Universitat Autònoma de Barcelona

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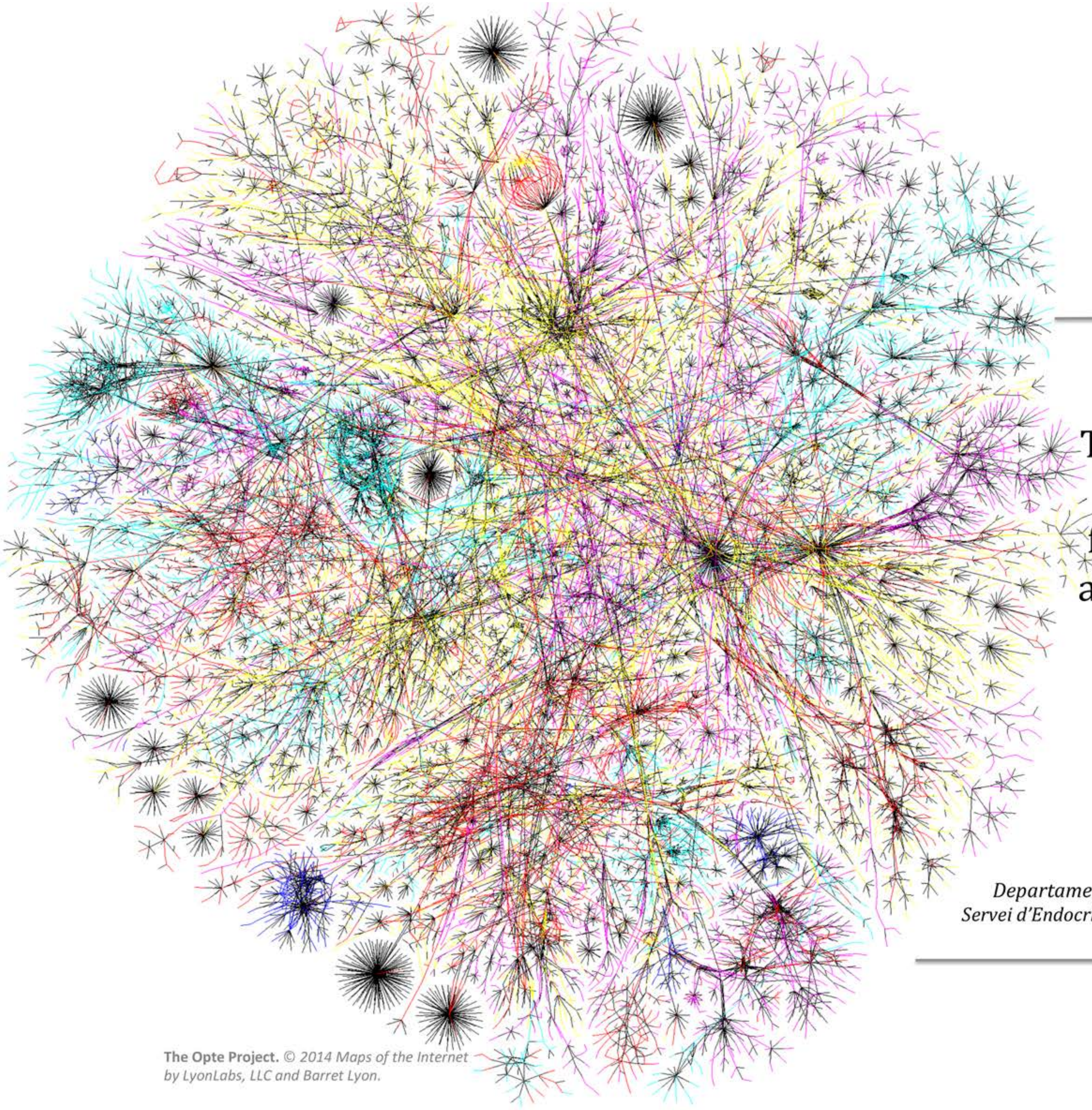
Valeria Alcántara Aragón



The Opte Project. © 2014 Maps of the Internet
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Tesis presentada por

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Para optar al grado de
Doctora por la Universidad de Barcelona (UAB)

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Tesis adscrita al Departamento de Medicina, programa de doctorado en Medicina

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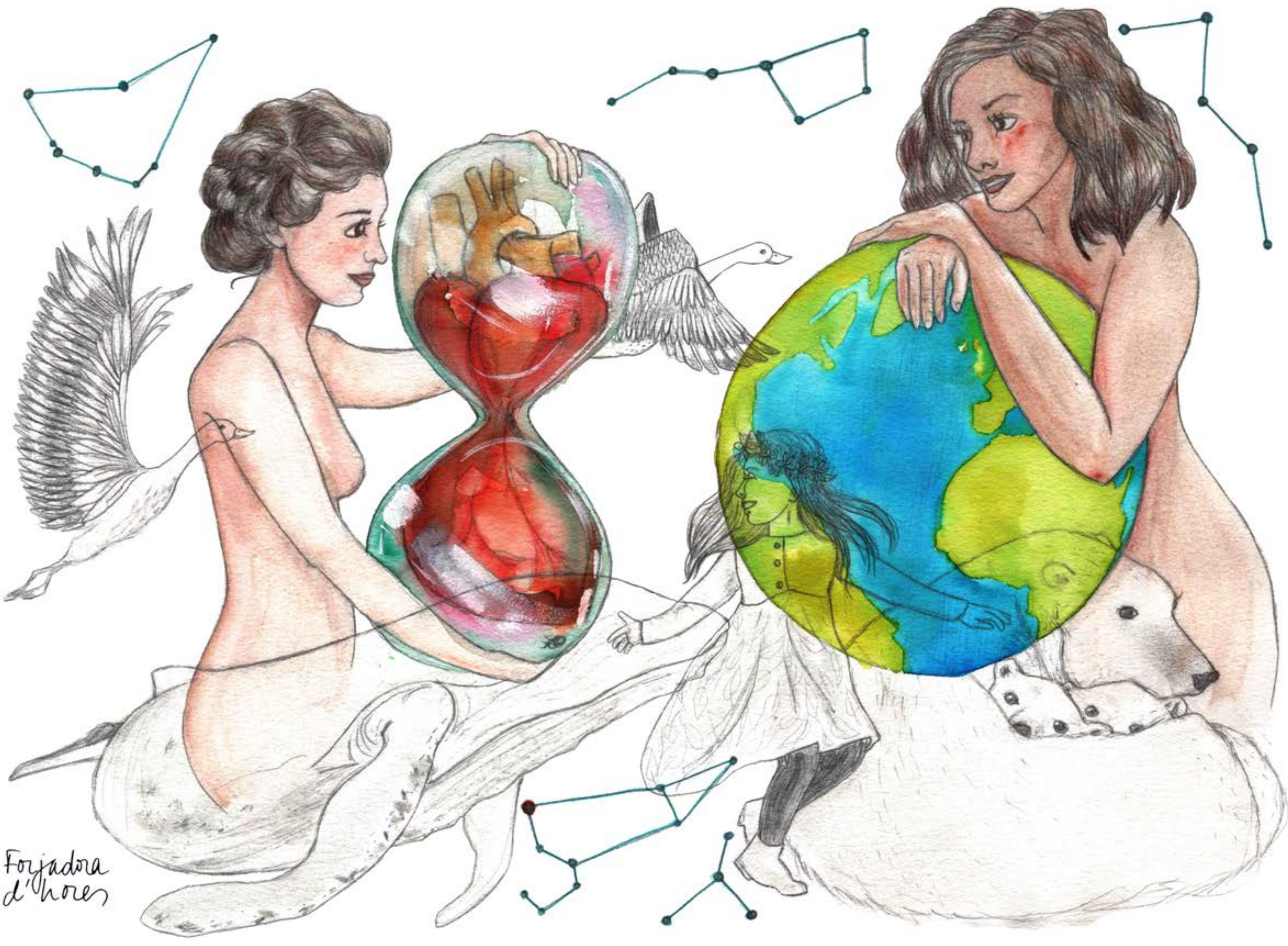
Dr. Alberto de Leiva Hidalgo (Director/tutor)	Dra. Cintia Gonzalez Blanco (Directora)

Valeria Alcántara Aragón
(estudiante)

con cariño a mis pacientes …



El Tiempo es Oro
Antonia Pelaez
#forjadoradhores

La dedicatoria y los agradecimientos de esta tesis se iban a quedar solo en esa primera y tan bonita página, pero es imposible no agradecer a muchas otras personas por su apoyo y porque de alguna manera me entrenaron el corazón para hacer mi trabajo con cariño:

**A Clara y los Raúles, Daniel, Markel y familias; la chilanga-banda, Toñi, Justa, María José, Jenny, Ana Claudia, Pepe, Susanita, Karla, Gil, Pelin, Anna A y Anna D - todos aquellos amigos sinceros que a través de los años han reforzado en mi todo el cariño, la curiosidad, el inconformismo, y las ganas.*

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Abbreviations & Acronyms:

T2DM: type 2 Diabetes Mellitus
BMI: Body-mass-index
NTI: Non-telematic intervention
TI: Telematic intervention
HbA1c: Glycated hemoglobin
MWU: Man-Whitney U test
DMT2: Diabetes Mellitus tipo 2
IMC: Índice de masa corporal
GNT: Grupo control de intervención no telemática
GT: Grupo experimental de intervención telemática
WHO: World Health Organization
PDA: Personal digital assistants
SMS: Short message service
CI: Confidence interval
WL: Weight-loss
MD: Mean difference
ETE: Estimated treatment effects
WC: Waist Circumference
WLM: Weight-loss maintenance
PP5%: Percent of participants with ≥5% weight-loss
NS: Non-significant
QoL: Quality of life
UPM: Madrid Polytechnic University
BEDCA: Base de Datos Española de Composición de Alimento (Spanish food composition database)
CESNID: Centre d'Ensenyament Superior de Nutrició i Dietètica (Centre of Superior Studies in Human Nutrition and Dietetics)
kg: kilograms
IPAQ: International Physical Activity Questionnaire
ACTA: Attitudes towards change in eating disorders questionnaire
PP: Per protocol
ITT: Intention to treat analysis
LOCF: Last observation carried forward
MI: Multiple imputation
X^2: Chi-squared test

WHR: Waist/hip ratio
RHR: Resting heart rate
SBP: Systolic blood pressure
DBP: Diastolic blood pressure
PF: Physical functioning domain- QoL
RP: Role-physical domain -QoL
BP: Bodily pain domain – QoL
GH: General Health domain- QoL
VT: Vitality domain – QoL
SF: Social Functioning domain – QoL
RE: Role-emotional domain – QoL
MH: Mental Health domain – QoL
PCS: Physical component summary QoL
MCS: Mental component summary QoL

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Summary

Obesity, Type 2 diabetes mellitus (T2DM) and their complications are public health issues that have progressively increased in the past decades at an almost worldwide scale. Given this alarming trend and the growing population affected, most health-care systems are unable to assume the intensified treatments that would be needed for obesity and T2DM prevention. *Telemedicine* is a promising field given the broad and ubiquitous use of the Internet and the popularization of connection devices. The term *telemedicine* literally means "*healing at a distance*". The telemedicine project PREDIRCAM2, consisted of the design and clinical validation of a web platform for the treatment of obesity, T2DM prevention and healthy lifestyle promotion. A multidisciplinary team composed of engineers and health professionals designed the platform. Healthy volunteers tested its functionality and then it was validated in a clinical trial. Inclusion criteria were: adults younger than 65 years old, body mass index (BMI) of 30 to 39kg/m^2, not receiving any medications for blood glucose, blood pressure, lipid or weight control at the time of recruitment. 183 participants were recruited in two participant centers and were randomized in two groups: a non-telematic (NTI) intervention control group, and an experimental group that received a telematic intervention (TI). Both groups received one-year follow-up. Participants in the NTI group received full in-person care in 9 visits and participants of the TI group received 5 in-person visits plus access to the web platform were they performed 4 telematic visits and received continued telematic support for 1-year. General dropout rates were 31.1% at 6 months and 42.1% at 12 months. At 6-months follow-up the dropout rates were significantly higher for the TI group (38% TI vs. 24% NTI, X^2 p = 0.034); this difference tended to diminish towards the end of the study. Both groups lost weight significantly at short term. The TI group lost more

weight however this difference was not statistically significant in the intention-to-treat analysis. Metabolic results were similar between groups, finding a progressive reduction of HbA1c values during follow-up. At long term, both groups tended to regain weight beginning at 9-months follow-up, these 9 to 12-month changes were not statistically significant. In the completers analysis, the percentage of participants who achieved a ≥5 weight loss was significantly greater for the TI group (65% TI vs. 43% NTI, MWU p = 0.031). BMI, waist circumference and percentage of weight-loss showed similar results at 9 months follow-up. However these differences were not significant in the intention-to-treat analysis. Satisfaction evaluations showed an adequate acceptance of the telematic intervention and functionality of the PREDIRCAM2 platform. The need to incorporate behavior change psychologists into the multidisciplinary team for future interventions is suggested by the most frequently reported reasons for dropout, as well as by expressed participant opinions. The incorporation of automatized systems may be useful to improve dietary logging, potentially improving usability and adherence. The cost-effectiveness evaluation showed the TI intervention was -113 €/patient/year less expensive than traditional non-telematic care, mainly by reducing cost in health-care appointments. The use of physical activity tracking devices with pulsometers made the TI more expensive than the NTI (+24 € (p=0.001, CI 95% 7.5 – 24.35). Every day technologies, such as mobile devices, pedometers, and social media should be incorporated into future studies of telemedicine interventions on obesity and T2DM prevention and may improve their cost-effectiveness. Telemedicine treatment delivered by the PREDIRCAM2 web platform is effective for the treatment of obesity, T2DM prevention at a reduced cost when compared to traditional full in-person intensified care.

Resumen

La obesidad, la diabetes mellitus tipo 2 (DMT2) y sus complicaciones son problemas de salud pública que han presentado un progresivo incremento en las últimas décadas, prácticamente a nivel global. Debido a esta tendencia alarmante, la mayoría de los sistemas sanitarios del mundo no están siendo capaces de atender a toda la población que necesitaría tratamiento. *La telemedicina* es un campo que ofrece muchas posibilidades debido a la amplia red de internet y el popular uso de dispositivos con conexión. El término *telemedicina* literalmente quiere decir "*curar a distancia*". El proyecto de telemedicina PREDIRCAM2, consistió en el diseño y la validación clínica de una plataforma web para el tratamiento de la obesidad, la prevención de DMT2 y la promoción de estilos de vida saludables. Fue diseñada por un equipo multidisciplinar de bioingenieros y profesionales sanitarios. Una vez diseñada la herramienta, fue probada por un grupo de voluntarios sanos. Verificada su funcionalidad, dio inicio un ensayo clínico para validar su uso en el tratamiento de la obesidad y la prevención de DMT2. Los criterios de inclusión fueron: adultos de hasta 65 años de edad, obesidad con índice de masa corporal (IMC) de 30 a 39 kg/m^2, no estar recibiendo tratamientos farmacológicos para DMT2, control de peso, hipertensión o dislipemia al momento de inclusión en el estudio. Se incluyeron 183 personas, reclutadas en 2 centros sanitarios distintos y fueron aleatorizadas en 2 grupos: un grupo control de intervención no telemática (GNT) y un grupo experimental de intervención telemática (GT). Ambos grupos recibieron tratamiento y seguimiento durante un año. Los participantes del GNT recibieron el tratamiento de forma tradicional en 9 visitas presenciales y los participantes del GT recibieron 5 visitas presenciales además de utilizar la plataforma web, donde realizaron 4 visitas telemáticas y recibieron soporte telemático continuado a lo largo de todo un año. Las tasas generales de abandono fueron 31.1% a los 6 meses y 42.1% a los 12 meses. A los 6 meses las tasas de abandono fueron significativamente más altas en el GT (38% GT vs. 24% GNT, X^2 $p = 0.034$); esta diferencia entre grupos tendió

a disminuir hacia el final del estudio. A corto plazo ambos grupos perdieron peso de forma significativa. El GT perdió más peso que el GNT, sin embargo esta diferencia no fue estadísticamente significativa en la comparación entre grupos en análisis por intención de tratar. Los resultados metabólicos fueron similares entre los grupos, observando una disminución significativa y progresiva de HbA1c a lo largo del seguimiento. A largo plazo, ambos grupos presentan tendencia a la re-ganancia de peso a partir de los 9 meses, estos cambios no fueron estadísticamente significativos. En el análisis por protocolo, la proporción de participantes que logró reducciones de ≥5% del peso corporal fue significativamente mayor en el GT (65% GT vs 43% GNT, MWU $p = 0.031$). El IMC, diámetro de cintura y el porcentaje de peso corporal perdido mostraron resultados similares a los 9 meses. Sin embargo estas diferencias no fueron significativas en el análisis por intención de tratar. Las evaluaciones de satisfacción mostraron una adecuada aceptación de la intervención telemática y de la funcionalidad de la plataforma PREDIRCAM2. La incorporación de psicólogos expertos en cambios de comportamiento al equipo multidisciplinar, está implícita en los motivos de abandono reportados por los participantes así como las valoraciones de satisfacción con el programa. La incorporación de sistemas automatizados serán de utilidad para el agilizar el registro dietético y así mejorar la usabilidad y con esto probablemente también mejorar la adherencia. En el análisis de costo-efectividad, la intervención telemática fue -113 €/paciente/año más económica que la tradicional no telemática, principalmente ahorrando en gasto asistencial. La intervención telemática no resultó costo-efectiva con el uso de dispositivos con pulsómetro para monitorizar la actividad física (+24 € $p=0.001$, CI 95% 7.5 – 24.35). En futuros estudios de intervenciones en este ámbito es recomendable la incorporación de tecnologías de uso diario como los dispositivos móviles, los contadores de pasos y las redes sociales. Los resultados sugieren que el tratamiento mediante telemedicina con el uso de la plataforma web PREDIRCAM2 es efectivo dentro de un programa de tratamiento intensificado para la obesidad y la prevención de DMT2, con un coste reducido en comparación con las intervenciones intensificadas tradicionales.

Chapter 1. Introduction

1.1. Obesity Definition and Epidemiology

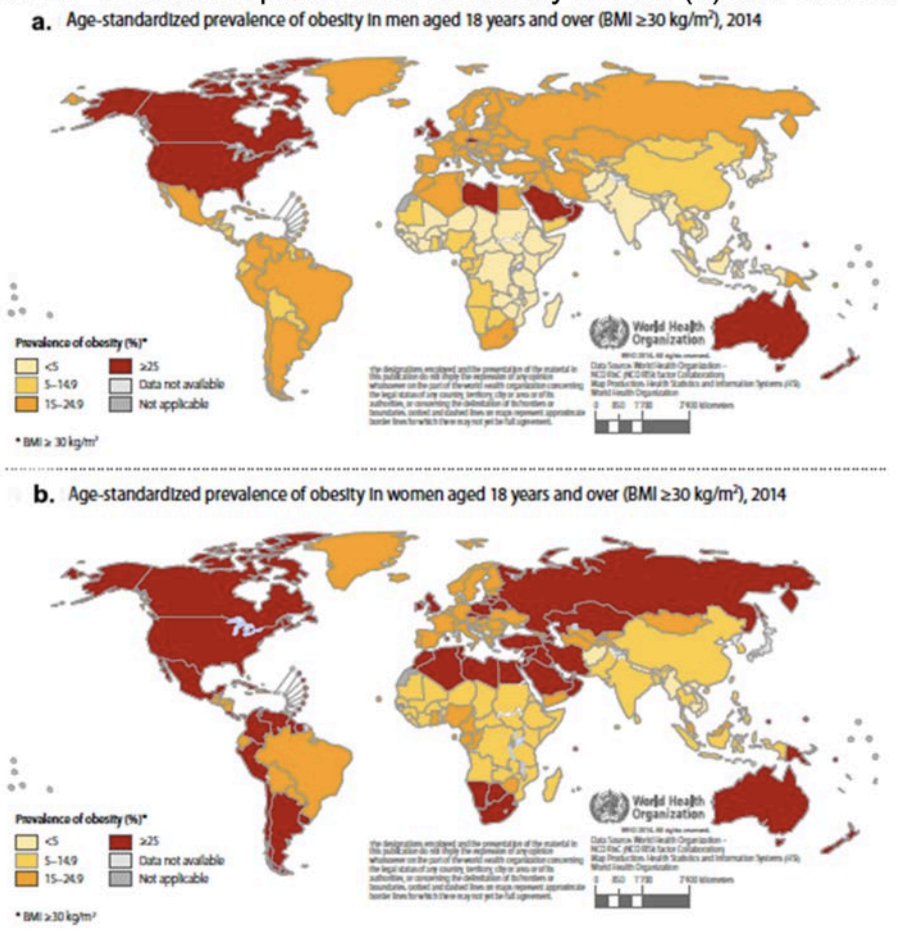
Obesity is the pandemic of our age. It has been called "*globesity*" given its ubiquitous spread (1). It is one of the main sources of preventable diseases and a major economic challenge for healthcare systems worldwide (2). Comorbidities related to overweight and obesity reduce quality of life and cause 3.4 million deaths around the world, mainly due to cardiovascular diseases (1,3,4).

