focused on promoting a long-term lifestyle change in children suffering from childhood obesity and their families and that affects an improvement in the quality of life. This intervention program was designed, conducted, supervised and analyzed by professional researchers in the areas of health (medicine, physiotherapy, nursing, psychology, physical education and sports), education and computer science [16]. In this work we will present a case of study about a child patient with obesity and diabetes type II, as well as the main results obtained.

2 Case of study: obesity and diabetes

2.1. Summary

This section describes the materials and methods used in the study, as well as the main results obtained. There are no problems or risks derived from the study for the patient. The legal guardians have been informed and have signed a consent to use their data for the study and to share them with the scientific community. The treatment, communication and transfer of personal data of all participating subjects comply with the provisions of the Organic Law 15/1999, of December 13, on the protection of personal data. The protocols used in the study have been approved by the Ethics Committee of the University Hospital of the Canary Islands.

2.2. Method

A 3-year longitudinal and prospective study was conducted (2014-2017). The case study presented in this study was a patient of the Pediatric External Consultations of the University Hospital of the Canary Islands (HUC) and was in outpatient treatment for childhood obesity. It was part of the experimental group, and followed all the activities designed in PROVITAO [17]. The activities designed in PROVITAO were organized in different stages that are described below (Figure 1).
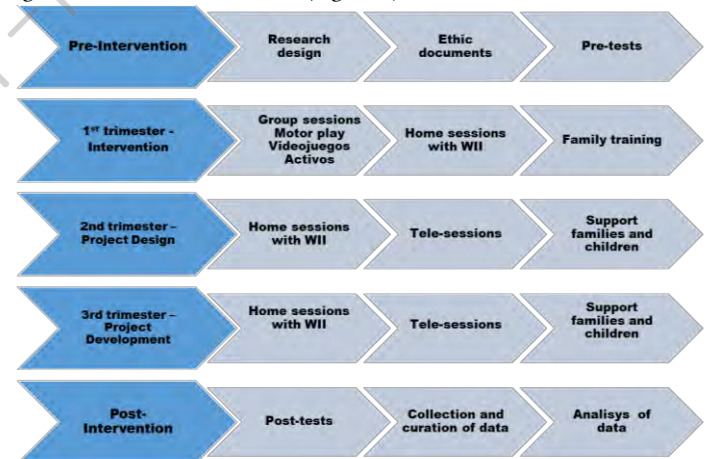

Figure 1: Stages and instruments used in the program.

2.3. Instruments

The following instruments were used to measure body composition and biomedical measurements: digital weight with height rod, lipo-caliber, inextensible tape measure, BMI formula, growth curve to determine percentiles, and blood tests were used to determine biochemical values (cholesterol, triglycerides, insulin, hormones).

To analyze the emotions during the intervention we used the Emodiana [19], an instrument that allows us to measure 10 basic

emotions, represented with different expressions of a character associated with their corresponding labels, adjusted to the language used by children from 8 to 12 years old. This instrument is represented as a target allowing the intensity of each emotion to be measured, on a Likert scale, with 5 being the most intense emotion in the center and 1 the weakest one on the outside of the target. It is used during group intervention sessions.

To study the behavior and personality of children and adolescents we have selected the BASC (System for the evaluation of the behavior of children and adolescents) [20] Spanish adaptation of the Reynolds and Kamphaus questionnaire, it is a multidimensional questionnaire that measures numerous aspects of the behavior and personality of the less. In the self-report, the child or adolescent describes their emotions and perceptions and provides information on clinical, adaptive scales and global dimensions.

To know the habits of physical activity and the perception of well-being, we opted for an adaptation of the questionnaire designed by Manuel Delgado and Pablo Tercedor in 2002 in the "Strategy of intervention in education for health from education". The Adaptation of the Questionnaire about physical activity-sport and health-well-being, is a questionnaire of 22 items in which are valued: states of physical activity (physical activity or sport practiced, days and hours a week, hours of inactivity, etc), enjoy physical activity; self-perception of motor competence and utility of physical activity and sport; feeding; health and personal well-being. To determine adherence to the Mediterranean diet, considered heart-healthy, it was assessed using the KIDMED questionnaire [21]. This test has 16 items of dichotomous type of affirmative or negative response that includes the main indicators of food. The affirmative answers in the questions that represent a negative connotation in relation to the Mediterranean Diet are worth -1 point, and the affirmative answers in the questions that represent a positive aspect in relation to the Mediterranean Diet are worth +1 point. If the answer is do not know / do not answer do not score. Therefore, said index can range between -4 and 12.