Obesity and overweight have been defined as body-mass-index (BMI) >30kg/m^2 and >25kg/m^2 respectively. This definition however has been challenged for it's simplistic character. Cut-off points may have racial variations, and an adiposity index might be more appropriate, however more complicated to obtain at a general population-scale. Asian regions, for example, have recognized in their populations a higher incidence of obesity comorbidities at lower BMI; thus reflecting the need to redefine obesity for their population at a lower BMI cutoff or ideally considering other adiposity measures (5,6).

Figure 1. Prevalence of overweight in adults 18+, 2016, World Health Organization

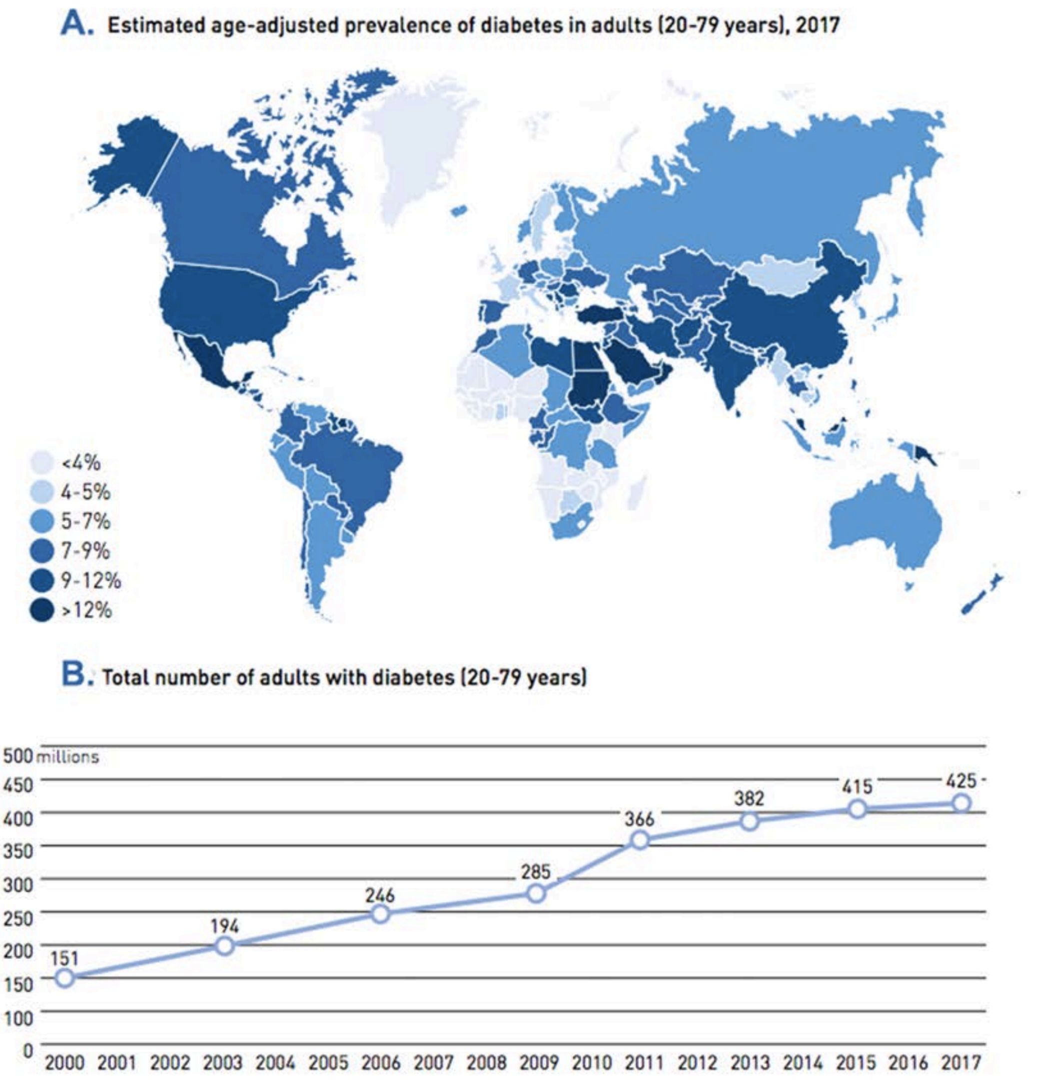
The proportion of adults with a BMI of 25 kg/m^2 or above has continued to rise. Today approximately one-third of the world's population has a BMI ≥25kg/m^2. Thus, in 2016 39% of adults worldwide were overweight according to data from the World Health Organization (WHO) (Figures 1-2) (3,4,7).

Figure 2. Worldwide prevalence of obesity in men (a) and women (b).



In developed countries the rate of increase of obesity is slowing down, while in developing countries this rate is continuing to rise in adults, adolescents and children. In 2017, more than one in two adults and nearly one in six children are overweight or obese in the countries of the Organization for Economic Co-operation and Development (8). No country has reported a decrease in obesity in the past 33 years (3). These trends may also be seen for obesity comorbidities, such as Diabetes (Figure 3) (9). The trends also coincide with an increase of obesity stigma, reported to be increasing in developed countries (10,11). With stigma, comes social alienation, higher indices of psychological ailments such as anxiety and depression as well as disordered eating (10,11). These alarming trends reflect the failure of current programs to reach the populations in need of affordable, and sustainable treatments as well as a desperate need for novel strategies.

Figure 3. Prevalence (a) and incidence (b) of type 2 diabetes mellitus in adults



International Diabetes Federation (IDF) Diabetes Atlas 8th edition 2017

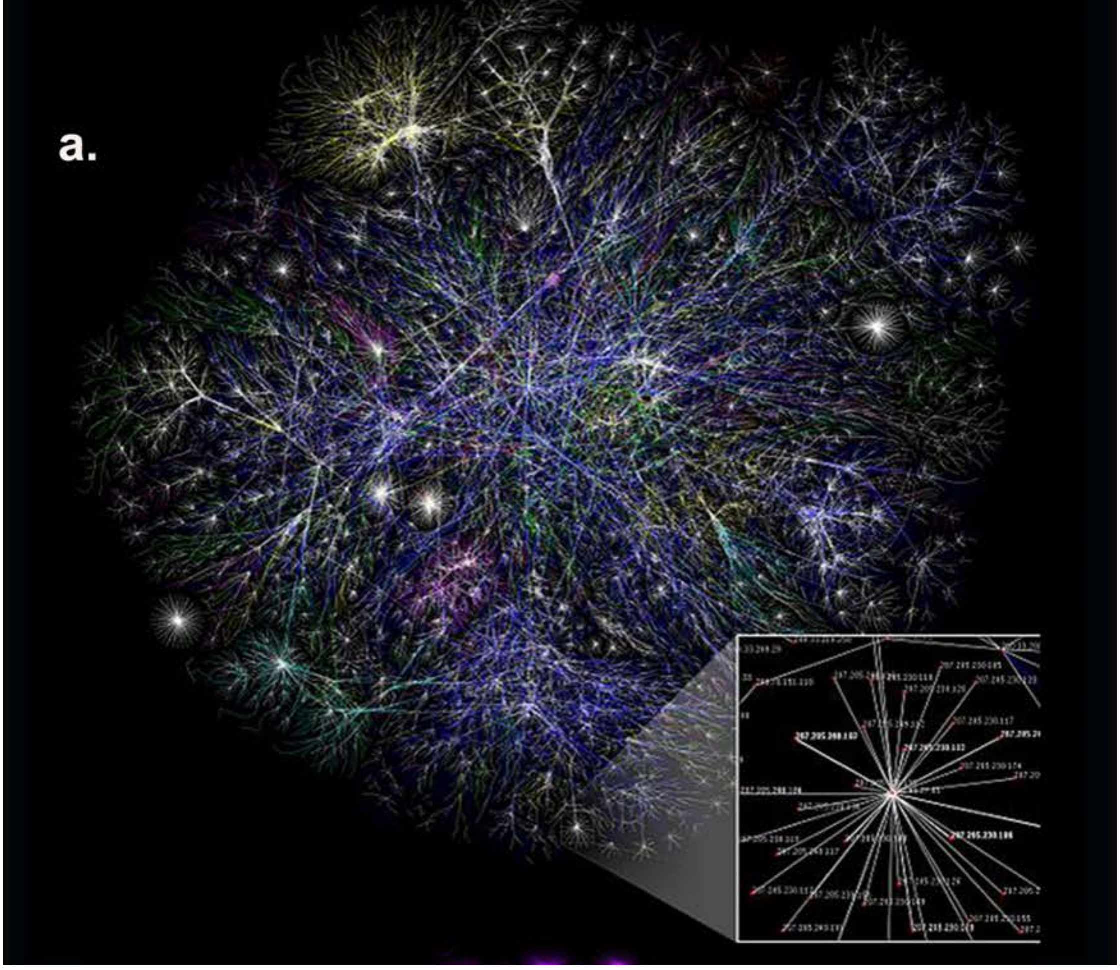
Landmark clinical trials have shown that intensified lifestyle interventions for weight reduction through the increase of physical activity and healthy dieting can prevent, or at least delay cardio-metabolic risks, and particularly delay the onset of obesity comorbidities such as type 2 diabetes (T2DM) (12,13). In this sense, behavior modification therapy has proven to be effective. Multidisciplinary approaches and intensive follow-ups are generally required to achieve weight-loss through behavior modification, to detect and treat possible obesity comorbidities, to promote motivation, treatment adherence, and to achieve weight-loss maintenance (14,15). Unfortunately, these intensified interventions and long-term follow-ups are not economically feasible for most health care systems worldwide. Furthermore, the economic challenge is greatest for those worst affected by obesity: developing countries, low-income and minority populations (3). In this sense, telemedicine may provide cost-effective tools to affront this challenge (16–20).

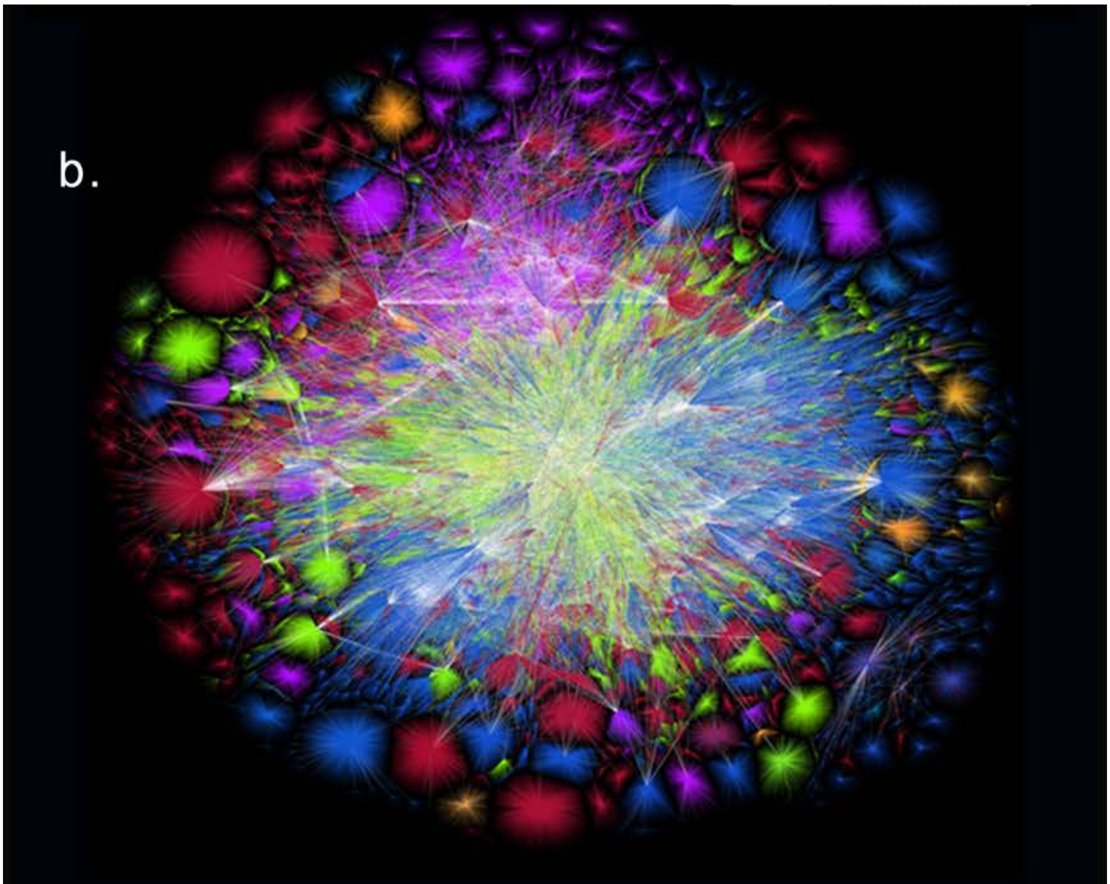
1.2. Telemedicine

Modern telemedicine is a term coined in the 1970's by the National Aeronautics and Space Administration in the United States of America (21). The term literally means, "*healing at a distance*". It allows healthcare professionals to evaluate, diagnose and treat patients in remote locations. The broader term Telehealth also includes non-clinical uses of technology in medical practice, such as patient and professional health-related education, health data management and administration. The term eHealth refers to the use of information and communication technologies for health. mHealth is a subset of Telehealth that is supported by mobile devices, such as smartphones, tracking devices, personal digital assistants (PDA), and other wireless devices. mHealth enables the real-time monitoring of patients and feedback by E-mail, phone, short message service (SMS), voice messages, interactive voice response, virtual reality, or other interactive technologies. In this text the term telemedicine will be used as a reference to all of the above-mentioned technologies.

Growing Internet connectivity has allowed for an intricate and ubiquitous network to develop (Figure 4), and with it the potential to reach whole populations worldwide.

Figure 4. **Partial maps of the Internet (a) from 2005 and (b) from 2015.**





a. The Opte Project made this map in 2006 based on data from 2005. Each node represents an IP address, and the lenght of the line drawn between nodes represents the delay between them. Color codes stand for domain RFC 1918 allocations: **yellow- .net, .ca, .us, purple- .com, .org, green- .mil, .gov, .edu, blue- .jp, .cn, .au, .de, light green- .uk, .it, .pl, .fr, dark blue- .br, .kr, .nl, black- unknown.** This graph represents less than 30% of the class C networks reachable by the data collection program in 2005.

b. The Opte Project made made this map with data from 2015. Color codes stand for the following country allocations: **orange- Africa, purple- Latin America, blue- North America , light green-Europe , red- Asia Pacific.**

Coinciding with the commercial availability of the Internet, publications about telemedicine have increased fairly steadily from 1994 to this date (Figure 5) (22). As telemedicine rises, more than 40,000 healthcare Internet and smartphone-applications have been developed. Up to 5,400 applications have been designed to promote weight-loss and healthy lifestyles (23,24).

Unfortunately, very few of them have been tested for feasibility, validity or cost-effectiveness and their applicability is still to be determined (18,24,25).

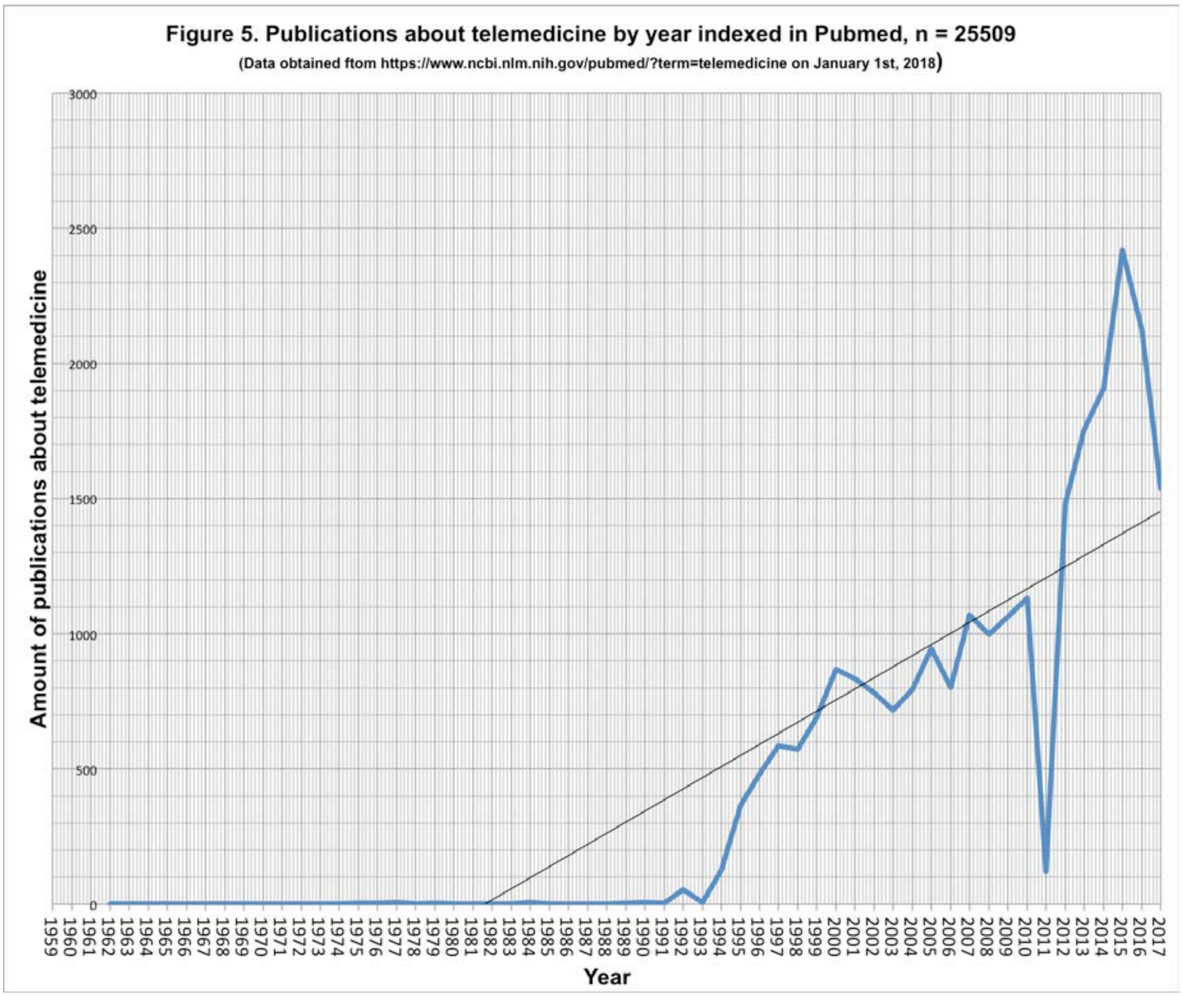


Figure 5. Publications about telemedicine by year indexed in Pubmed, n = 25509
(Data obtained ftom https://www.ncbi.nlm.nih.gov/pubmed/?term=telemedicine on January 1st, 2018)

1.3. Telemedicine applied to obesity treatment

1.3.1 A review of the current state of the art

A search query was designed to include clinical trials containing the key terms: telemedicine, mobile health, mHealth, tele-health, eHealth, and tele-care; and the terms obesity therapy, T2DM and metabolic syndrome control and prevention from the year 2000 to present. The filtered query in PubMed yielded 122 results in the last search performed on January 1st, 2018. In addition to this, the reference lists of the publications retrieved by this query were also manually checked in search for more eligible clinical trials.

All of the abstracts and full texts were assessed for relevance and compliance with the following inclusion criteria: prospective clinical trials that tested a telemedicine behavioral intervention, follow-up of at least 3 months duration, a non-telemedicine intervention control group, adult non-pregnant non-disabled study populations, and the inclusion of weight-loss, BMI or waist circumference as primary or secondary outcome measures. There is high heterogeneity among control groups of telemedicine intervention studies. A lot of these studies have wait-list controls that have not received any interventions at all; they are not included in the review for this reason. Other studies have also used telemedicine strategies as key elements in their control group interventions thus cannot be considered as usual care and are not included in this review, but may still have relevant findings that will be mentioned in this text when appropriate.

A total of 28 relevant publications (26–53) from 23 different study groups were reviewed and are included in this introductory analysis. Mean study duration was 11.44±8.6 months (range 3-36, median 6.25 months). Table S1 in the supplementary section of this text, shows a summary of these publications.

1.3.2. Study Populations

Twenty-five studies (89%) were performed in health care settings. Eleven studies (39%) were performed in primary care settings. Two studies were performed in specific settings: a work-site intervention (28) and an intervention in a military setting (32).

These studies were performed in 8 different countries. Most of them were performed in North America (68%, mainly the United States) followed by Northern Europe (14%, United Kingdom, Finland and Germany), Asia (11%, all from South Korea), and only two studies were from Mediterranean Europe (7%, Greece and Spain).

Study populations were predominantly female. Nineteen publications (68%) reported study populations that were more than 60% female (27–29,31,33–36,38,40,41,43,45–49,51–53). Seven publications (25%) reported a close to even sex ratio (26,32,37,39,44,50,52) and two publications from the same group did not mention the gender proportion of their study populations (30,42).

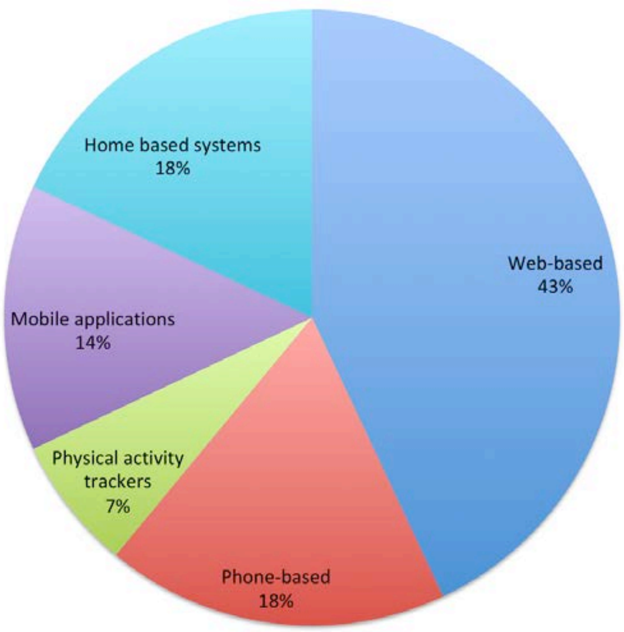
Socio-economical and racial characteristics were diverse. Three studies were performed in underserved or marginalized populations (27,44,51). Five studies (18%) included populations with at least 50% of subjects from racial minority groups (27,28,49,51,52). Eleven studies (39%) were performed in populations composed of mostly white subjects (29,31,33–35,40,43–47,49). Studies that were from outside the USA did not mention the racial characteristics of their populations.

All participants of these studies had a BMI over 25. Six studies were performed in a population with T2DM (30,37,38,42,44,52), two in a hypertensive population (27,50) and two in populations with an elevated cardio-metabolic risk (26,39).

1.3.3. Types of interventions

The most common type (43%) was a combination of a web-based Internet intervention with one or more of the following feedback systems: a web-integrated automatic message system, phone calls, e-mail or SMS (Figure 6).

Figure 6. Types of telematic interventions tested in randomized controlled clinical trials for obesity and diabetes prevention (n=28)



Six publications describe the use of websites that were specifically tailored for the interventions (28,29,40,43,46,50), one described the testing of a web application that is commercially available (47) and five do not describe the application used in their studies (27,34–36,41). Five interventions (18%) were based on automated, interactive voice-response or regular phone calls (33,38,45,51,52), some in combination with e-mail. Five interventions (18%) used home-centered systems for the transmission of measurements and healthcare feedback (26,30,42,44,48). Two interventions (7%) used physical-activity tracking devices and used the commercial web-links of the devices for feedback (31,32) without reporting any other form of feedback. Four publications (14%) reported the use of mobile applications on smartphones or PDAs (37,39,49,53). In general, the studies that used mobile equipment in their interventions are from the year 2011 to present.

1.3.4. Weight-loss and maintenance

Twenty-three publications evaluated weight-loss, one of them in combination with weight-loss maintenance (30). Thirteen (46.4%) of the telemedicine intervention groups lost significantly more weight than control groups (27,29,34,36,37,39,42,44,45,48–51). Two of the telemedicine intervention groups (7.14%) lost significantly less weight than control groups (43,47). The remaining thirteen studies (46.4%) found no significant differences between groups (26,28,30–33,35,38,40,41,46,52,53). The telemedicine intervention groups showed weight changes ranging from +2.8kg to -11.8kg (median -2.43kg, mean -3.8±3,7kg), a mean of 0.59± 0.67kg weight-loss per month. Waist circumference changes ranged from -1,2 to -3.5cm (median -3,0, mean -2.5±1.2cm). BMI changes ranged from +0.3 to -4.1 kg/m^2. The control intervention groups showed weight changes ranging from +0.7 to -9.8kg (median -0.77kg, mean -2.2±2.92kg), a mean of 0.29 ±0.45kg weight-loss per month. Waist circumference ranged from +1 to -3.6cm (median -2.3cm, mean -1.6±2.4cm). BMI changes ranged from +0.2 to -0.33kg/m^2 (median 0, mean -0.04kg/m^2). The only study (30) that evaluated weight-loss maintenance, found no significant differences between groups, with mean weight regain of +2.8kg in the telemedicine intervention group vs. +4.4kg for the control group at 24 months.

1.3.5. Management of obesity comorbidities

Sixteen studies (57%) evaluated obesity comorbidities and cardio-metabolic risk factors as outcome measures (26–28,30,35–39,41,42,44,48,50–52). Nine studies reported significant improvements in comorbidities of telemedicine intervention groups compared to control (27,36,37,39,41,42,44,48,51). In three studies performed in populations with T2DM, the telemedicine intervention groups showed a significant improvement in glycated hemoglobin (HbA1c) compared to control (37,42,44), one of them also showed a reduction of anti-diabetic drug use (42). Two studies reported significant improvements in blood pressure (28,36). One found improvements in both systolic and diastolic blood pressure but no significant differences between groups (28). The study by Park et al found significant differences between groups for both systolic (-6.5 vs +0.9mmHg, p=0.001) and diastolic blood pressure (-4.6 vs +1.5mmHg, p=0.001) (36). However, the two studies performed in hypertensive populations reported no significant changes in blood pressure (27,50).

1.3.6. Satisfaction, adherence, quality of life, and behavior change

The two studies that included satisfaction in their evaluations reported positive results from telematic interventions (39,53). Quality of life was assessed through standardized questionnaires and was reported by three research groups (28,40,48), with score improvements but no significant differences between groups and no relation to weight-loss. Adherence was evaluated by 5 groups, however there is heterogeneity in the strategies employed, and results are inconclusive (33,40,47,49,53).

Behavior change strategies and assessment methods are heterogeneous and underreported. Huber et al suggests the impact of telemedicine on behavior change could be specific for certain populations; as his research found gender-specific changes in behavioral constructs and eating behavior self-efficacy following a telematic intervention (45). Only 3 studies (11%) found a correlation of behavior changes with weight-loss in telematic intervention groups (31,34,44). Izquierdo et al described a mediation effect for diet and exercise knowledge assessed by questionnaires, in achieving a reduction of BMI and waist circumference (44). Polzien et al, found a correlation of time of armband on body with weight-loss in their telemedicine intervention groups (34). Shuger et al also reported that the use of an armband for physical activity tracking was related to weight-loss in their study (31). More recent publications however, show contradictory results from the use of wearables as motivational tools for physical activity and weight-loss (54,55).

1.3.7. Cost-effectiveness

Five publications report cost-effectiveness results. Methodologies are heterogeneous and results are mixed. McConnon et al reported the total costs per person per year were higher for an internet-based therapy (992£) than for traditional therapy (276.12£), while there were no significant differences in weight-loss or quality-adjusted life-years (40). Similarly, a phone counseling intervention was 132$ per 1kg of weight loss while the traditional intervention cost was 72$ per kg lost. The accomplished weight loss was also similar between groups (33).

In a population of obese type 2 diabetic patients, Luley et al found an 83€ reduction in medication costs per patient at 6 months while achieving significant weight-loss in their ABC tele-monitoring intervention program (42). Stumm G et al in an extension of the same program evaluated weight maintenance and estimated a cost of $47 per kg-year, compared to usual care costs of 219- 437$ per kg-year (30). Krukowski et al, in a population of non-diabetic obese women, evaluated cost-effectiveness of a web-based intervention as total costs, payer costs, participants time costs, life gained years, and as an incremental cost-effectiveness ratio. In their cost evaluation they did not include the costs of web development. Cost-effectiveness differences between the web-based intervention and usual care were insignificant when measured in life years. However, when including participants time costs or calculating the incremental cost-effectiveness ratio they report internet-based weight-loss interventions could be cost-effective (43).

1.4. Summary - State of the Art, Gaps and Needs

There is high heterogeneity among the interventions reported in the literature, making it difficult to assess the specific impact of telemedicine when integrated into obesity behavioral interventions. There is scarce data available from Mediterranean populations, and given their unique cultural and socio-economical conditions results may not me replicated in these populations. The specific motivational elements required to improve adherence and behavior change are still to be explored. According to available results, telemedicine interventions show to be at least as effective as usual care for initial weight loss, although more studies are required to assess the role of telemedicine in weight loss maintenance and behavior change. Table 1 summarizes the potential gaps and needs in the state of the art.

Table 1. Potential gaps and needs in the state of the art- Telemedicine as a tool in behavior change interventions for obesity treatment

Gap	Need
Few studies have evaluated weight-loss maintenance and none report long-term behavior change analysis.	Long term evaluations to assess weight maintenance and sustained behavior change
Most studies have been performed in developed countries from North America and Northern Europe.	Studies in populations from other countries, to assess their particular responses and needs.
The combination of telemedicine and in-person sessions shows satisfactory weight-loss results.	Define the amount and type of contacts that may be telematic in an intensified intervention.
The use of physical-activity tracking devices in telematic interventions, could improve weight management, however current results are mixed	Explore the impact of physical activity trackers in obesity telematic interventions.
The specific motivational elements required to improve adherence to telematic-intensified interventions are still to be determined.	Evaluate adherence in relation to participant characteristics and needs.
Cost-effectiveness results are scarce, mainly from countries in North America or North Europe	Cost-effectiveness analyses in a Mediterranean public health-care setting.

Chapter 2. Research justification & hypothesis

Obesity and diabetes are major epidemiological and socio-economical concerns. Intensified life-style interventions for obesity treatment and diabetes prevention have proven to be effective, however they are generally unavailable for all the population that would require them. Previous research suggests that, with the popularization of Internet connectivity, telemedicine may be effective when integrated to health-care interventions and health promotion programs. However, it is unknown if these interventions could be effective for healthy life-style promotion in the treatment of obesity and diabetes prevention in our setting, if the strategy could be cost-effective, the key characteristics that the technology should possess, and how it should be delivered (Table 1).

Our research team started to work in this field with the development of an earlier version of a health web platform for the treatment of obesity and diabetes prevention (PREDIRCAM1) (56). This development was tested in a feasibility pilot, but was not clinically validated. The need for a new development with a clinical validation was triggered by this previous experience.

Our hypothesis is that the integration of a tailored bio-medical web platform to a telematic intensified treatment program for obesity is at least as effective as a traditional face-to-face delivery, in terms of weight-loss, cardio-metabolic risk reduction and with a better cost-effectiveness than traditional strategies.

Chapter 3. Objectives

- **Main objective:** To design and evaluate the efficacy of a web platform for the telemedicine tailored treatment of obesity and cardio-metabolic risk prevention.

- **Specific objectives:**

  1. To design a web platform for the treatment of obesity and diabetes prevention; integrated by tailored prescription and registry of dietary intake, exercise, anthropometric changes, and continued support from health-care providers.

  2. To validate the use of the web platform in a randomized controlled clinical trial with evaluation of the following study variables: anthropometric changes, proportion of participants with ≥5% weight-loss (PP5%) per group, body composition changes, blood pressure, resting heart rate and metabolic outcomes: lipids, fasting glucose, HbA1c, insulin resistance, pre-diabetes status per group, and medication requirements for T2DM or hypertension.

  3. To evaluate quality of life (QoL) and satisfaction of participants.

  4. To evaluate cost-effectiveness of the intervention.

Chapter 4. Methods

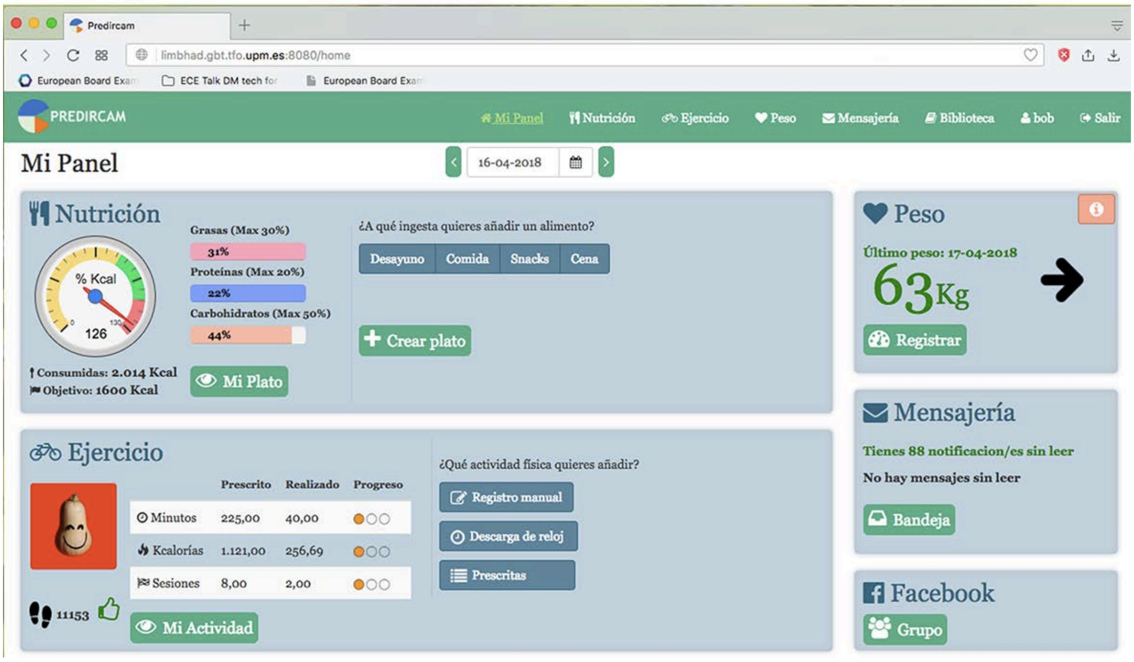
4.1. Design of the web platform and feasibility testing

A multidisciplinary team, including the PhD candidate, designed the PREDIRCAM2 web platform (http://limbhad.gbt.tfo.upm.es:8080/) and its contents from 2014 to 2015. The team was composed of registered dietitians, clinical endocrinologists and nurses from Santa Creu I Sant Pau Hospital in Barcelona, and bioengineers from the Polytechnic University (UPM) in Madrid. The research team held frequent telematic meetings to discuss the content and design of the platform. In the summer of 2015, a 4-week feasibility pilot test was performed with post-pilot evaluation surveys.

4.2. Description of the web platform

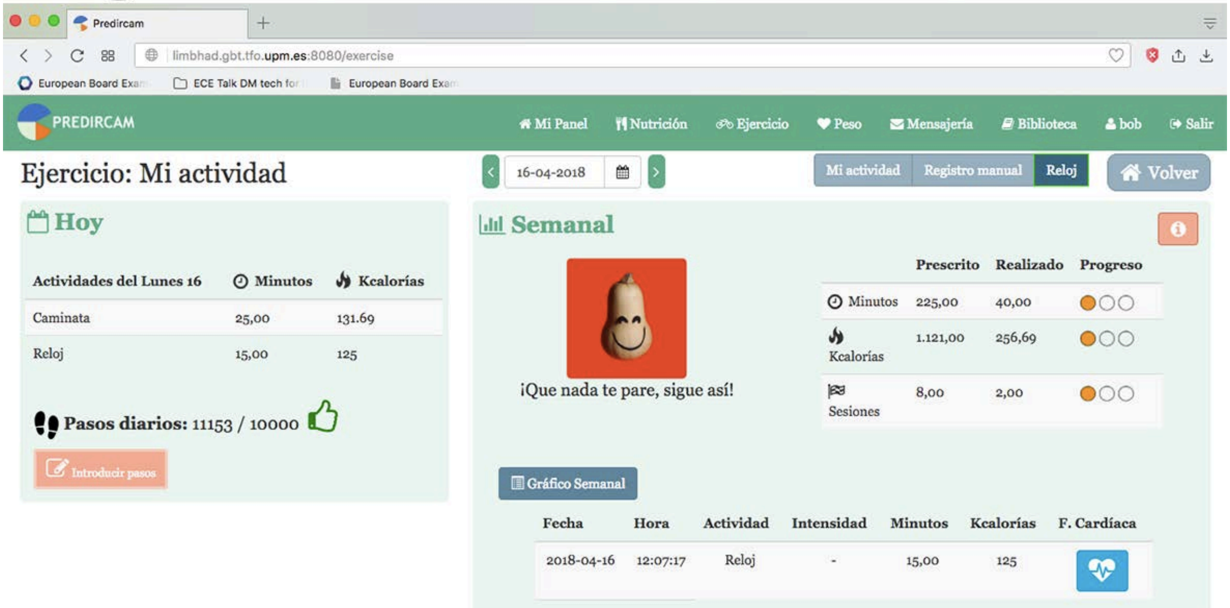
The PREDIRCAM2 web platform was designed as an educational tool for preventive and therapeutic applications. It allows healthcare providers to tailor dietary and physical activity goals, and follow the users in the process of adjusting their life-styles to recommendations. Image 1 shows the general control panel in the user interface with all its modules.

Image 1. PREDIRCAM2 General control panel



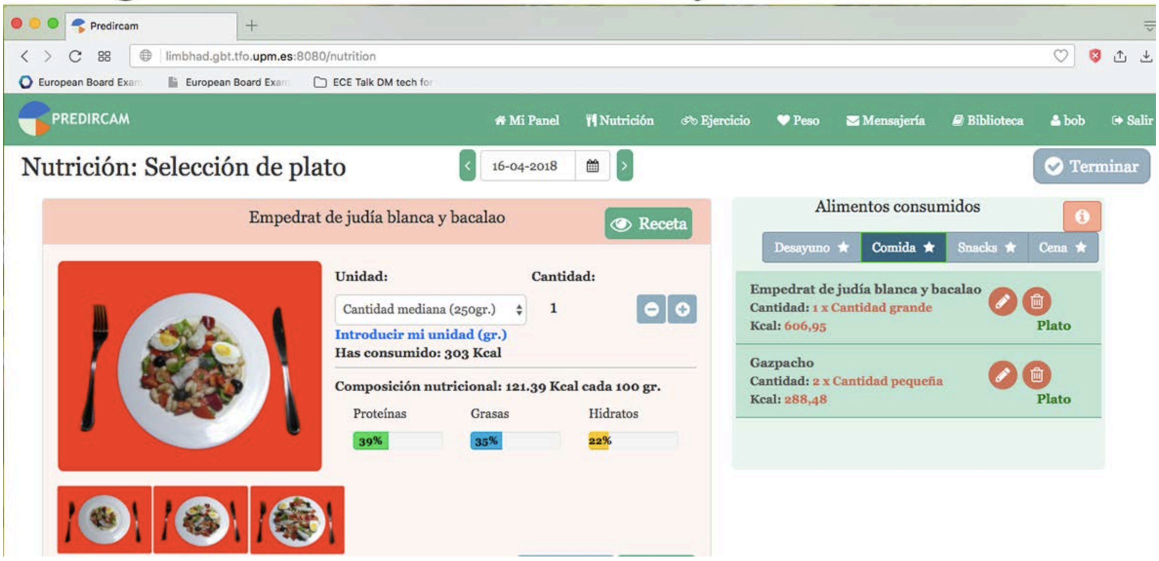
The exercise module allows for tailored prescription. Users may manually register their physical activities and step counts. Information on energy expenditure to calculate manual user input was taken from Ainsworth BE et al Compendium of Physical Activities (57). The module also receives input from Polar RS400 heart rate monitors. Its contents and automatic feedback are based on general physical activity recommendations for adults according to WHO guidelines (58). The dashboard in the user interface of this module is shown in image 2.

Image 2. PREDIRCAM2 exercise module



The dietary module is based on a Mediterranean dietary pattern (59) and feeds on a dynamic database that grows according to the users activity and requests. A food image bank, based on the plate model (60,61) was incorporated into the database of this module, to facilitate quantity recognition and food logging. Twenty percent of the images were donated by Roche Diabetes Care ® in 2015. The rest of the images were created and edited by the PhD candidate following the same protocol: weighing of food on the same balanced kitchen scale and using the same utensils for all the images (same size white dishes, cutlery and glass-ware), with a color coded background according to the food group of the ingredient. The database is structured upon ingredients and allows users to save personal ingredient combinations as dishes and edit existing ones to better resemble their own. Nutritional information derives mainly from national nutrition datasets: Spanish food composition database (BEDCA) and data from the Centre for Superior Studies in Human Nutrition and Dietetics (CESNID). Nutritional information of processed foods was taken from manufacturer's labels. Once the clinical trial was ongoing, the team's registered dietitian assessed and included the users ingredient suggestions, and when possible incorporated an image to facilitate quantity estimation of that ingredient or dish. Image 3 shows the user interface of the dietary module.

Image 3. PREDIRCAM2 dietary module



The platform provides general automatized notifications and also automatic graphic feedback when users log their dietary intake and physical activity. Image 4 shows the automatic graphic feedback the user receives from the dietary module and image 5 shows graphic feedback from the exercise module including heart rate monitoring. A messaging system integrated into the platform enables personalized feedback and advice by allowing the users to communicate with healthcare providers. This messaging system also enables programed telematic visits with health care providers.