Finally, to know the profile of the children's gamer we have chosen the Player Profile Test, an adaptation of the Questionnaire on Use and Attitudes towards Videogames by Alfageme, B., & Sánchez, P. [22], is a questionnaire with a total of 12 questions that focus on the type of videogames that the child plays, the hours a week he or she dedicates, and the values and beliefs regarding videogames. All the questionnaires that were used in the project were previously validated.

2.4. Case description

An 11-year-old female patient who joined the study sent from the Outpatient Consultations of Pediatrics of the University Hospital of the Canary Islands with diagnosis of Obesity and Resistance to insulin (prediabetes type II), in pharmacological treatment with Metformin 850mg.

Family background:

• Mother and father both overweight. The mother suffers from obesity and suffers from type II diabetes. The father is asthmatic, smoker, suffers from psoriasis.

• Maternal grandmother: Type II diabetes, asthma, uterine cancer and Lupus.

• Maternal grandfather: hypertension, type I diabetes, nephropathy, and heart disease.

• Paternal grandmother: HTA.

• Paternal grandfather: Lung cancer.

Personal history:

This is an asthmatic girl who needs treatment and follows up at the Pneumology Service of the University Hospital of the Canary Islands (HUC) since her birth due to respiratory problems, a main reason that generates a continuous demand for a large part of her childhood due to bronchial asthma, catarrh of upper tracts and laryngitis on multiple occasions.

Regarding obesity, said pathology was detected for the first time in the Primary Care consultation of his Pediatrician in the third year review, this weight elevation above the Percentile 97 is maintained in all health controls until the moment of the evaluation in this project, maintaining normal percentiles with respect to its size. The first data available in the electronic medical record in this regard is in the review of the 3 years where its weight is 21,800 kg (percentile greater than 97) and its size of 94.5 cm (25-50 percentile). It is not until the review of the 4 years where the alarms jump, and Obesity II is diagnosed, in that visit the minor weighs 29g (percentile >> 97), measures 103cm (50-75th percentile), and its body mass index (BMI) is 27.3; his mother assures that "he eats everything and varied". At that time strict control of the diet is prescribed (avoiding fatty foods, fried and refined sugars, ensuring a balanced diet by educating on the use of fresh fruits, vegetables, salads, grilled meats, etc.), practicing in a Regular sport and control of weight and height in 3 months. However, the girl does not go to that control.

In later years, weight and height controls are retaken and nurses and pediatricians insist on the measures to be taken to improve life habits and help control weight gain, despite this, most of these Controls are punctual in time and do not prove to be effective. After reviewing the 7 years, and for a short period of time (between January and June 2011) visits and periodic checks are made that seem to achieve an improvement in eating habits and weight control (reduction of 1.6kg in 2 months), but these controls are interrupted again and it is not until the 9-year review (June 2013 -Size: 140 - Pc: 50.75. Weight: 64 - Pc: 100) where the girl is referred from the pediatric office of her Health Center to the Endocrinology office of the HUC for control and evolution of Obesity III (morbid), "with control attempt for some years without answer ". In September 2013, controls on weight and blood pressure were taken again by order of the HUC that were carried out for 2 months, and shortly after treatment with Metformin 850mg (February 2014). Treatment that has been specified throughout the study according to medical guidelines.

She joined the Experimental Group of PROVITAO in October 2014, performing anthropometric and analytical controls before and after the intervention, the follow-up at 6 months and the last control at the beginning of the intervention. Below are some of the measurements taken in these controls (Table 1).

Tabla 1. Measures taken in the exploration

	Pre-intervention	Post-intervention (3 months)	Control (6 months)	Anual
Age	10	11	11	12
Weight (kg)	71.6	72	72.3	78.3
Height (cm)	1.47	1.48	1.52	1.54
BMI	33.13	32.52	31.29	32.68
Perimeter waist (cm)	104.5	100.5	97	101.5

Next, we will describe the results obtained with the patient in the intervention program, dividing into different sections according to the evaluated dimension (physical, emotional, physical activity, healthy habits).

Physical assessment:

As can be seen, both the weight, the abdominal perimeter and the BMI improved in the post-intervention control and in the follow-up of 6 months, achieving a greater decrease in all the figures in the control performed at 6 months, however, in the control performed at the end of that year, where 6 months passed without any intervention, there was an increase in the BMI and abdominal perimeter figures very close to the values recorded at the beginning of the study (Table 2).