Image 4. PREDIRCAM2 feedback from dietary module

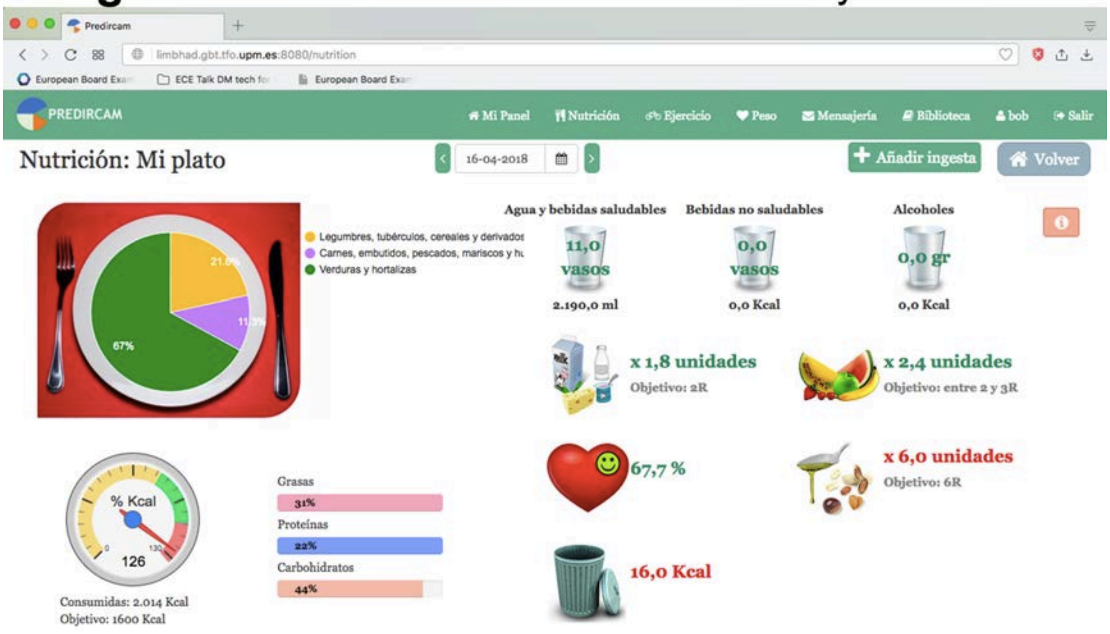
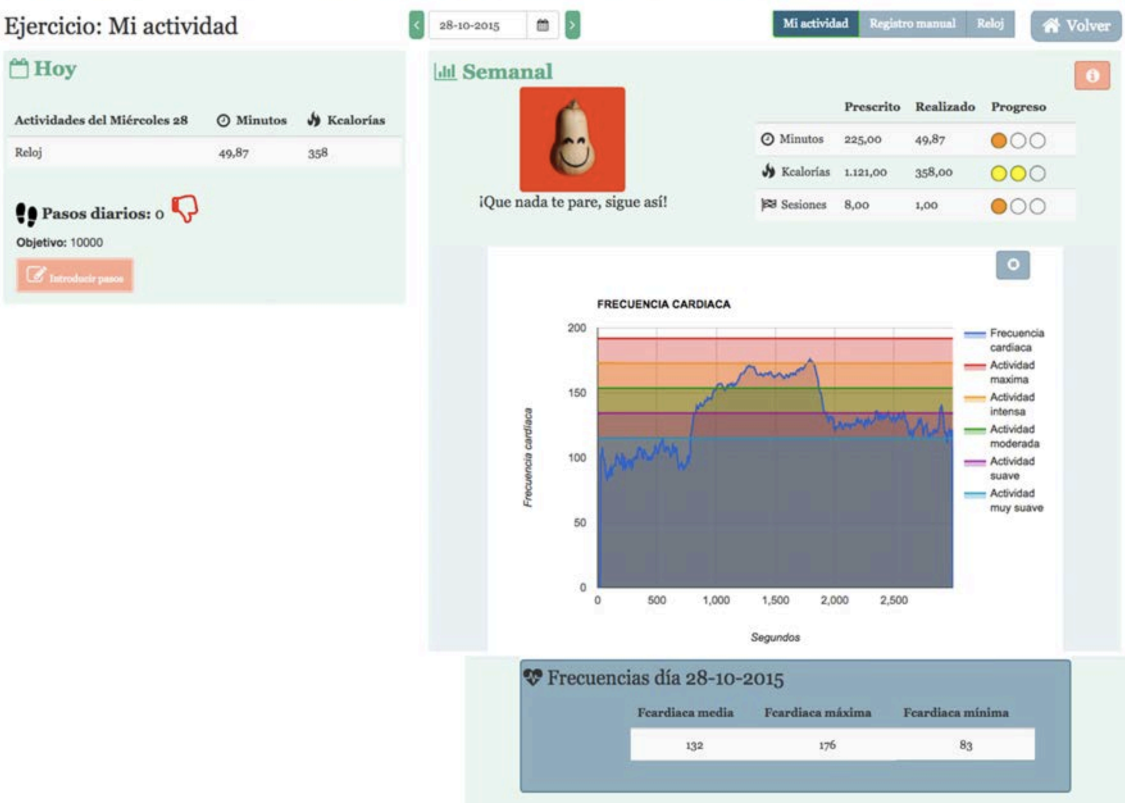


Image 5. PREDIRCAM2 feedback from the exercise module



The platform contains a digital library with informative material created by the research team; such as exercise general recommendations, healthy tips and recipes that the users may download. Users will also find a link to a private group on Facebook®, where they may interact amongst themselves and with healthcare providers.

4.3. Clinical trial - study population and methodology

The participant institutions bioethics committee approved the study protocol. Participants were recruited at the Nutrition and Endocrinology Departments of Hospital de la Santa Creu I Sant Pau, in Barcelona and Hospital Clinico la Fe, in Valencia. Participants were referred by their primary care physicians or by the hospitals occupational health departments. Eligibility criteria were: adults 18 to 65 years old, BMI between 30 and 39.9kg/m2, no severe illnesses, not pregnant, and not receiving any medications for glucose, lipid, blood pressure or weight control. A randomization list was generated at https://www.sealedenvelope.com/ to allocate participants in two groups.

4.3.1 Program structure

The program was structured in 12 appointments. Participants provided their informed consent and underwent evaluation of inclusion criteria with medical history anamnesis and blood testing for screening. Participants were randomly allocated to receive either a telematic intervention (TI) supported by the PREDIRCAM2 web platform, or a non-telematic usual care intervention (NTI). Table 2 shows the activity schedule for both groups in the program.

Table 2. Activity schedule

VISIT NUMBER / TMc (Telematic contact for TI group)	1	2	3	4	5	6/ TMc	7	8/TMc	9/TMc	10	11/TMc	12
DURATION (min) in-person / telematic	30	90	5	90	90	60 / 20	60	90 / 20	60 / 20	90	60 / 20	90
MONTH				0	0.5	1	2	3	4	6	9	12
WEEK	-3	-2	0	1	2	4	8	12	16	24	36	48
Inclusion criteria analysis and informed consent	X											
Blood testing for screening	X											
Blood test, evaluation of screening results		X										
Anthropometric evaluation and body composition analysis		X										X
Randomization			X									
Body weight, BMI, waist, WHR, RHR, BP	X	X		X	X	X	X	X	X	X	X	X
Interview				X	X	X	X	X	X	X	X	X
Baseline 3-day dietary log				X								
Dietary tailored advice and compliance evaluation				X		X	X	X	X	X	X	X
Web dietary logging and interpretation - training session				X								
Physical activity tailored plan and prescription				X								
Physical activity, tailored recommendations				X	X	X	X	X	X	X	X	X
Web physical activity monitoring and interpretation - training session					X							
Web logg evaluation physical activity and dietary pattern						X	X	X	X	X	X	X
Blood testing including study variables				X						X		X
Electrocardiogram		X										X
Quality of life SQ (SF36v2)		X										X
Behavioral change evaluations through SQ: ACTA, IPAQ		X						X		X		X
AdHoc-questionnaires: Satisfaction and personal costs evaluation												X

TI: telematic intervention, BMI: body mass index, WHR: waist-hip ratio, RHR: resting heart rate, BP: blood pressure, SQ: standardized questionnaire
ACTA: Attitud towards change, IPAQ: The International Physical Activity Questionnaire

All participants received one-year follow-up and treatment. Both interventions consisted of tailored exercise and dietary prescriptions. Dietary prescriptions were based on the Mediterranean dietary pattern. The Harris-Benedict formula estimated total dietary energy intake, calculated for adjusted weight, adjusted to physical activity level, and prior diet history. Exercise prescriptions were based on general WHO exercise recommendations for adults (58,59). TI group participants received a heart rate monitor watch at baseline to estimate their physical activity intensity and energy expenditure (Polar RS400). Both groups had access to the same informative material and were asked to log their food intake; TI group through the web platform and NTI group on paper. The health-care provider team was composed of registered nurses certified in diabetes education, nutritionists and endocrinologists. The same team was responsible for both the in-person and telematic visits.

All programed in-person visits for both groups included an interview were behavior change was reassessed. Behavior change strategies employed included: information, self-monitoring, feedback on current behavior, planning, self-efficacy constructs (62,63), behavior substitution, goal setting and comparison between current behavior and goal based on *Control Systems Theory (20)*. Missed visits were rescheduled for up to 3 opportunities, at the third missed appointment the visit was considered failed.

Telematic visits consisted in the evaluation of the users anthropometric, dietary and exercise logs, and the emission of a text message with tailored feedback from healthcare providers. Participants received a reminder one week before the visit. The minimum requirements in order to complete the telematic visit were: dietary logs of at least 3 full days, physical activity of one full week and a monthly log of weight, waist and hip circumference. Upon failure to complete these logs the participant received another reminder and two more opportunities to complete the telematic appointment. At the third missed opportunity the visit was considered failed.

Criteria for withdrawal of participants from the study were the following: pregnancy, severe illness diagnosis, medications that may influence body weight, lipid or glucose metabolism, and failure to attend two consecutive visits. The same withdrawal criteria were applied for both groups.

4.3.2. Anthropometry, body composition, blood pressure and resting heart rate assessments

Weight and height were measured in kilograms (kg) and centimeters respectively. They were measured at Barcelona with a medical rail scale with telescopic measuring rod (Seca 644, Seca 223; Medical scale and measurement systems, Birmingham, United Kingdom), with a graduation of 50 grams and 1mm respectively. At Valencia weigh was measured on a bariatric platform scale (Seca 635 Medical scale and measurement systems, Birmingham, United Kingdom) and height with a Holtain stadiometer (Crosswell, Crymych, Pembs., SA41 3UF, UK), graduation of 50 grams and 1mm respectively. Weight was recorded with participants wearing only light clothes and no shoes. For self-measurements, participants were instructed to weight themselves under the same conditions, and approximately at the same time of day. BMI was calculated by the standard formula: weight in kg divided by height in meters squared.

Waist circumference was measured in centimeters at the midpoint between the iliac crest and the last palpable rib at the end of a normal and complete expiration, following WHO STEPS guideline (64). Participants were trained and instructed to follow the same protocol for self-measurements. Skin folds were measured with a caliper (Saehan®, India) three times on every assessment to obtain a mean. Body composition was estimated by bio-impedance with a Tanita body composition analyzer (BF 350, Tanita Corporation, Maeno-cho, Itabashi-ku, Tokyo, Japan). Blood pressure and resting heart rate were measured twice on every assessment, after the participant had been seated for at least 5 minutes.

4.3.3. Biochemistry

Biochemical assessments were performed on blood samples obtained after an overnight fast of 12 hours. Glucose was measured by the hexokinase method. Insulin was determined by electrochemiluminescent immunoassay (cobas e601; Roche Diagnostics GmbHm, Manheim, Germany), with a precision (CV) of 4,9 and 2,5 % for mean concentrations between 47,6 and 5188 pmol/L respectively. Insulin resistance was assessed by calculation of HOMA-IR, according to Wallace and Mathews et al (65). HbA1c was determined by high-performance liquid chromatography (Variant^{TM} II turbo hemoglobin A1c Kit 2.0 and analyzer instrument, and BIO-RAD Hb-Advisor^{TM} software, BIO-RAD 1000 Alfred Nobel Drive Hercules, California 94547, USA). Cholesterol, cholesterol fractions, and triglycerides were measured according to standard routine laboratory practices in both participant hospitals.

4.3.4. Questionnaires

Standardized questionnaires were used to assess behavior changes: *The International Physical Activity Questionnaire* (IPAQ) to assess changes in daily physical activity and the adapted Spanish version of “Attitudes towards change in eating disorders” (ACTA) of Prochaska and DiClemente to assess potential for behavior change (66). To assess adaptation participants of both groups were regularly asked if they felt restricted or on a diet, and if they felt anxiety towards food or eating.

The Spanish (Spain) SF-36v2® Health Survey was used to assess QoL (QualityMetric™, sublicense 536-10950). To assess satisfaction with the intervention, an adapted version of the questionnaire by Wadden TA et al. was administered to participants from both groups at study completion (67). An ad-hoc questionnaire composed of Likert scales and complementary open questions, was used to evaluate satisfaction with the telematic intervention and web platform use.

4.3.5. Statistical analysis

Per protocol, sample size was determined to be 111 participants per group, with α unilateral error of 5% and power of 80%, for a tolerated difference of 2kg and standard deviation of ±6kg.

To deal with missing data two types of analysis were performed: completers only per protocol analysis (PP), and an intention-to-treat analysis (ITT). The strategy used for the ITT was last-observation-carried-forward (LOCF). Values of $p < 0.05$ were considered significant. Normal distribution was assessed by box-plot evaluation.

Chi-squared tests (x^2) were used to assess categorical variables. Numerical variables that were normally distributed were analyzed in two-way ANOVA tests to assess the effect of group and time. Homogeneity of variances was assessed by Levene's test and the Greenhouse-Geisser correction was applied whenever sphericity violations for the two-way interactions were encountered. The Man-Whitney U test (MWU) was used for non-parametric testing.

Statistical analyses were performed using SPSS package (version 23.0 for Mac OS; SPSS Inc, Chicago IL, USA). Figures were created using Microsoft® Excel® for Mac (2011) version 14.7.7, and *ggplot2* package in RStudio (RStudio Team (2016). RStudio: Integrated Development for R. R Studio Inc., Boston, MA URL http://www.rstudio.com/).

4.3.6. Cost-effectiveness evaluation

The costs included in this evaluation were: participant's costs, health-care provider costs per visit, continued support expenses and wearable technology expenses. As suggested by Krukowski et al, the cost of web development was not included in the cost-effectiveness evaluation assuming the average cost of development would be amortized in the long term (43).

Participant's costs were assessed through an ad hoc survey administered at study completion. Subjects were asked to estimate their personal expenses in commuting and the estimated amount of hours lost from their jobs to participate in the 12-month intervention. The hours missed from work were accounted for according to the Catalan Statistics Department with data from the year 2016: 32 328 € per year, 2694 € per month, considering 40 hours of work per week resulted in an estimated 16.84 € per hour. Given that only participants who completed the study answered the costs and hours-lost from work evaluations, two types of analysis were performed: completers only direct cost analysis, and an ITT with median imputation.

Health-care provider costs per visit were obtained from one of the participant hospital's billing department, considering the private reference list price. This price accounts only for traditional in-person visits with healthcare providers and does not consider the visit's duration. The mean duration of an in-person follow-up visit in this program was 60 minutes. The duration of a telematic visit was estimated to be 20 minutes. Considering in-person visits were charged at the reference price, telematic visits were considered to be one third of this price, given that in the same amount of time three participants would be visited instead of only one.

Continued support costs were estimated considering support personnel costs (technicians and registered nutritionists), Internet access, and data security copies. Given that wearables to monitor physical activity are currently available at a wide range of prices, cost estimations were made to consider the use of a device that included pulsometer and pedometer. The price was estimated based on currently available products from three leading commercial brands.

For evaluation of total cost differences between groups, bootstrapping was used for calculation of confidence intervals of the median differences, using the *Median.diff* function of the *pairwiseC*I package in R studio (RStudio Team (2016). RStudio: Integrated Development for R. R Studio Inc., Boston, MA URL http://www.rstudio.com/).

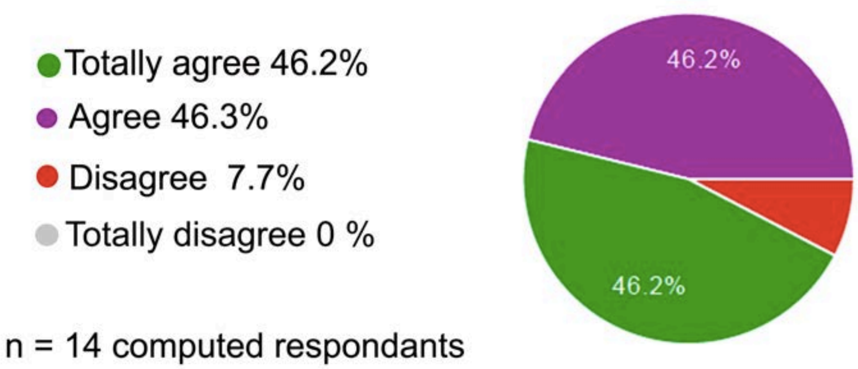
Chapter 5. Results

5.1. Objective 1. Design and feasibility

The PREDIRCAM2 platform is described in chapter 4 (*p.30-35*). The functionality of this platform was tested in a 4-week feasibility pilot test. Twenty-two healthy volunteers aged 31 to 72 years old, from Madrid, Valencia and Barcelona participated in the pilot test. At the end of this test 14 volunteers (63%) completed the evaluation surveys. These evaluations were positive in general. Figure 7 shows responses to an item in the evaluation survey regarding intuitiveness; evaluation for functionality, and usability showed similar results. Free text fields were available for reporting technical incidences and for suggestion of general improvements. Following these survey evaluations and the corresponding changes to the web platform, it was deemed ready to be used in a clinical trial.

Figure 7.

Answers to the question ***"All the web scenarios are clear and intuitive "*** :



5.2. Objective 2. Results from a randomized controlled clinical trial

5.2.1 Study population characteristics at baseline and flow of participants

The dropout of a third participating center prior to recruitment, limited our total sample size. 183 participants were recruited in two tertiary care centers, one in Barcelona and one in Valencia, Spain. Participants were randomly allocated in two groups. Table 3 shows the baseline characteristics of the study population. There were significant differences between groups in education level and T2DM diagnosis at baseline. More participants in the TI group had a higher education degree, compared to the NTI group (*61* vs *47%,* p = 0.045). All participants who had been diagnosed with T2DM were in the TI group (*4.4* vs *0%,* p = 0045). Primary care physicians diagnosed these participants more than one year prior to recruitment. No significant correlations were found

Table 3. Baseline characteristics of the study population

	General n = 183	TI Group, n = 91	NTI Group, n = 92	p - value
Age (years)	44.5 ± 10.8	43.9 ± 11.2	44.6 ± 11.5	ns
Females (%)	83.6	86	82	ns
High education level (%)	54	61	47	0.0446
Smokers (%)	16	18	13	ns
Ex-smokers (%)	28	27	30	ns
Hypertension (%)	5	5.4	5.5	ns
Type 2 Diabetes Mellitus (%)	2	4.4	0	0.0449
Dyslipidemia (%)	11	11	12	ns
BMI (kg/m2)	34.75 ± 2.75	34.5 ± 2.7	35 ± 2.8	ns
Weight (kg)	94.17 ± 12.68	93.2 ± 12.1	95.1 ± 13	ns
Waist (cm)	105.93 ± 9.5	104.71 ± 9	105.87 ± 10.1	ns
WHR	0.912 ± 0.08	0.911 ± 0.08	0.913 ± 0.09	ns
Body fat (%)	42.33 ± 4.53	40.89 ± 5.47	40.9 ± 5.52	ns
RHR (bpm)	73.2 ± 12.1	74.1 ± 11.4	74.2 ± 11.8	ns
SBP (mmHg)	128.85 ± 14.6	129.4 ± 14.4	127.5 ± 14.4	ns
DBP (mmHg)	83.81 ± 9.18	84.3 ± 8.9	82.4 ± 8.4	ns
HbA1c (%)	5.47 ± 0.36	5.44 ± 0.40	5.41 ± 0.33	ns
Insulin (pmol/l)	88.42 ± 42.75	94.33 ± 47.74	92.26 ± 49.94	ns
LDL cholesterol (mg/dl)	120.4 ± 29	120.8 ± 26.4	123.7 ± 31.5	ns
Non-HDL cholesterol (mg/dl)	138.98 ± 32	140.97 ± 31.02	142.98 ± 33.6	ns
HDL (mg/dl)	55.24 ± 14	54.4 ± 13	53.4 ± 14	ns
LDL/ApoB	1.21 ± 0.21	1.22 ± 0.2	1.21 ± 0.2	ns
Triglycerides (mg/dl)	93.71 ± 36	104.03 ± 61.50	99.41 ± 46.33	ns
HOMA-IR	2.93 ± 1.57	3.09 ± 1.68	3.04 ± 1.74	ns

TI: telematic intervention, NTI: non-telematic intervention, WHR: waist/hip ratio, RHR: resting heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure between these variables and outcome variables. No other significant differences between groups were present at baseline.

The general dropout rate was 14.7% at 3 months, increased to 31.1% at 6 months, and to 42.1% at 12 months. Figure 8 shows the flow of participants in the study. Group differential dropout rates were statistically significant at 6 months: 38.5% for the TI group vs. 23.9% for the NTI group (p =0.034). Table 4 shows the dropout differential rates per month. The most frequent dropout reason reported by the TI group was having family issues followed by lack of motivation and finding the intervention too time consuming. The most frequent dropout reason for the NTI group was unknown, from the participants who simply stopped showing up for appointments. The second most reported reason from the NTI was finding the intervention too time consuming. Figure 9 shows participant dropout counts and the reported reasons for dropout. The most frequently reported family issues were having a sick child, sick or terminally ill parent or spouse. Health related issues for dropout or study withdrawal included eating disorders, cancer diagnosis, accidents, and one case of medication requirements for glucose control.

Table 4. General and differential dropout rates by month.

	3 months				6 months				9 months				12 months			
	Gen.	Dif.		p	Gen.	Dif.		p	Gen.	Dif.		p	Gen.	Dif.		p
Dropout (%)	14.7	**NTI (%)**	9.8	ns	31.1	**NTI (%)**	24	*	39.9	**NTI (%)**	34	ns	42.1	**NTI (%)**	37	ns
		TI (%)	19.8			**TI (%)**	38			**TI (%)**	46			**TI (%)**	47	

Gen. : General rates**, Dif.** : differential rates by group, **NTI:** non-telematic intervention, **TI:** telematic intervention, *X^2 *, between groups p = 0.034.*

Figure 8. Flow of participants in the study

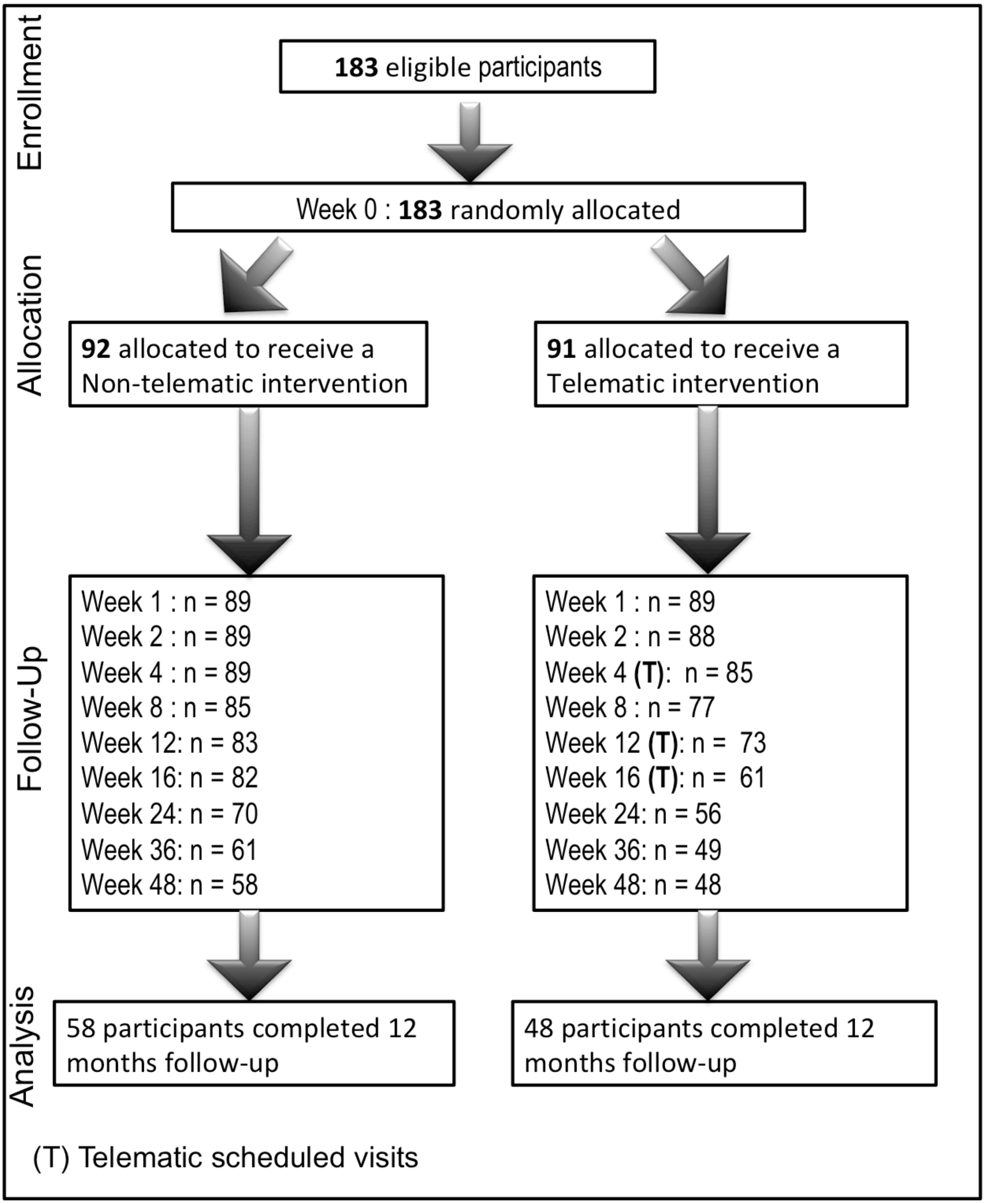
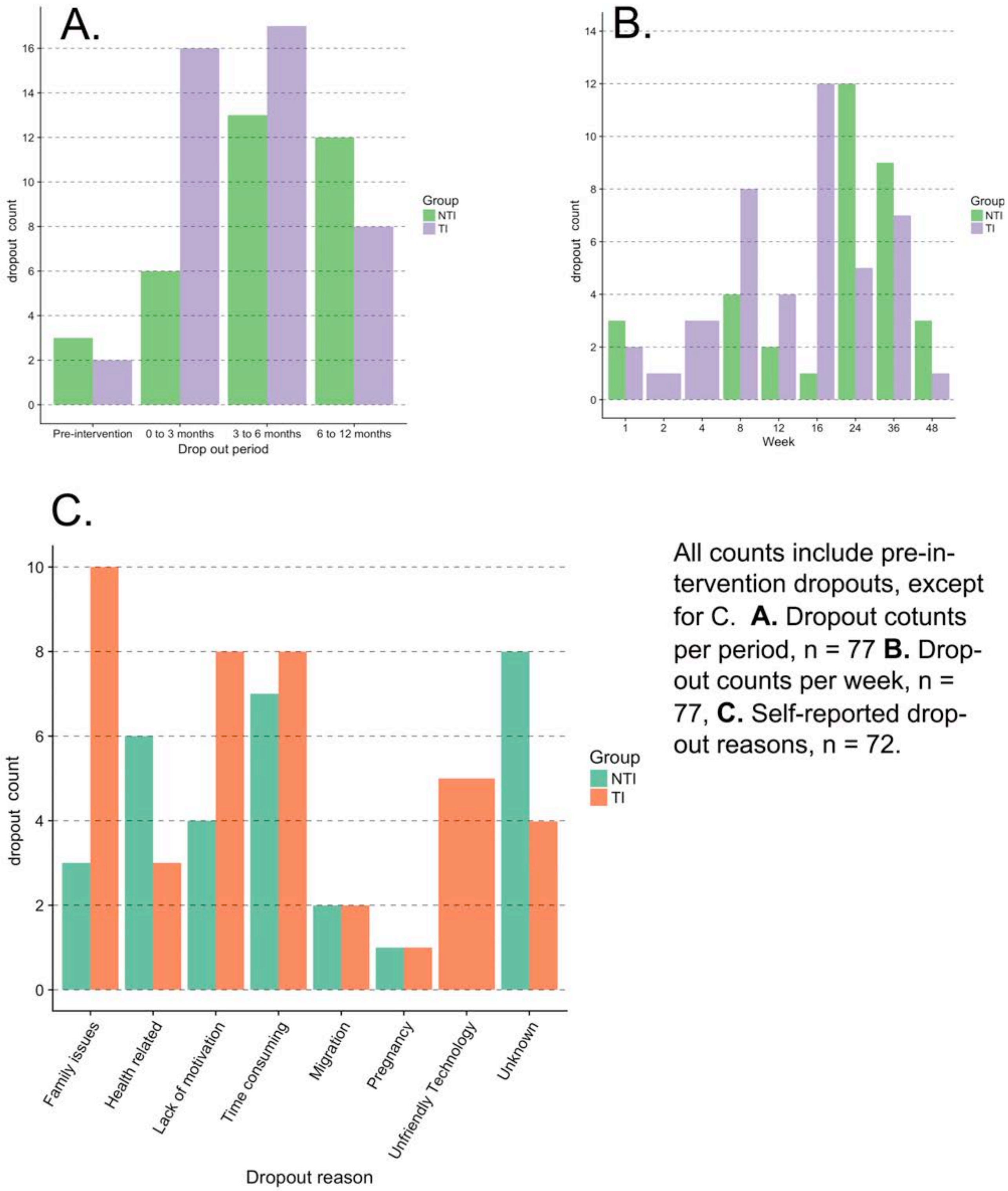


Figure 9. Drop out counts and reasons



All counts include pre-intervention dropouts, except for C. **A.** Dropout cotunts per period, n = 77 **B.** Dropout counts per week, n = 77, **C.** Self-reported dropout reasons, n = 72.

5.2.2 Results from study variables

Table 5 shows a summary of results from study variables in both types of analysis.

Table 5. Results in time and between groups from two types of analysis

	COMPLETERS, n = 106				ITT, n = 183				p
	0-3	0-6	0-9	0-12	0-3	0-6	0-9	0-12	
Weight (kg)	-4.0± 0.3***	-5.1±0.5***	-5.9±0.6***	-5.4±0.7***	-2.9±0.2***	-3.3±0.4***	-3.6±0.4***	-3.3±0.5***	ns
BMI (kg/m2)	-1.5±0.1***	-1.9±0.2***	-2.1±0.2***	-1.9±0.2***	-1.1±0.1***	-1.2±0.1***	-1.3±0.1***	-1.2±0.2***	ns
Waist (cm)	-4.3±0.5***	-5.8±0.5***	-5.5±0.6***	-5.7±0.6***	-3.4±0.3***	-4.4±0.4***	-4.1±0.5***	-4.1±0.5***	ns
WHR	-0.02±0.004***	-0.025±0.004***	-0.022±0.004***	-0.021±0.004***	-0.015±0.003***	-0.019±0.003***	-0.016±0.003***	-0.016±0.003***	ns
Body Fat (%)				-3.2±0.45***				-1.8±0.3***	ns
RHR (bpm)	-2.5±0.9	-2.7±1.1	-1.9±1.1	-5.0±1.4**	-2.5±0.6**	-2.9±0.7**	-2.3±0.7*	-3.97±0.9***	ns
SBP (mmHg)	-3.7±1.3*	-2.3±1.3	-2.8±1.2	-5.5±1.1***	-3.0±0.7**	-2.1±0.7	-2.4±0.7*	-3.8±0.7***	ns
DBP (mmHg)	-1.7±0.7	-1.6±0.8	-1.6±0.8	-2.2±0.7*	-1.4±0.4*	-1.3±0.5	-1.2±0.5	-1.4±0.5*	ns
HbA1c (%)		-0.074±0.023**		-0.140±0.031***		-0.048±0.015**		-0.091±0.019***	ns
Insulin (pmol/l)		-7.8±3.8		-1.3 ±3.6		-2.8±2.6		1.5±2.5	ns
HOMA-IR		-0.24±0.15		-0.07±0.14		-0.07±0.10		0.04±0.09	ns
LDL cholesterol (mg/dl)		-3.8±1.5*		-1.1±1.9		-2.8±1.1*		-1.5±1.3	ns
Non-HDL (mg/dl)		-5.3 ± 1.8*		0.6±2.2		-2.0±1.5		1.5±1.6	ns
HDL cholesterol (mg/dl)		-0.6±0.7		0.74±1.1		-0.66±0.6		0.046±0.8	ns
Triglycerides (mg/dl)		-4.1±3.3		-2.6±3.8		0.3±2.6		1.3±2.9	ns

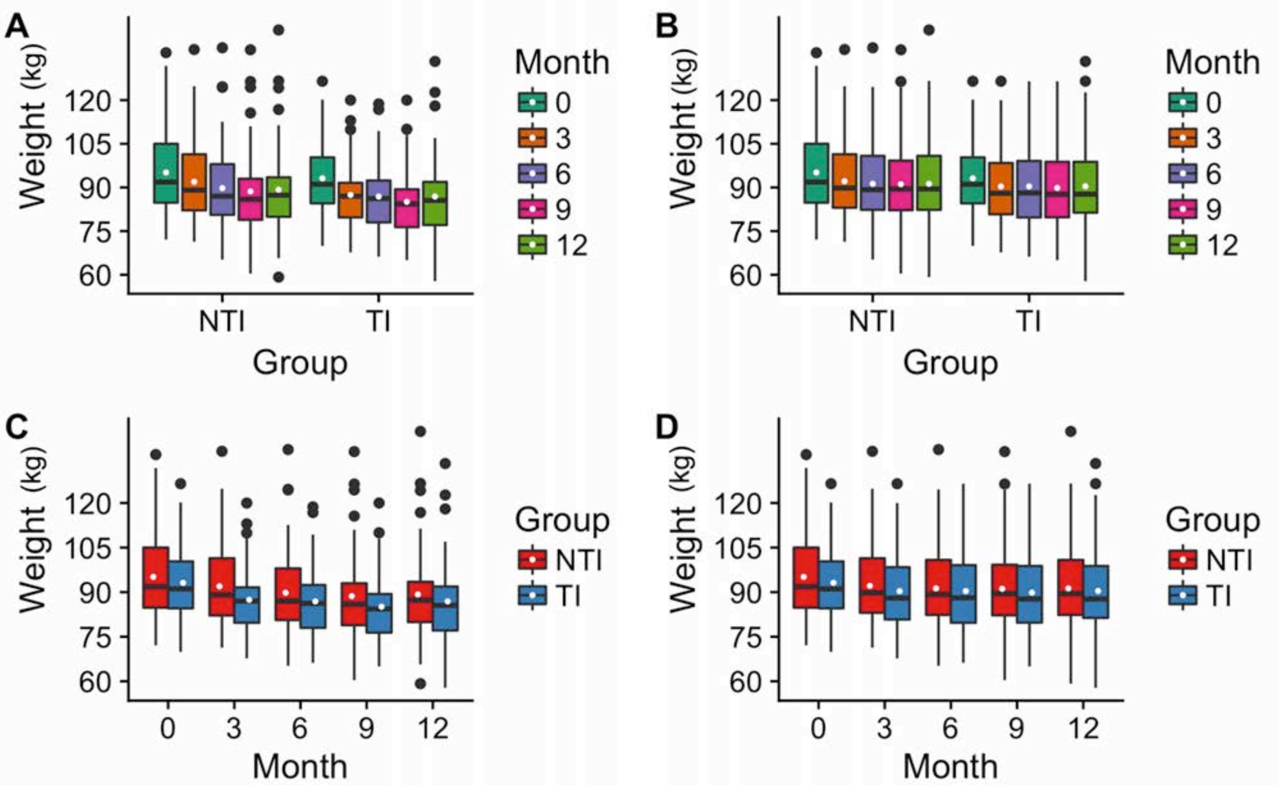
All values are mean differences between baseline and 12-month time points ± standard error, ***p:*** p-values from group comparisons. **TI:** Telematic intervention, **NTI:** Non-telematic intervention, **WHR:** waist/hip ratio, **RHR:** resting heart rate, **SBP:** systolic blood pressure, **DBP:** diastolic blood pressure. * p <0.05, ** p <0.01, *** p <0.001, for changes in time.

5.2.2.1. Weight, PP5% per group, BMI, WC, and body composition

Weight and PP5% per group

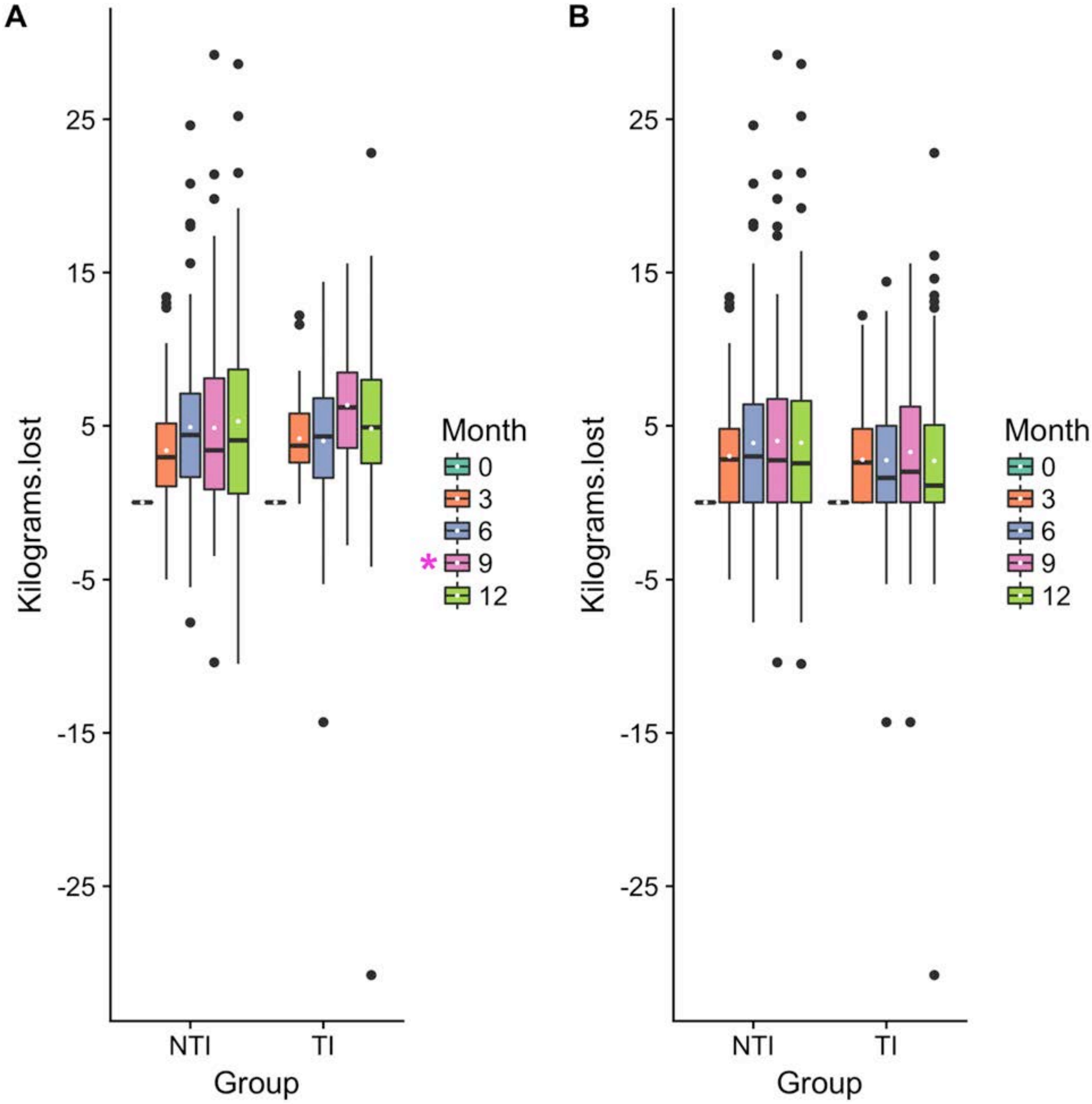
In the completers analysis (n = 106), weight changes were statistically significant at all time points compared to baseline (12-month MD: -5.42± 0.68 kg, p <0.001, CI 95%: -7.36– -3.47); between 3 and 6 months (MD -1.12± 0.28 kg, p = 0.001, CI 95%: -1.9 – -0.33) and between 6 and 9 months (MD -.75± 0.24 kg, p = 0.019, CI 95%: -1.43– -.075). Weight regain was +0.49±0.26kg between 9 and 12-months (p = 0.61, CI 95% -0.25- 1.23). TI group lost more weight but group differences were not statistically significant (MD -3.51 ± 2.7 kg, p = 0.195, CI 95%: -8.86 – 1.84). In the ITT, weight changes were significant at all time points compared to baseline (12-month MD -3.3± 0.47kg, p <0.001, CI 95% -4.6– -1.97). Weight regain was +0.35±0.17kg between 9 and 12-months (p = 0.39, CI 95% -0.13- 0.82). The TI group lost more weight but mean group differences were not statistically significant (MD -1.37±1.919kg, p = 0.477, CI 95% -5.155 – 2.419). Figure 10 shows results for weight by month and group and Figure 11 shows kilograms lost.