Tabla 2. Analytical values and reference levels for an 11-year-old girl.

	Pre-test	Post-test (6 months)	Post-test (anual)
Glucose basal Lower 100 mg/dl	93	84	93
Cholesterol total Lower 170 mg/dl	148	152	149
HDL Upper 45 mg/dl	37	46	46
LDL Lower 110 mg/dl	92	92	92
Triglycerides Lower 90 mg/dl	94	69	52
TSH basal Lower 4,5µUI/ml	2.1900	2.2700	-
Insulin basal	25.6	33.7	-

Next, we will explain the reason for the differences between the analytics. We have the complete pre-intervention analytic and the follow-up at 6 months (time elapsed 9 months). The post-intervention analysis was not performed because the girl underwent other tests for acute pathologies, the parents deciding that it was unnecessary to perform another blood collection in that period. The analytical that had to be performed a year is incomplete because the endocrine considered that it was not necessary to carry out a basal insulin control again.

We must also remember before performing the interpretation of these values that the minor was being treated with Metformin 850mg 1 time a day (at breakfast) several months before the start of the study. This drug acts directly on glucose by reducing the postprandial and basal plasma levels by 3 mechanisms: it reduces the hepatic glucose production, it increases the insulin sensitivity in the muscle and the peripheral glucose uptake (important when doing physical activity) and delays the intestinal absorption of glucose (decreases the probability of producing hypoglycemia). Which means that in all the analytics we find normal levels of basal glucose and basal insulin.

In relation to cholesterol and triglycerides, we found an improvement in HDL levels or called good cholesterol and triglycerides between the pre-intervention and follow-up analytics, this may be due to the realization of physical activity during the intervention and later with the project vocational (the girl enrolled in Zumba classes) and the improvement in eating habits that will be better explained later.

Finally, TSH was requested in the analyzes because it has been proposed that TSH increases in obese patients as part of an adaptive process that seeks to restore the balance of energy balance through the increase in resting expenditure. The levels of thyroid hormones vary according to the measurement technique used, age and pubertal development and are related to BMI, central obesity, and plasma insulin. We do not find in this case an alteration in TSH levels.

Emotional assessment:

On the emotional assessment of face-to-face group activities, the patient attends 100% of the face-to-face sessions, always reporting positive emotions, specifically joy, upon entry. In the beginning justified in most cases the emotion for issues outside the activity. At the exit, the selection of the same emotion is always kept increasing, as a general rule, the intensity and becoming justified by reasons related to the activity. This is indicative of a motivating effect of physical activity, the social environment developed and the gamification strategies (Figure 2). On the other hand, it does not perceive the activity as intense (Figure 3), when the activity carried out has been in some cases intense-moderate (Figure 4, Table 3).
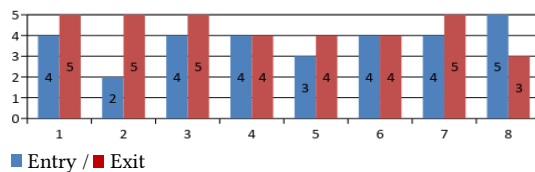

■ Entry / ■ Exit

Figure 2: Intensity (y=1-5) of the emotion "joy" informed at the beginning and end of each face-to-face session (x=1-8) Note. The intensity scale is as follows: 1 very little, 2 little, 3 normal, 4 quite, 5 much.

Physical activity assessment:

After each session of physical activity, the patient was asked about her perception of the effort demanded by the activity performed in the motor games session. This perception was contrasted by the biometric data collected by the biometric sensors (wristwatch) that were placed before the session began and retired at the end of the session. It can be seen in figures 8 and 9, as well as in tables 9 and 10, that although the physical activity that was being performed was moderate-high reaching even a maximum heart rate of 205.2, his perception was never negative, considering that I was doing a very easy or easy activity (M = 3) in 100% of the seven sessions.
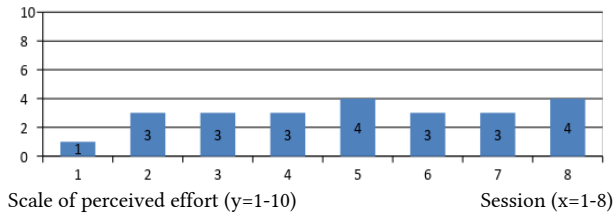

Scale of perceived effort (y=1-10)   Session (x=1-8)

Figure 3: Perceived effort in each face-to-face session (motor game)

Note. The scale is as follows: 1 Very, very easy, 2 Very easy, 3 Easy, 4 Feeling a little effort, 5 Starting to be heavy, 6 Being quite heavy, 7 Heavy, 8 Very heavy, 9 Very, very heavy, 10 So hard that I have to stop.

Table 3. Average, maximum and minimum heart rate collected by the biometric sensors for the case.

Session/Heart rate	s1	s2	s3	s4	s5	s6	s7
Media	136	150	138	135	129	117	106
Max	197	197	182	174	167	156	157
Min	72	95	97	63	90	85	62

Hearth rate		Standard
FcMax	205,2	215
FcReserva	124,2	155
FcReposo	81	60
70% Hearth rate of work by Karvonen = (HR max-HR repose)·0,7 + HR repose		
	167,94	HR of training by Karvonen
	161,64	Case of study

Tabla 4. Recommended heart rate, maximum and minimum collected by the biometric sensors for that matter.

Recommended physical activity		MIN Case	MAX Case
Very soft intensity: 50-60%, useful for recovery work, heating and return to calm.	143.1	132.6	147.12
Soft intensity: 60-70%, area for basic work of physical condition, highly recommended for people who are new to sports and want to start building a good physical shape. Also used at the beginning of the season of athletes to start establishing a work base.	155.52	147.12	161.64
Moderate intensity: 70-80%, interval in which an objective of improvement in performance is already pursued and the efficiency of the heart is worked (use of less energy for the realization of an effort). Recommended for cycles of preparatory training to medium-long duration tests where an important aerobic base is established.	167.94	161.64	176.16
Hard intensity: 80-90%, this is already a step where fatigue appears manifestly. The objective is to gain performance and be able to work at high intensity over time. It is not recommended for programs that seek improvement of basic physical condition, for that are the previous steps. This is one more interval for specific and anaerobic training that pursues performance in sport.	180.36	176.16	190.68
Maximum intensity: 90-100%, it is the maximum effort that can tolerate our organs and muscles, it is an anaerobic training that due to its hardness can only be applied in short periods of time (less than 5 minutes). It is only recommended for specific training of athletes seeking performance.	192.78	190.68	205.2

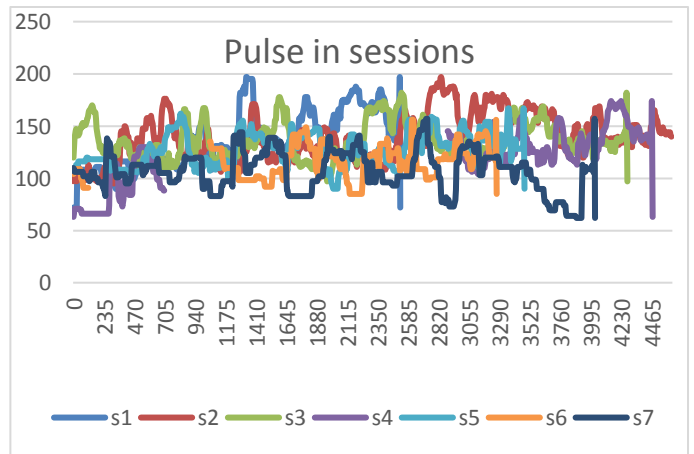Nota: HR Max (chicas) =226 - edad y en chicos 220-edad

Figure 4: Pulsations of the patient during the group sessions of physical activity.

Note: Maximum detected HR: 205.2

Global assessment of habits change:

Non-data overlapping indices have been calculated, a technique usually applied to check the effectiveness of treatment in individual cases (for example, in psychology). We have opted for this technique because they do not require having many measurements in the baseline, not in the follow-ups, in spite of this, since we have only one measure of each indicator in the baseline, the following data must be considered with caution. not being able to detect the possible presence of a trend in it, but they are indicative to understand the changes that have occurred. The method of non-overlapping all pairs (NAP) has been used, based on the realization of the ROC curves, for this, the three follow-ups are considered together, as information periods on the effectiveness of the totality of the intervention. We present the effect sizes for the evolution of the indices assessed by the questionnaires, with the category proposed by their authors, according to the assessment: 0-65% weak effect; 66-92% average effect; 93-100% large effect, considering from 90 to 100% a very effective treatment (Table 5).