Figure 10. Weight by group and month



A. Weight by group per month, **Completers analysis:** n = 106, **B.** Weight by group per month, **ITT with LOCF** , n = 183. **C.** Weight by month per group, **Completers analysis:** n = 106, **D.** Weight by month per group, **ITT with LOCF,** n = 183. ***Means are shown in white.***

Figure 11. Kilograms lost from baseline by group and month

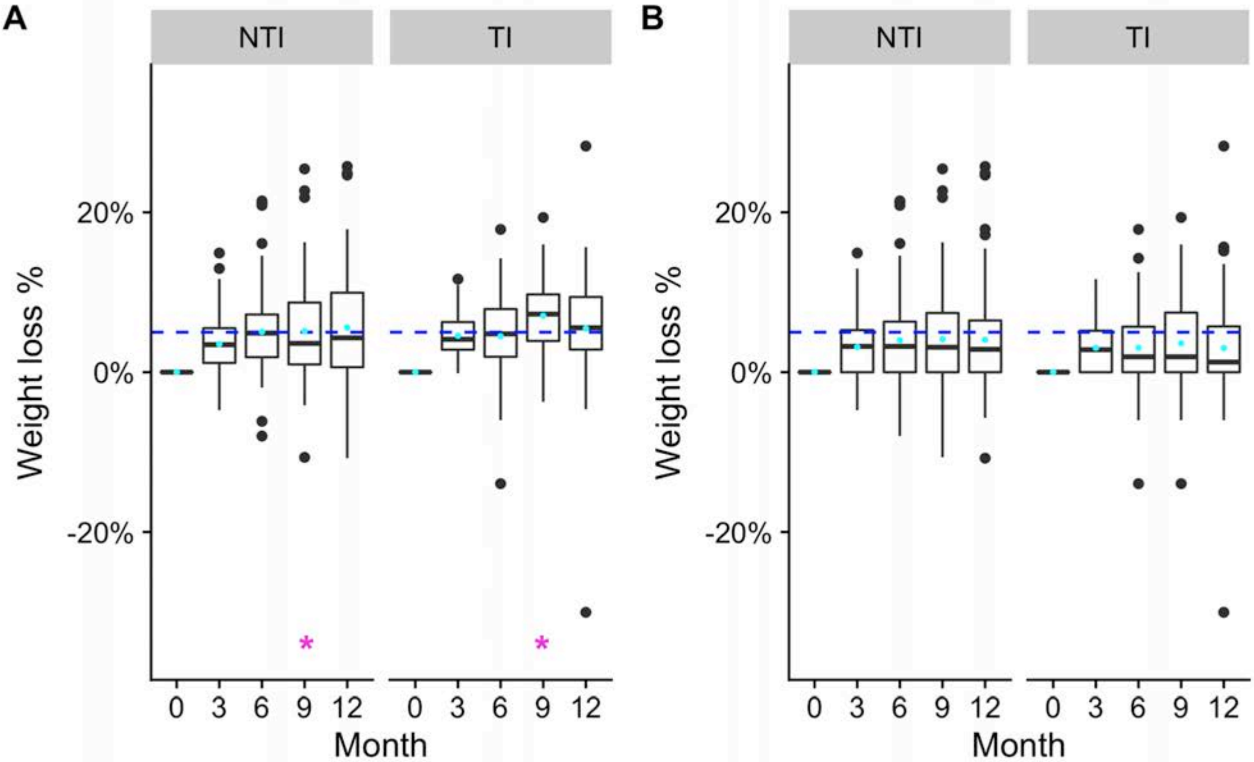


A. Completers Analysis: n = 106, **B. ITT with LOCF:** n = 183

Means are shown in white. **significant differences between groups (MWU p <0.05).*

In the ITT differences in PP5% per group were not statistically significant. In the completers analysis, at 9 months the distribution of weight-loss percentage differed significantly between the two groups (MWU, $p = 0.029$, medians = NTI 3.96% vs. TI 7.45%) and differences between groups in PP5% were statistically significant (X^2, TI 65.2% vs. NTI 43.3, $p = 0.031$). Figure 12 shows weight loss percentage per group and PP5%.

Figure 12. Weight-loss percent by month (A and B) and PP5% per group by month (C).



C. Proportion of participants with ≥5% weight-loss

Type of Analysis	Completer Analysis, n = 106				ITT with LOCF Analysis, n = 183			
Group / month	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
NTI (%)	30.5	45.1	43.3	46.6	27.2	35.9	34.8	33.7
TI (%)	39.3	41.1	65.2	56.3	26.4	31.9	35.2	30.8
p	ns	ns	0.031	ns	ns	ns	ns	ns

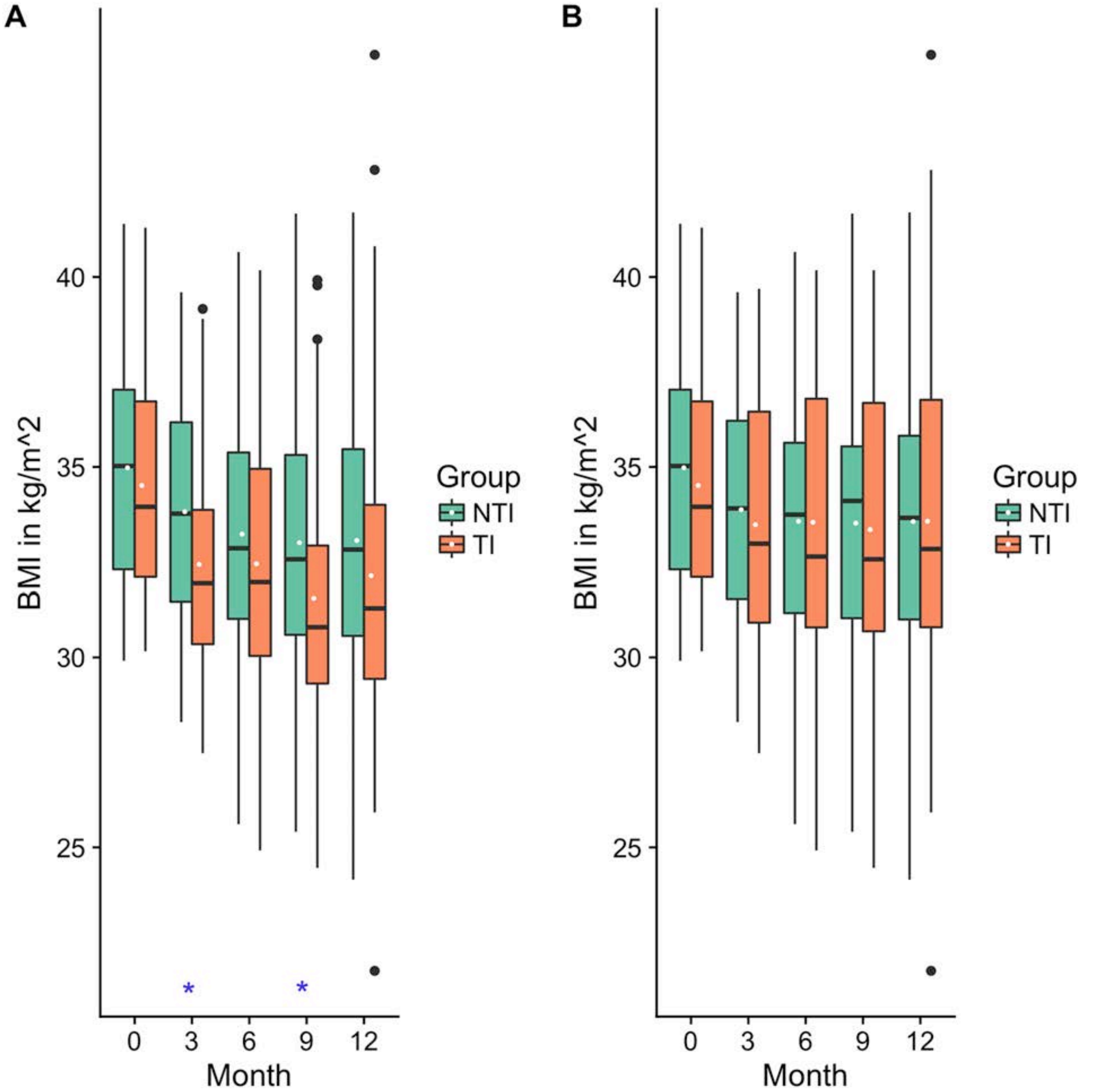
A. Completers analysis, n = 106, **B. ITT with LOCF**, n = 183, **C.** Proportion of participants that achieved ≥5% weight-loss, *p is for comparison between group proportions (x^2).* In A and B means are shown in cyan, the blue dashed lines mark the clinically significant cuttoff value of 5% weight-loss.
* ***differences between groups, MWU p= 0.029.***

BMI

In the completers analysis BMI changes were significant at all time points compared to baseline (12-month MD -1.95 ± 0.26 kg/m^2; $p < 0.001$, CI 95%: -2.7 – -1.2). Mean group differences were not statistically significant (MD -1.24 ± 0.63 kg/m^2; $p = 0.052$, CI 95%: -2.49 – 0.011). At 3 and 9 months the distributions of BMI differed significantly between the two groups (at 3 months: MWU, $p = 0.004$, medians: NTI 33.2 vs. TI 31.7; at 9 months: MWU, $p = 0.027$, medians: NTI 32.5 vs. TI 30.8). Figure 13 shows results for BMI.

In the ITT, BMI changes were significant at all time points compared to baseline (12-month MD -1.18 ± 0.17 kg/m^2; $p < 0.001$, CI 95%: -1.67 – -0.69). Mean group differences were not statistically significant (MD -0.21 ± 0.467 kg/m^2, $p = 0.654$, CI 95%: -1.130 – 0.711).

Figure 13. BMI per group by month



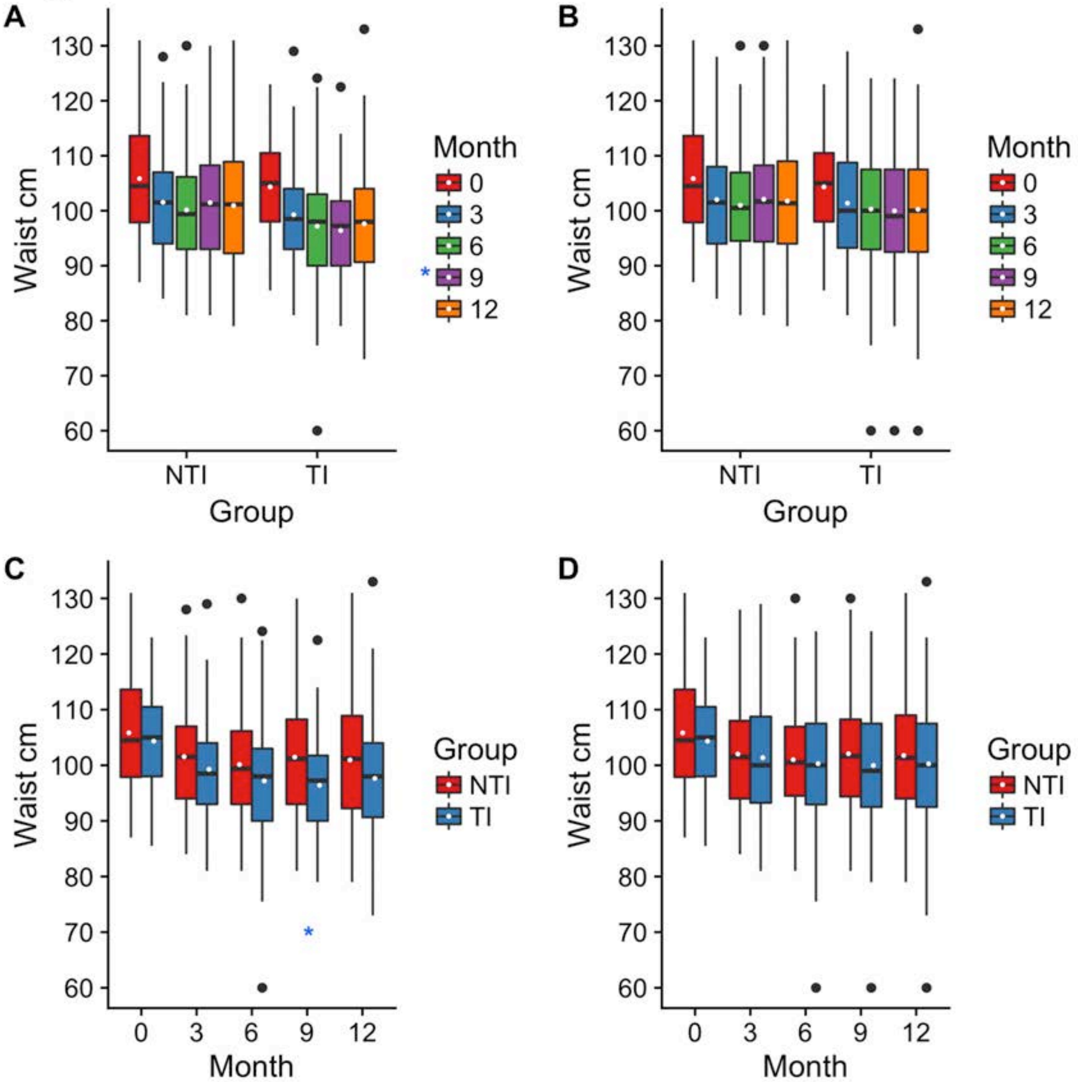
A. Completers Analysis: n = 106. **B. ITT LOCF Analysis:** n = 183. * difference between groups, $p < 0.05$ in non-parametric test. Means are shown in white.

Waist circumference

In the completers analysis, WC changes were significant at all time points compared to baseline (12-month MD -5.66 ± 0.63cm, p < 0.001, CI 95%: -7.47– -3.85), and between 3 and 6 months (MD -1.52± 0.35cm, p <0.001, CI 95%: -2.53 – -0.50). Mean group differences were not statistically significant (MD -3.65 ± 1.97cm, p = 0.067, CI 95%: -7.55 – 0.259). At 9 months the distributions of waist differed significantly between the two groups (MWU, p = 0.021, medians: NTI 100.6 vs. TI 97.25). Figure 14 shows results for WC.

In the ITT, waist changes were significant at all time points compared to baseline (12-month MD -4.08 ± 0.50cm, p <0.001, CI 95%: -5.5 – -2.64). Mean group differences were not statistically significant (MD -1.29 ± 1.46 cm, p = 0.378, CI 95%: -4.18 – 1.596).

Figure 14. Waist circumference



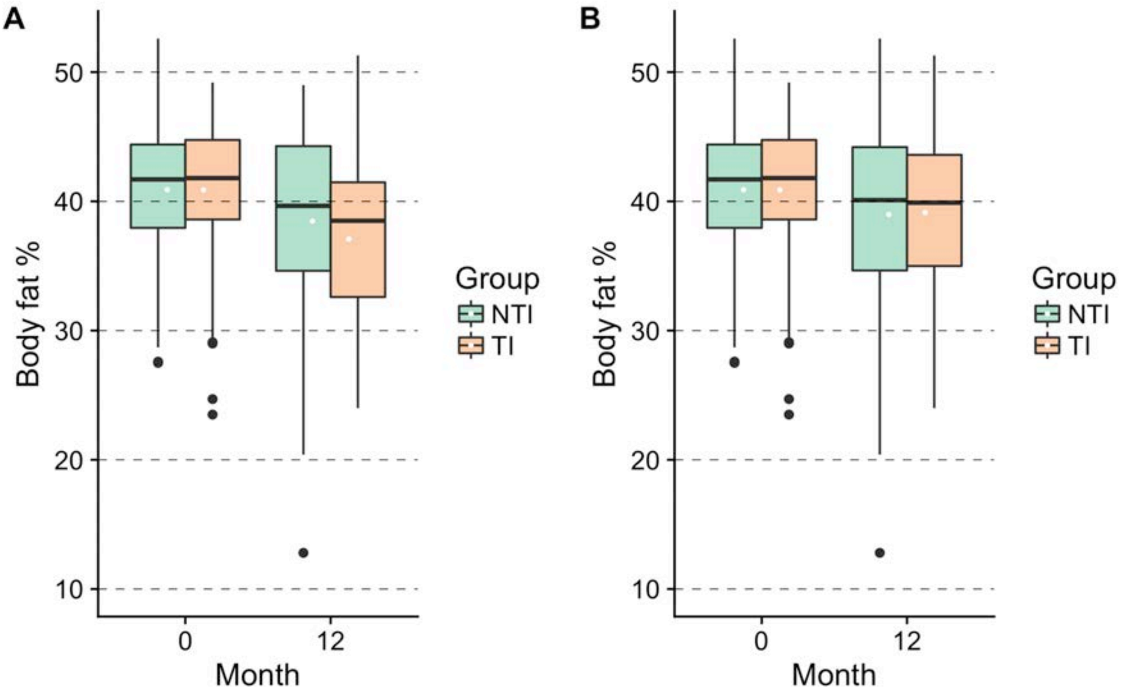
A and **C** are completers analysis (n = 106), **B** and **D** are ITT with LOCF analysis (n = 183), means are shown in white. * *significant differences between groups (MWU p= 0.021).*

Body Composition

In the completers analysis, body fat percentage changes were significant at 12 months compared to baseline (MD -3.16 ± 0.45%, $p < 0.001$, CI 95% -4.06 – -2.28). Mean group differences were not statistically significant (MD -1.23 ± 1.11%, $p = 0.27$, CI 95%: -3.43 – 0.97). Figure 15 shows results for body fat changes.

In the ITT, body fat percentage changes were significant at 12 months compared to baseline (MD -1.83 ± 0.28 %, $p < 0.001$, CI 95% -2.39 – -1.27). Mean group differences were not statistically significant (MD -0.07 ± 0.85 %, $p = 0.93$, CI 95%: -1.62 – 1.76).

Figure 15. Body fat percentage per group by month



A. Completers analysis, n = 106. **B. ITT with LOCF**, n = 183. Means are shown in white.

5.2.2.2. Resting heart rate (RHR) and blood pressure

RHR

In the completers analysis RHR showed significant differences between baseline and 12 months (MD -5.23±1.43 bpm, p = 0.007, CI 95% 0.912 – 9.14). Mean group differences were not statistically significant (-0.48 ± 1.78 bpm, p = 0.79, CI 95% -4.00 – 3.05). In the ITT, RHR showed significant differences between baseline and all time points (p <0.001). Mean group differences were not significant (MD -0.005±1.467bpm, p = 0.997, CI 95% -2.9 –2.9).

SBP

In the completers analysis SBP changes were significant between baseline, 3 and 12-month time points (3-month MD -3.75±1.27 mmHg, p = 0.042 CI 95% -7.41– -0.079, 12-month MD -5.50±1.15mmHg, p <0.001, CI 95% -8.82–-2.19). Mean group differences were not statistically significant (MD -1.29 ± 2.29 mmHg, p = 0.57, CI 95% -5.84–3.25). In the ITT, SBP changes were significant between baseline and 3, 9 and 12-month time points (12-month MD -3.82 ± 0.69mmHg, p <0.001, CI 95% -5.79 – -1.85). Mean group differences were not statistically significant (MD 0.196 ± 1.99 mmHg, p = 0.92, CI 95% -3.73–4.12).

DBP

In the completers analysis DBP changes were significant between baseline and 12 months (MD -2.22±0.75mmHg, p = 0.037, CI 95% -4.36 – -0.075). Mean group differences were not statistically significant (MD -1.61 ±

1.35 mmHg, p = 0.24, CI 95% -4.3–1.08). In the ITT, DBP changes were significant between baseline 3 and 12-month time points (3-month MD -1.36 ± 0.422 mmHg, p = 0.015, CI 95% - 2.56 – -0.16; 12-month MD -1.37±0.47mmHg, p=0.043, CI 95% -2.72– -0.025). Mean group differences were not statistically significant (MD -1.81 ± 1.24 mmHg, p = 0.145, CI 95% -4.25–0.63).

5.2.2.3. Metabolic outcomes

Lipids

In both types of analysis, there were no significant changes of triglycerides in time and mean group differences were not statistically significant (MD 0.481±7.5mg/dL, p = 0.949, CI 95% -14.41–15.369).

In the completers analysis, total cholesterol showed no significant changes in time. Mean group differences were not statistically significant (MD -7.6±5.88mg/dL, p = 0.197, CI 95% -19.27 – 4.03). LDL cholesterol showed significant changes between baseline and 6 months (MD -3.78±1.51mg/dL, p = 0.042, CI 95% -7.46–-0.11), mean group differences were not statistically significant (MD -4.46±5.49mg/dL, P = 0.418, CI 95% -15.34 – 6.42). HDL showed no statistically significant changes in time, and mean group differences were not significant (MD -2.18±2.54mg/dL, P = 0.39, CI 95% -7.22 – 2.87). Non-HDL cholesterol showed no significant changes in time, and mean group differences were not statistically significant (MD -5.74±5.78mg/dL, p =0.32, CI 95% -17.19 – 5.72).

In the ITT analysis with LOCF, total cholesterol showed no significant changes in time, and no significant differences between groups (MD -1.56±4.82mg/dL, p =0.75, CI 95% -11.06 – 7.94). LDL cholesterol showed statistically significant changes between baseline and 6 months (MD -2.84±1.14mg/dL, p =0.042, CI 95% -5.61 – 0.08). Mean group differences were not statistically significant (MD -3.071±4.31mg/dL, p = 0.48, CI 95% -11.57 – 5.43). HDL showed no statistically significant changes in time, and mean group differences were not significant (MD -0.551±1.88, P = 0.77, CI 95% -4.25 – 3.15). Non-HDL cholesterol showed no significant changes in time, and mean group differences were not statistically significant (MD -2.06±4.84mg/dL, p =0.67, CI 95% -11.62 –7.5).

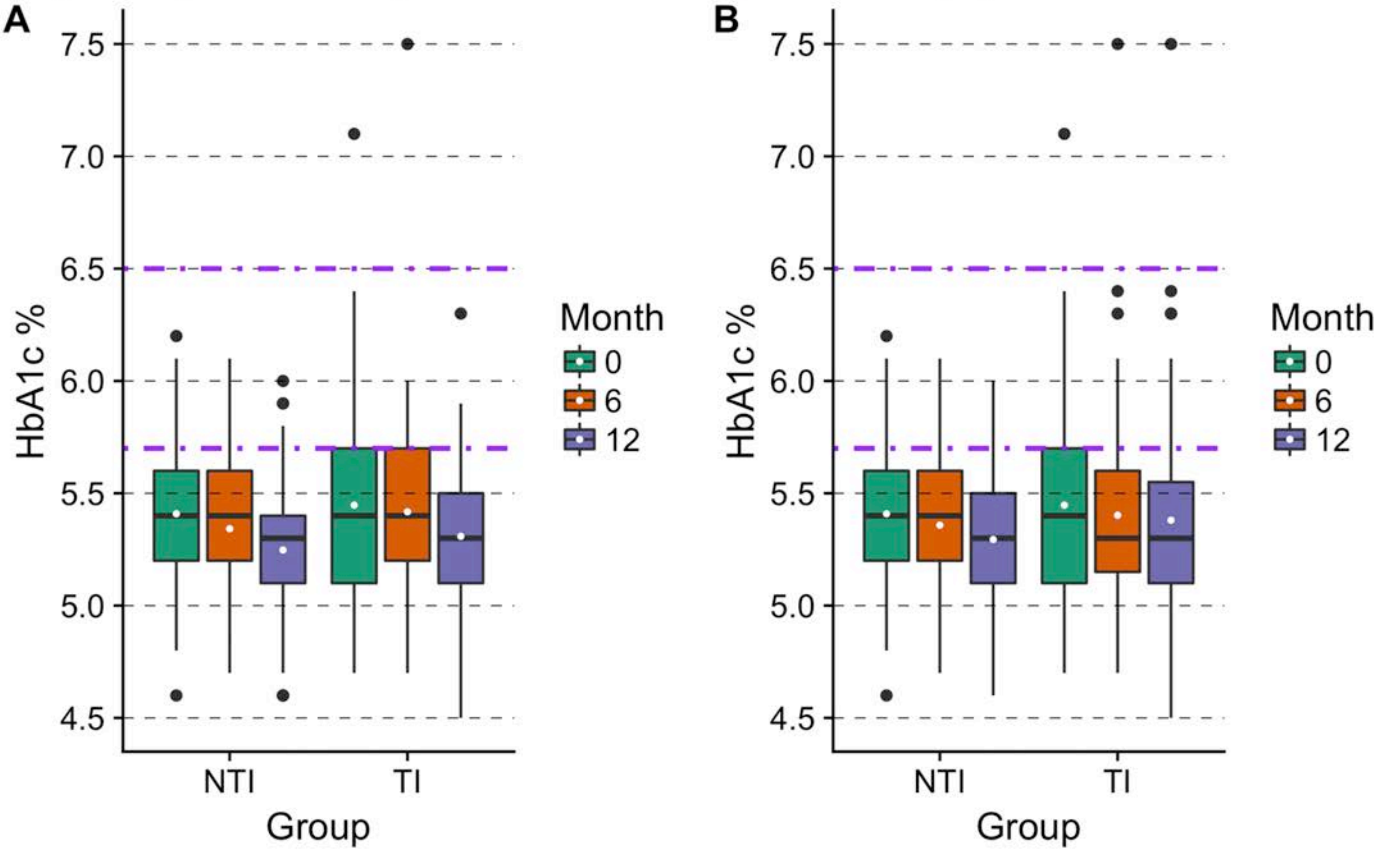
Fasting blood glucose, HbA1c, HOMA-IR and pre-diabetes status per group (HbA1c 5.7% to <6.5%)

In both types of analysis, fasting blood glucose, insulin and HOMA-IR showed no significant changes in time, and mean group differences were not significant.

In the completers analysis HbA1c showed significant changes at both time points compared to baseline (6-month MD -0.074±0.023%, p = 0.005, CI 95% -0.13– -0.02; 12-month MD -0.14±0.031%, p <0.001, CI 95% -0.21– -0.06). Mean group differences were not significant (MD 0.035±0.058%, p =0.058, CI 95% -0.079 – 0.15). In the ITT, HbA1c showed significant changes at both time points compared to baseline (6-month MD -0.05±0.01%, p =0.005, CI 95% -0.084– -0.012; 12-months MD -0.091±0.019%, p <0.001, CI 95% -0.138 – -0.044). Mean group differences were not statistically significant (MD 0.056±0.051%, p =0.051, CI 95% -0.045 – 0.16).

No significant differences between groups were detected in proportion of participants with pre-diabetes-range HbA1c at 12 months. Figure 16 shows results for HbA1c and proportion of participants with pre-diabetes range HbA1c.

Figure 16. HbA1c by group per month (A and B) and proportion of participants with pre-diabetes range HbA1c (C).



C. Proportion of participants with pre-diabetes range HbA1c

Type of Analysis	**Completer** Analysis, n = 106			**ITT with LOCF** Analysis, n = 183		
Group / month	**0**	6	12	**0**	6	12
NTI (%)	20.9	16.9	13.1	20.9	16.3	13.0
TI (%)	27.5	26.3	14.6	27.5	22.0	18.7
p	ns	ns	ns	ns	ns	ns

A. Completers analysis, n = 106, **B. ITT with LOCF**, n = 183, **C. Proportion of participants with Prediabetes range HbA1c.** In A and B: purple dashed lines mark pre-diabetes range HbA1c%, means are shown in white.

Medication requirements

One participant, from the TI group had to be withdrawn from the study due to prescription of pharmacological treatment for T2DM with metformin. This participant had a known T2DM diagnosis at baseline and was treated with diet and exercise only. Due to an intercurrent event, glucose control worsened with an HbA1c of 7.5%. No other participant in the study initiated T2DM pharmacological treatment.

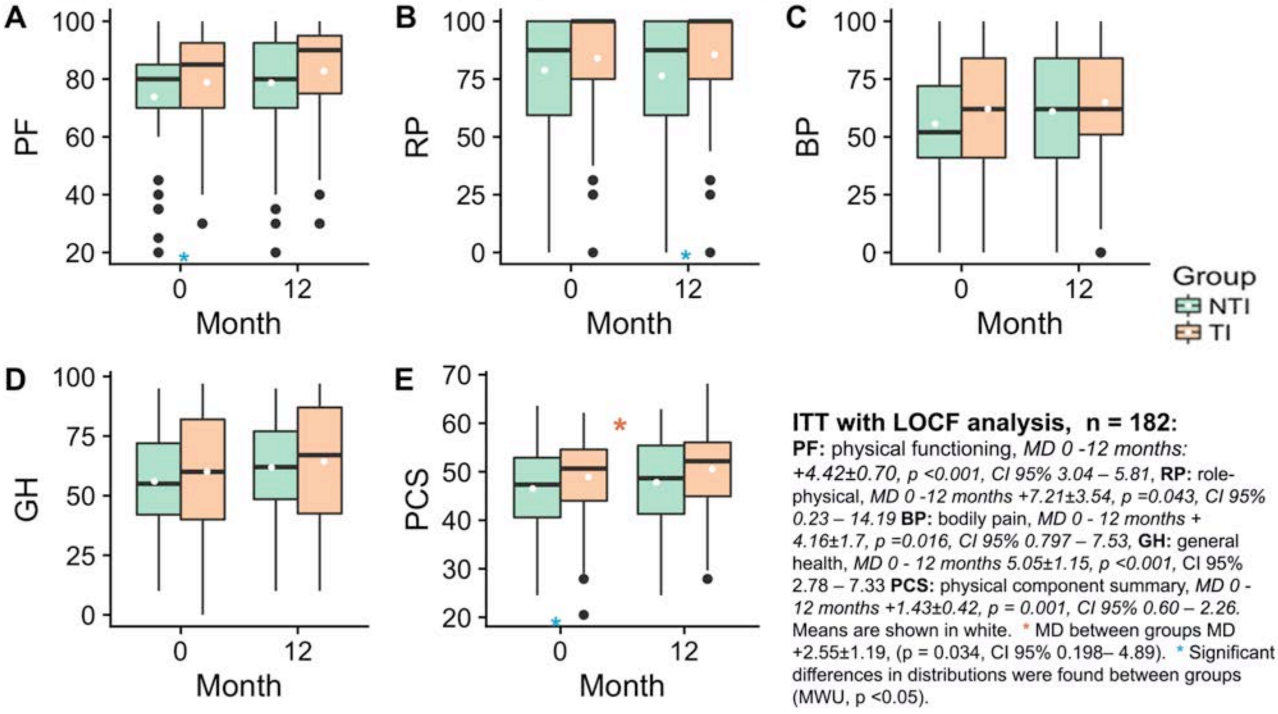
Two participants from the NTI group were withdrawn from the study when they started treatment with topiramate following the diagnosis of a non-specified eating disorder. Three other participants (2 from TI and 1 from NTI group) did not report a start of medication but dropped out from the study reporting the diagnosis of an eating disorder.

Six participants (2 NTI and 4 TI group) started treatments for hypertension with a diuretic, angiotensin II receptor blocker, or an angiotensin-converting-enzyme inhibitor. These participants were not withdrawn from the study.

5.3. Objective 3. Quality of life (QoL) and satisfaction with the intervention

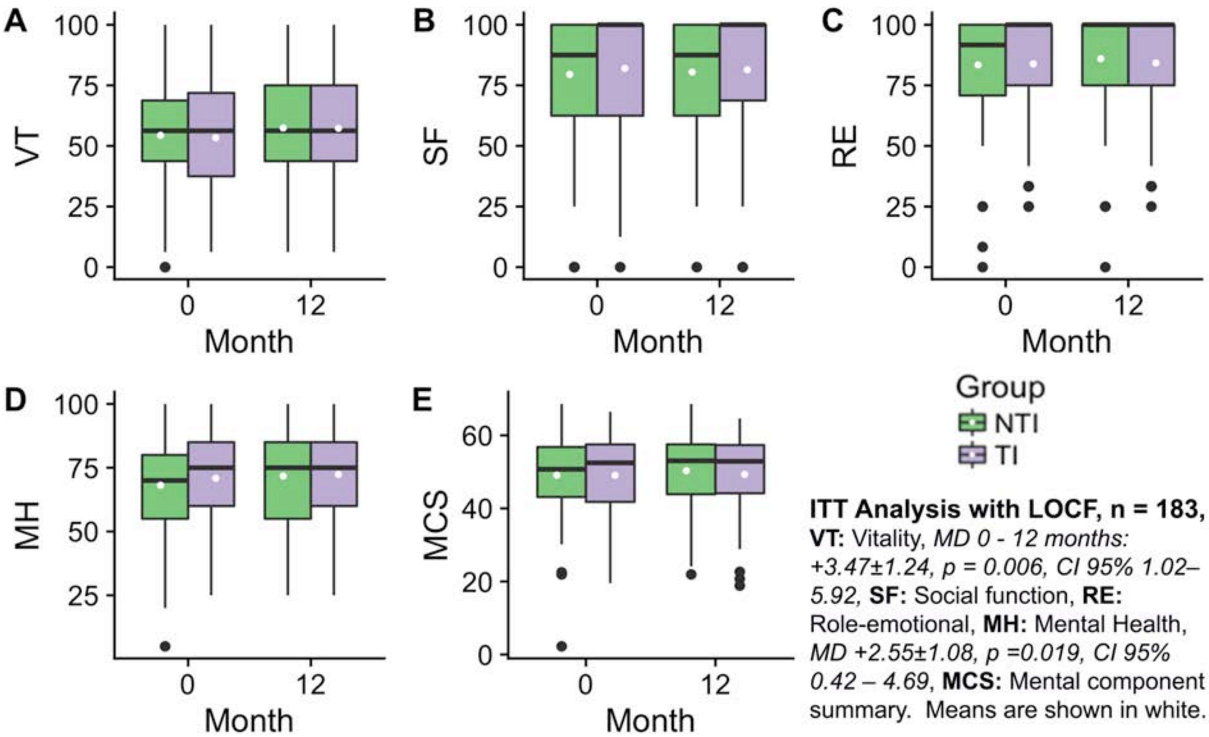
QoL evaluations showed results were within the range of normality at baseline and at post-intervention. Figure 17 shows a summary of results for the physical domains, and figure 18 for the mental domains of QoL. At study completion, general satisfaction evaluations showed participants from both groups were satisfied with the program (n = 106).

Figure 17. Results for quality of life (QoL)- Physical domains



ITT with LOCF analysis, n = 182:
PF: physical functioning, *MD 0 -12 months: +4.42±0.70, p <0.001, CI 95% 3.04 – 5.81*, **RP:** role-physical, *MD 0 -12 months +7.21±3.54, p =0.043, CI 95% 0.23 – 14.19* **BP:** bodily pain, *MD 0 - 12 months + 4.16±1.7, p =0.016, CI 95% 0.797 – 7.53*, **GH:** general health, *MD 0 - 12 months 5.05±1.15, p <0.001*, CI 95% 2.78 – 7.33 **PCS:** physical component summary, *MD 0 - 12 months +1.43±0.42, p = 0.001, CI 95% 0.60 – 2.26.* Means are shown in white. * MD between groups MD +2.55±1.19, (p = 0.034, CI 95% 0.198– 4.89). * Significant differences in distributions were found between groups (MWU, p <0.05).

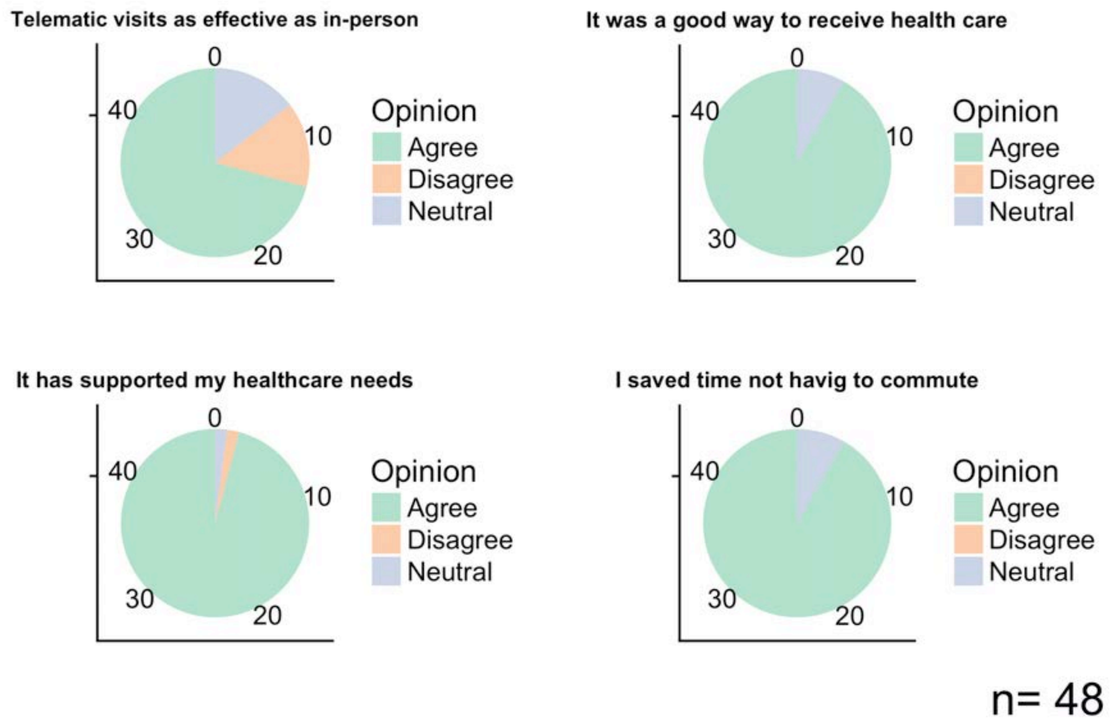
Figure 18. Results for quality of life (QoL)- Mental domains



ITT Analysis with LOCF, n = 183, VT: Vitality, *MD 0 - 12 months: +3.47±1.24, p = 0.006, CI 95% 1.02–5.92,* **SF:** Social function, **RE:** Role-emotional, **MH:** Mental Health, *MD +2.55±1.08, p =0.019, CI 95% 0.42 – 4.69*, **MCS:** Mental component summary. Means are shown in white.

A summary of results for satisfaction evaluations of the telemedicine intervention is shown in figure 19. Most users agreed this type of intervention saved them time by avoiding commuting (92%, n = 48). Almost all users agreed that the telematic intervention supported their heath-care needs at a distance (96%, n=48). One user disagreed, stating that psychological support was an unmet health-care need, from both the program and the platform. A percentage of participants disagreed that telemedicine visits were as effective as in-person (15%, n =48). One of these users stated that the telematic approach was more impersonal, decreased adherence to treatment and it would always be better to receive lifestyle recommendations in-person.

Figure 19. Satisfaction with the telematic intervention.



A summary of evaluation results from PREDIRCAM2 platform use is shown in figures S1 to S7 in the supplement section of this text. User experience with the PREDIRCAM2 web platform was positive in general. More than half of the users agreed it complied with their expectations (69%, n=48), and was pleasant to use (81%, n =48). Two users reported their main unmet expectation was that PREDIRCAM2 was not optimized for mobile devices.

General usability evaluations were positive. Almost all users agreed that PREDIRCAM2 platform was easy to use (85%, n=48) and to learn to use (96%, n=48). A user stated that an adaptation of the platform for mobile devices would also improve usability.

Almost all users agreed that manual exercise logging was easy (94%, n=48) and swift (94%, n=48). Almost all users agreed the dashboard of exercise logs was easy to interpret (94%, n = 48). Ten percent of users disagreed about pulsometer usability. The reported reasons for decreased pulsometer usability were: discomfort in the use of wrist and chest bands, finding the device screen and buttons confusing and struggles with the device's connectivity.

Most users agreed that daily dietary logging was easy to do (79%, n=48) and feedback on dashboard was easy to interpret (87%, n=48). This logging and feedback took more than 5 minutes for most users (96%, n=48). Thirty-one percent of the users considered 5 to 10 minutes to log, was too long. One user suggested the incorporation of a nutrition barcode scanner to improve logging time and precision of the dietary module. Two other users suggested there should be more detailed nutritional information provided about the ingredients and dishes, as well as more Mediterranean dishes to be incorporated into the database.

Most users agreed that weight and WC logging were easy (75%, n=48); and 19% (n=48) of users disagreed that feedback on dashboard was easy to interpret.

Most users agreed the messaging system was easy to use (96%, n=48), and allowed them to effectively communicate with health-care professionals. More than half of the users agreed that automated notifications were useful for motivation (67%, n=48), but 17% and 8% disagreed on the frequency of automated notifications and emails respectively. Users, who disagreed, stated that receiving automated notifications and emails was impersonal, repetitive and so frequent that became uninteresting.

Regarding the use of a private group in Facebook®, 22 users (46%, n =48) reported joining, and more than half of them agreed the group was motivating towards behavior change (64%, n =22). The most frequently reported reason for users not to join this private group was not being a prior Facebook® user (65%, n =26).

5.4. Objective 4. Cost-effectiveness evaluation

Given that results from all outcome variables were similar between groups, their effectiveness was considered to be equivalent. Table 6 shows a summary of cost evaluations. No significant differences between groups were found in self-reported personal costs in the completers analysis. When imputing medians, the ITT showed the TI group reported higher personal costs than NTI. Support costs for the TI were estimated to be 15324.00 € for all study participants per year, without including the use of physical activity trackers.

When comparing the total costs, the TI was less expensive than the NTI: Median difference of -113 € per patient per year ($p < 0.001$, CI 95%, -129.82 - -112.98). When including physical activity trackers the TI was more expensive than the NTI: Median difference +24 € ($p=0.001$, CI 95% 7.5 – 24.35).

Table 6. Intervention cost evaluations

Type of Analysis	Completers, n = 106			ITT, n = 183		
	TI	**NTI**	p	**TI**	**NTI**	p
Personal costs* Median (25th-75th percentiles)	30.5 (7.5 - 62.6)	30.5 (16.8- 47.34)	0.920	24.3 (24.3-30.5)	7.5 (7.5-30.5)	0.018
Health-care visits	507	720	<0.001	507	720	<0.001
Continued support	83.7	-	-	83.7	-	-
Total cost Median (25th-75th percentiles)	621.4 (598.4 - 653.5)	751.22 (737.6 – 768.1)	<0.001	615.24 (615.2, 621.4)	728.22 (728.22-751.22)	<0.001
Total cost, TI + trackers Median (25th-75th percentiles)	758.73 (735.7 – 790.9)	751.22 (737.6 – 768.1)	0.082	752.67 (752.6 – 758.7)	728.22 (728.22-751.22)	<0.001

All costs are per person/year expressed in euros.
* Personal costs include: 12-month retrospective self-reported hours lost from work, and commuting expenses.
p: p-value between group comparison, MWU test. **TI:** Telematic intervention, **NTI:** Non-telematic intervention.

Chapter 6. Discussion

Results from this clinical trial show that a telemedicine intervention delivered by a tailored web platform is feasible for the treatment of obesity and T2DM prevention in this setting. In most parts of the world, there is an unmet need for strategies to curb obesity and its comorbidities. Health technologies could provide cost-effective telemedicine solutions for demands such as intensified follow-up visits and support for behavior change. As previously stated, in Mediterranean settings little is known about the potential impact of telemedicine in the intensified care of obesity and cardio-metabolic risk prevention (41,48).