Tabla 5.Effect size index

		NAP	Conventional interpretation
Auto report	Physical activity states	16.7%	Weak effect
	Self-perception about motor skills and utility of AFoD	66.67%	Media effect
	Feeding	100%	Strong effect
	Health and personal welfare	100%	Strong effect
Parents	Healthy habits	100%	Strong effect
	Feeding habits	100%	Strong effect
	Knowledge about feeding	50%	Weak effect
	Free time	33.33%	Weak effect
	Actitudes to videogames	100%	Strong effect
	KidMed	66.67%	Media effect

Finally, when we observe adherence to the Mediterranean diet, the scores always indicate that it is desirable to improve feeding habits.

3 Conclusions

In this work we have presented the study of a unique case of a female patient of 11 years of age referred from outpatient clinics of HUC Pediatrics with diagnosis of obesity and insulin resistance (pre-diabetes type II). The patient became part of the experimental group in the first phase of PROVITAO. Therefore, the anthropometric and analytical controls were carried out before and after surgery, the follow-up at 6 months and the last one at the start of the intervention. Both weight, abdominal perimeter and BMI improved in post-intervention control and follow-up at 6 months. The values suffered an increase when no face-to-face intervention was made. The analytics reported normal values of basal glucose and basal insulin when the patient was being treated with Metformin 850mg daily. In relation to cholesterol and triglycerides we find an improvement in HDL levels at the end of the intervention, an issue that we believe is due to the realization of physical activity during the same. We also see a long-term improvement, since the patient developed a vocational project related to moderate physical activity (Zumba), and developed healthier eating habits. No alterations in TSH levels were found.

The group face-to-face sessions motivated and elevated emotional well-being, manifesting joy with a high-very high intensity. This may be due to the motivating effect of physical activity based on active motor games and video games, the social environment and gamification. We emphasize that, although the physical activity developed has been moderate and intense in some cases, as can be seen through the data collected by the biometric sensors, the patient perceives it as low intensity, being immersed in the developed games.

In addition, we have proven the effectiveness of the treatment in individual cases, seeing that in food, health and personal well-being, healthy eating habits, attitude towards video games, has had a large effect (100%) on the self-perception of motor competence. and adherence to the Mediterranean diet an average effect (66.67%) and a weak effect on the states of physical activity (16.7%) and free time (33.3%).

ACKNOWLEDGMENTS

REFERENCES

[1] Dieta, N., & de Enfermedades Crónicas, P. (2003). Informe de una Consulta Mixta de Expertos OMS/FAO. OMS, Serie de Informes Técnicos, 916, 1-152.

[2] Organización Mundial de la Salud. (2018). Obesidad y sobrepeso. Available in: https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight

[3] Campillo, J. E., Carmena, R., Casanueva, F., Durán, S., Fernández-Soto, M. L., Formiguera, X., & Ríos, M. S. (2000). Consenso SEEDO'2000 para la evaluación del sobrepeso y la obesidad y el establecimiento de criterios de intervención terapéutica. Med Clin (Barc), 115, 587-597.

[4] Ahrens, W., Bammann, K., Siani, A., Buchecker, K., De Henauw, S., Iacoviello, L., ... & Molnár, D. (2011). The IDEFICS cohort: design, characteristics and participation in the baseline survey. International Journal of Obesity, 35(S1), S3.

[5] Ortega, R. M., López-Sobaler, A., Aparicio, A., González, L. G., Navia, B., & Perea, J. M. (2014). Estudio ALADINO 2013: Estudio de Vigilancia del Crecimiento, Alimentación, Actividad Física, Desarrollo Infantil y Obesidad en España 2013. Madrid: Agencia Española de Consumo, Seguridad Alimentaria Y Nutrición. Ministerio de Sanidad, Servicios Sociales e Igualdad.

[6] Estudio ALADINO 2015: Estudio de Vigilancia del Crecimiento, Alimentación, Actividad Física, Desarrollo Infantil y Obesidad en España 2015. Agencia Española de Consumo, Seguridad Alimentaria y Nutrición. Ministerio de

Sanidad, Servicios Sociales e Igualdad. Madrid, 2016. Available in: http://www.aecosan.msssi.gob.es/AECOSAN/docs/documentos/nutricion/observatorio/Estudio_ALADINO_2015.pdf

[7] Organización Mundial de la Salud. (25 de enero de 2016). de la Salud, A. M. (2016). Informe de la Comisión para acabar con la obesidad infantil: Informe de la Directora General (No. A69/8). Organización Mundial de la Salud.

[8] de la Torre Díez, I., Garcia-Zapirain, B., López-Coronado, M., Rodrigues, J. J., & del Pozo Vegas, C. (2017). A new mHealth app for monitoring and awareness of healthy eating: development and user evaluation by spanish users. Journal of medical systems, 41(7), 109.

[9] Khaylis, A., Yiaslas, T., Bergstrom, J., & Gore-Felton, C. (2010). A review of efficacious technology-based weight-loss interventions: five key components. Telemedicine and e-Health, 16(9), 931-938.

[10] Lewis, B. A., Napolitano, M. A., Buman, M. P., Williams, D. M., & Nigg, C. R. (2017). Future directions in physical activity intervention research: expanding our focus to sedentary behaviors, technology, and dissemination. Journal of behavioral medicine, 40(1), 112-126.

[11] Nogueira, T. F. D., & Zambon, M. P. (2013). Reasons for non-adherence to obesity treatment in children and adolescents. Revista Paulista de Pediatria, 31(3), 338-343.

[12] González-González, C. S., del Río, N. G., & Navarro-Adelantado, V. (2018). Exploring the Benefits of Using Gamification and Videogames for Physical Exercise: a Review of State of Art. International Journal of Interactive Multimedia & Artificial Intelligence, 5(2).

[13] Lanningham-Foster, L., Foster, R. C., McCrady, S. K., Jensen, T. B., Mitre, N., & Levine, J. A. (2009). Activity-promoting video games and increased energy expenditure. The Journal of pediatrics, 154(6), 819-823.

[14] Mellecker, R. R., & McManus, A. M. (2008). Energy expenditure and cardiovascular responses to seated and active gaming in children. Archives of pediatrics & adolescent medicine, 162(9), 886-891.

[15] González, C. S., Gómez, N., Navarro, V., Cairós, M., Quirce, C., Toledo, P., & Marrero-Gordillo, N. (2016). Learning healthy lifestyles through active

videogames, motor games and the gamification of educational activities. Computers in Human Behavior, 55, 529-551.

[16] del Río, N. G., González, C. S. G., González, R. M., Adelantado, V. N., Delgado, P. T., & Fleitas, Y. B. (2018, April). Gamified educational programme for childhood obesity. In Global Engineering Education Conference (EDUCON), 2018 IEEE (pp. 1962-1668). IEEE.

[17] del Río, N. G., González-González, C. S., Martín-González, R., Navarro-Adelantado, V., Toledo-Delgado, P., & García-Peñalvo, F. (2019). Effects of a Gamified Educational Program in the Nutrition of Children with Obesity. Journal of medical systems, 43(7), 198.

[18] González-González, C. S., Toledo-Delgado, P., Padrón, M., Santos, E., & Cairos, M. (2013). Including gamification techniques in the design of TANGO:H Platform. J. Teknol, 63, 77-84.

[19] González-González, C. S., Cairós-González, M., & Navarro-Adelantado, V. (2013). EMODIANA: Un instrumento para la evaluación subjetiva de emociones en niños y niñas. In Actas del XIV Congreso Internacional de Interacción Persona-Ordenador. https://doi. org/10.13140/RG (Vol. 2, No. 5112.2169).

[20] Reynolds, C. R., Kamphaus, R. W., & Marqués, J. G. (2004). BASC: Sistema de evaluación de la conducta en niños y adolescentes: manual. TEA.

[21] Serra-Majem, L., Ribas, L., Ngo, J., Ortega, R. M., García, A., Pérez-Rodrigo, C., & Aranceta, J. (2004). Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. Public health nutrition, 7(7), 931-935.

[22] Alfageme González, M. B., & Sánchez Rodríguez, P. A. (2003). Un instrumento para evaluar el uso y las actitudes hacia los videojuegos. Pixel-Bit. Revista de Medios y Educación, 20, 17-32.

[23] García-Peñalvo, F. J. (2014). Formación en la sociedad del conocimiento, un programa de doctorado con una perspectiva interdisciplinar. Education in the Knowledge Society 15, 1, 4-9.

[24] García-Peñalvo. F. J. (2015). Engineering contributions to a Knowledge Society multicultural perspective. IEEE Revista Iberoamericana de Tecnologías del Aprendizaje (IEEE RITA) 10, 1, 17-18. DOI:10.1109/RITA.2015.2391371