6.2.0. Study population characteristics

The study population was majorly female, as in most obesity interventions and as in most real-life clinical settings. Differences between groups in education level and previous T2DM diagnosis did not affect our study results; given that no specific correlations were found between education level or previous diabetes diagnosis and any of the outcome variables.

6.2.1. Anthropometric changes (Weight, PP5% per group, BMI, WC, and body composition)

Moderate weight changes achieved by participants in our study correspond to an intensified integral lifestyle intervention to promote behavior change, as opposed to a strict hypo-caloric dietary intervention. Previous lifestyle intervention studies have reported similar anthropometric changes in their telemedicine intervention groups (41,49,53). The magnitude of short-term weight-loss and waist circumference reductions at 6 months vary significantly depending on the characteristics of the intervention. Previous studies have shown that telemedicine interventions can be at least as effective as usual care for short-term weight-loss. In our setting, with the use of the PREDIRCAM2 web platform we have found similar results at 6 months, please see supplementary material, p. IX (68).

Weight regain started to occur in our sample at 9 months. The magnitude of this regain is similar to results from other long-term telemedicine interventions (26,38,40,41). In our study's completers analysis, a higher percentage of participants from the TI group had achieved at least a 5% weight-loss compared to the NTI group at 9 months. These proportions were very similar to the ones reported by Appel et al at 6 and 24 months follow-up of their telemedicine intervention group (69). BMI and WC showed similar results at 9 months. This may suggest an advantage in the use of telemedicine and continuous web support for weight maintenance after a 6-month weight-loss. However, our high dropout rates may be a source of bias in this group difference, given that our ITT did not show significant differences between groups. Long-term weight loss and maintenance are harder to evaluate given the high dropout rates in obesity studies (70). A few studies have shown long term results from telemedicine interventions on obesity (29,30,39,44,51,71); one in a Mediterranean setting (41).

6.2.2. Blood pressure and Resting heart rate (RHR)

Although statistically significant, no clinically relevant changes were detected in our study sample for blood pressure and resting heart rate. This may be explained by the normal mean SBP and DBP values at baseline. Telemedicine interventions for weight loss that have been performed in populations with high blood pressure have failed to show significant improvements in spite of achieving weight loss (27,50). In fact, the need to start medication for blood pressure control in 3.3% of our study participants is similar to the percent of participants that had a known diagnosis of high blood pressure at baseline 2.7%. The differences between groups in medication needs however (*0.004% TI vs. 0.002% NTI*), might be a result of the continuous support and recommendations for frequent blood pressure monitoring received by the TI group.

6.2.3. Metabolic outcomes

We found statistically significant lipid improvements at short term, however not clinically relevant. Goulis DG et al did find clinically relevant lipid improvements in their short-term telemedicine intervention despite a high female proportion in their study (48). These results may be explained by the different characteristics of their intervention and the higher short-term weight-loss achieved by participants in their study compared to ours. Tárraga et al reported a significant decrease in total cholesterol and an increase in HDL in all their study groups, including a telematic intervention group of similar characteristics to ours (41). Their study population included similar proportions of males and females, and they had suboptimal blood lipids at baseline. The lack of clinically relevant changes in lipids in our study is explained by having a majorly female population with high HDL levels and near-normal lipid values at baseline.

The magnitude of HbA1c changes achieved by participants in our study is similar to published results from life-style interventions in non-diabetic female populations. Hannon et al reported a decrease of -0.09% at three months of a lifestyle intervention in non-diabetic mothers and their children. This difference tended to become smaller towards the 12-months follow-up and for this reason the authors are unsure about its clinical relevance (72). In our study, however the changes were significant at all time points compared to baseline and HbA1c showed a trend to decrease progressively towards the end of the 12-months study.

The clinical relevance of this effect is also suggested by the progressive and long-term decrease in proportion of participants with pre-diabetes range HbA1c, as shown in figure 16. Long-term studies in other settings have shown telemedicine strategies for weight loss are effective for improving glycemic control in populations with T2DM. As is to be expected, the higher the HbA1c values at baseline the larger the magnitude of the changes reported. Short-term term studies report HbA1c changes ranging from -0.07 to -3.2%, achieved by telemedicine intervention groups (37,42,73,74). Weinstock et al reported long-term results from a telemedicine intervention showing up to -0.65% HbA1c reductions in a selected group of patients with T2DM, from a baseline HbA1c of 7.6% and a 5-year follow-up (71). Selected at-risk patients, such as patients with pre-diabetes, or T2DM, may obtain more benefits from these types of interventions than the general population with obesity.

6.3. Quality of life (QoL) and Satisfaction

Baseline quality of life scores were within the normal healthy-population range and they improved for both groups, reflecting similar characteristics between interventions.

In general, participants of the TI group in our study were satisfied with the telematic approach. However the in-person visits were highly valued, given that only 3 quarters of the TI participants agreed that telematic visits were as effective as in-person. Plus, a few participants directly stated they believed in-person visits were necessary and irreplaceable. These participants' opinions could reflect their special needs. Most probably, some participants require a different amount and frequency of in-person visits, and programs should be tailored according to individual needs (53). Rafiei and Gil studied the factors involved in successful self-directed weight-loss compared to direct care from health-professionals. They identified the characteristics related to effective 5% weight loss (75). These individuals with higher self-efficacy and motivation would probably require less in-person attention. Reducing in-person appointments for these individuals would reduce healthcare burden, leaving room for the in-person care of those who need it most.

Previous studies of telemedicine interventions for obesity have suggested the importance of in-person contacts in their interventions. Allen JK et al found a high attrition rate in the smartphone-only group and suggested the need for some degree of personal-contact in telemedicine interventions (53). Harvey-Berino et al performed a 3-arm study comparing an Internet-only intervention group, Internet plus personal-contact group, and a personal-contact-only control group. They found high participation rates for all 3 groups; however, the personal-contact control group lost significantly more weight than the two telemedicine intervention groups (47). These authors suggest social support in the personal contact arm largely explained their results. In this sense, the visit schedule in a telemedicine program, and the in-person-treatment *"dose"* may also be related to adherence. Having two consecutive telematic visits, as in our program, may not be ideal (see activity schedule in table 2) and might be a reason for the higher dropout rates shown by the TI group in the 3 to 6 months period of follow-up (figure 9). The ideal approach would be to individualize according to the patient's needs.

The web platform evaluations were positive in general but they reflect the need for swifter dietary registry and more feedback on detailed nutrition facts. There is a need to incorporate more automatized systems to facilitate dietary logging, as suggested by user evaluations in our study. Recent research has shown promising results with the use of technologies for mobile augmented reality and computer-vision based systems for food recognition and automatic nutritional analysis (76–78). Although it is still challenging to obtain full nutritional information, the GoCarb group recently reported the validation of their computer-vision based mobile app for carbohydrate counting. They obtained similar results comparing the app to the counts of a certified and experienced nutritionist (79). This research group has also reported glycemic control improvements with the use of this application for carbohydrate counting in a population with type 1 Diabetes Mellitus (76). Also, as suggested by our participants, the incorporation of nutritional barcode scanners may be useful for obtaining automatic dietary logs and detailed nutritional information (80). Applications like My-fitness-pal® have incorporated a nutritional barcode scanner and have shown high rates of user satisfaction (81). A combination of manual and automatic logging strategies might be the optimal solution, given that barcode scanning would not be useful for home made foods, and automatic food recognition systems may not be equally effective for all types of meals.

The most frequently reported suggestion for improvement was to enable access to the platform from mobile devices. As previously stated, telemedicine interventions from 2011 to present tend to be administered through mobile devices. Although, the use of mobile devices has not proven to be more effective than other strategies (53), most telemedicine experts agree on the fact that technologies that are already incorporated into the daily lives of users have a higher probability of success (19,40,82,83). In 2017 two-thirds of the world's population had mobile phones, most of them smartphones. In fact, more than half of all the current Internet traffic is from mobile phone access (82). This availability and widespread use makes them an ideal vehicle for telemedicine.

Most users, positively valued the messaging system that allowed for contact and asynchronous communication as a source of personalized professional care. In other settings, this type of communication has also shown to be well accepted among patients with chronic conditions (84). On the other hand, one third of the platform users in our study (33%) were not satisfied with the automatic notifications, considering they were too frequent and did not improve their motivation. This is a frequent finding from interventions that use automatic notifications (81). Complex systems approaches and machine learning algorithms may help to improve individualization of automatic notifications for decision aid in the near future.

In our study, most users of the program's private group in Facebook® agreed that joining this group was a motivation for behavior change. The use of social media in weight loss and lifestyle interventions is promising given the psychosocial and anthropologic characteristics of obesity, as well as its chronic nature. Social studies have shown the impact of peer pressure and social relations on healthy behavior adoption and weight control, suggesting the potential for success of social network interventions (85–87). In-silico models for network interventions apply complex systems perspectives to multi-factorial conditions such as obesity, and have also shown the potential success of network interventions for behavior change (88). Social media use has shown positive impacts on psychological, social and cognitive health of users with chronic conditions (89). There is an opportunity in social media for approaching obesity in a systemic way; therefore the use of popular social media in lifestyle interventions is interesting to investigate further.

6.4. Cost-effectiveness

The TI in this program was less expensive than control, mainly by reducing costs in health-care appointments. In most clinical settings, saving counseling time is beneficial for both the health-care system and patients (2). Surprisingly, in our study this difference was not found for self-reported personal costs. On the other hand, most users agreed that the TI was good for reducing commuting times (figure 19). This discrepancy and failure to show reductions in personal costs is most probably related to the retrospective and self-reported nature of personal expense reports, plus the bias of having only the evaluations from completers (n=106).

Cost-effectiveness results from other studies are heterogeneous. It is a challenge to evaluate cost-effectiveness of these interventions mainly due to their novelty. Certain telemedicine interventions could be better suited for specific populations. For example, the results from Luley et al suggest telemedicine weight-loss interventions might be cost-effective in obese populations with type 2 diabetes given the added value of reducing medication costs (42). This phenomenon is also explained by results from population surveys in which individuals who are affected by a disease they consider severe, tend to be more motivated, given that they place a higher value on health promotion programs, than seemingly healthy populations (90).

Standard methods for cost-effectiveness evaluation in health interventions were developed to assess traditional therapies and not designed to evaluate applied health technologies. It has been proposed that cost-effectiveness evaluations of applied health technologies should include the notion of added social value, the users time costs and improvements in quality of life rather than added years of life (90–92). Furthermore, cost-effectiveness can improve if the telemedicine interventions are designed to better respond to society's real needs and not only to economic concerns (90,92). As technology becomes more readily available, telemedicine interventions could also become more accessible and affordable in general.

When including physical activity tracking devices with pulsometers the TI in our study was more expensive than the NTI. Having no significant differences between groups for all outcome variables and a higher cost, the use of these devices cannot be justified by our results. Specific study designs would be needed to evaluate their added value and cost justification. It is important to note also that, simpler and less expensive devices have shown good long term results increasing physical activity, and they would probably result in cost-effective interventions (93).

The incorporation of everyday technologies, such as smartphones, social media, and inexpensive physical activity trackers could save in technology costs and result in cost-effective long-term interventions in which software development costs would be easily amortized.

6.5. Study limitations

The main limitation of our study was that it was underpowered to show potential differences between groups. The drop out of a third participant center before recruitment and ulterior participant drop out rates reduced our study population significantly.

Attrition is a frequent barrier encountered in obesity interventions, reported rates range from 10 to up to 90% (70). In twenty eight percent of the studies included in the introductory analysis of this text, researchers used incentives to improve adherence and participation, either by monetary compensations, paying for transportation fees, giving the participants vouchers to buy sports equipment, or giving them small gifts such as lunch bags, water bottles, healthy treats or drinks. Adherence to lifestyle modification treatments has always been challenging. Given that attrition and lack of motivation are frequently encountered problems in any type of weight-loss or weight-control program, the use of rewards might undermine the replicability of their results when attempted in other settings. In this sense, our study reflects real life conditions and may be easier to replicate in other Mediterranean settings.

In this study, the TI group had a significantly higher dropout rate compared to the NTI group at 6 months (38% vs. 24% p = 0.034). This difference tended to diminish and became non-significant towards the end of the study as the NTI dropout rates also tended to increase (figure 9, table 4). High drop out rates in obesity lifestyle interventions are frequent and important study limitations. However, differences in drop out rates and dropout reasons between groups are important to explore. The most frequently reported reason for dropout in the TI branch was having family issues. Technology use per se was not a frequent reason for dropout in this branch, therefore may not be directly attributable to the telemedicine approach or the web platform use.

The higher drop out rates for the TI group could be in relation to the program structure per se. As discussed earlier, our program structure with two consecutive telemedicine visits in the 3-to-6-months time period, may also explain the different dropout rates between groups at 6 months. More importantly, making dietary logs mandatory for the TI group while not for the

NTI group in this program, could be in relation to the higher dropout rates of this treatment branch in the first 6 months of the study (Table 5 and Figure 9). In relation to this, the reported time spent doing daily dietary logs corresponds with another frequently reported reason for dropout in both groups: the intervention being too time-consuming.

The highly reported frequency of family issues such as reporting caring for a sick or terminally ill family member, are common burdens of being the main home and family caregiver and may be related to having a majorly female population in our study. We speculate the “unknown reasons” of dropout from the NTI group could be of a similar nature. The high frequency of reported personal problems as a reason for dropout suggests the need to incorporate evidence-based behavior change psychology strategies into telemedicine, to support change in spite of some of these difficulties (87,94,95).

Chapter 7. Conclusions

- **Main conclusion:** We developed a web platform for the telemedicine treatment of obesity; results from a controlled clinical trial show that using this platform in a telemedicine intervention for the treatment of obesity and T2DM prevention is feasible in our setting.

- **Specific conclusions:**

  1. The PREDIRCAM2 web platform showed adequate functionality, usability and intuitiveness.

  2. A randomized controlled clinical trial showed the telemedicine intervention using PREDIRCAM2 web platform achieved similar results in weight loss and metabolic risk prevention compared to full in-person care at a reduced cost.

  3. The telematic intervention was similar to full in person care regarding QoL and satisfaction.

  4. Given the higher costs and similar results between groups, the use of wearables for physical activity tracking cannot be justified by our results.

Chapter 8. Recommendations for future research

Our results show that telemedicine delivered by a tailored web platform is a feasible approach for the treatment and follow-up of obesity, with no significant differences found when compared to full in-person care. For future research in our setting, we should consider the following:

1- Satisfaction evaluations from our TI intervention suggested the use of mobile devices for delivery of telemedicine could improve usability, and user experience. The availability and widespread use of mobile technology makes these devices ideal for future telemedicine interventions.

2- Pulsometer devices enabled individualized exercise prescription in our program; but the study design was not meant to evaluate the specific impact of these devices on study variables and their cost-effectiveness cannot be demonstrated by our results. Physical activity tracking devices are evolving; they have improved their connectivity, they have decreased in cost, and they have become popular in modern societies. Several studies have reported the use of these devices may improve weight-loss, waist circumference and cardiovascular risk (31,44,96,97). Other researchers have reported the use of wearable technology for physical activity tracking may not offer an advantage when compared to standard treatment (54,55). Costs, as well as the main complaints found in our evaluations regarding usability, may be tackled by incorporating simpler and less expensive devices (93). It is warranted to include physical activity tracking devices in future studies, with specific protocol designs to evaluate their impact in telemedicine interventions for obesity in our setting.

3- Our results show that dietary logging was the most time-consuming task of the PREDIRCAM2 web platform. This issue could be related to one of the major reasons for dropout, and suggests the need to incorporate more automatized technologies to facilitate dietary logging, reduce logging time and most importantly, as a way to improve usability and adherence.

4- Our results show that most of the users who joined the program's private group in Facebook© found this to be a motivator. In the first quarter of 2018, Facebook® had 2.9 billion active users per month. Social media offer interesting opportunities given their popularity, systemic and dynamic nature.

5- This clinical trial was performed in two tertiary care hospitals. As mentioned in the introduction, only one-third of published results from telemedicine interventions on obesity come from primary care settings. It is warranted to perform more interventions to evaluate telemedicine for obesity treatment and diabetes prevention in primary care settings, given that these are the settings were they would be applied at a community level in real life.

6- Among the most frequently reported reasons for dropout in our study were having a family issue, lack of time or motivation. Furthermore, participants in our study directly mentioned psychological support was an unmet health-care need of our program. As previously mentioned, obesity has important psychosocial implications. Behavior change psychologists are not usually involved in behavior change interventions in our setting. Technological platforms could be an opportunity for multidisciplinary care that includes psychologists. Including behavior change psychologists in a multidisciplinary approach, tailored and effective behavior change strategies could increase adherence and improve patients outcomes and satisfaction (98).

7- Our study results suggest that an individualized approach might be more appropriate than using the same predetermined program structure for all. Selected patients might respond better to telemedicine depending on their health status, their previous experiences with Internet and technology, and their motivation status. In future studies, telemedicine should be tested in a more individualized approach to maximize the potential benefits.

References

1. Hruby A, Hu FB. The Epidemiology of Obesity: A Big Picture. PharmacoEconomics. 2015 Jul;33(7):673–89.

2. Lehnert T, Sonntag D, Konnopka A, Riedel-Heller S, König H-H. Economic costs of overweight and obesity. Best Pract Res Clin Endocrinol Metab. 2013 Apr;27(2):105–15.

3. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 2014 Aug;384(9945):766–81.

4. Organisation mondiale de la santé. Global status report on noncommunicable diseases 2014: attaining the nine global noncommunicable diseases targets; a shared responsibility. Geneva: World Health Organization; 2014.

5. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet Lond Engl. 2004 Jan 10;363(9403):157–63.

6. Oh SW, Shin S, Yun YH, Yoo T, Huh B-Y. Cut-off Point of BMI and Obesity-Related Comorbidities and Mortality in Middle-Aged Koreans. Obesity. 2004;12(12):2031–2040.

7. WHO | Obesity and overweight [Internet]. [cited 2018 Mar 9]. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/

8. OECD. 2017 Obesity Update [Internet]. Available from: http://www.oecd.org/health/obesity-update.htm

9. IDF diabetes atlas - 2017 Atlas [Internet]. [cited 2018 Jan 4]. Available from: http://www.diabetesatlas.org/resources/2017-atlas.html

10. Spahlholz J, Pabst A, Riedel-Heller SG, Luck-Sikorski C. Coping with perceived weight discrimination: testing a theoretical model for examining the relationship between perceived weight discrimination and depressive symptoms in a representative sample of individuals with obesity. Int J Obes. 2016 Dec;40(12):1915–21.

11. Luck-Sikorski C, Riedel-Heller SG, Phelan JC. Changing attitudes towards obesity – results from a survey experiment. BMC Public Health [Internet]. 2017 Dec [cited 2018 Jan 4];17(1).

12. Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle among Subjects with Impaired Glucose Tolerance. N Engl J Med. 2001 May 3;344(18):1343–50.

13. The Diabetes Prevention Program Research Group. The 10-Year Cost-Effectiveness of Lifestyle Intervention or Metformin for Diabetes

Prevention: An intent-to-treat analysis of the DPP/DPPOS. Diabetes Care. 2012 Apr 1;35(4):723–30.

14. Levy RL, Finch EA, Crowell MD, Talley NJ, Jeffery RW. Behavioral intervention for the treatment of obesity: strategies and effectiveness data. Am J Gastroenterol. 2007 Oct;102(10):2314–21.

15. Wadden TA, Crerand CE, Brock J. Behavioral Treatment of Obesity. Psychiatr Clin North Am. 2005 Mar;28(1):151–70.

16. Yoong SL, Carey ML, Sanson-Fisher RW, D'Este CA. A cross-sectional study assessing Australian general practice patients' intention, reasons and preferences for assistance with losing weight. BMC Fam Pract. 2013;14(1):187.

17. Neve M, Morgan PJ, Jones PR, Collins CE. Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. Obes Rev. 2010 Apr;11(4):306–21.

18. Pagoto S, Schneider K, Jojic M, DeBiasse M, Mann D. Evidence-Based Strategies in Weight-Loss Mobile Apps. Am J Prev Med. 2013 Nov;45(5):576–82.

19. Tufano JT, Karras BT. Mobile eHealth Interventions for Obesity: A Timely Opportunity to Leverage Convergence Trends. J Med Internet Res. 2005 Dec 20;7(5):e58.

20. Coons MJ, DeMott A, Buscemi J, Duncan JM, Pellegrini CA, Steglitz J, et al. Technology Interventions to Curb Obesity: A Systematic Review of the Current Literature. Curr Cardiovasc Risk Rep. 2012 Apr;6(2):120–34.

21. Zundel KM. Telemedicine: history, applications, and impact on librarianship. Bull Med Libr Assoc. 1996 Jan;84(1):71–9.

22. Brief History of the Internet | Internet Society [Internet]. [cited 2018 Jan 15]. Available from: https://www.internetsociety.org/internet/history-internet/brief-history-internet/

23. Welcome to IQVIA - A New Path to Your Success Via Human Data Science [Internet]. [cited 2018 Jan 4]. Available from: https://www.iqvia.com/

24. Ventola CL. Mobile devices and apps for health care professionals: uses and benefits. Pharm Ther. 2014;39(5):356.

25. WHO Global Observatory for eHealth. MHealth: new horizons for health through mobile technologies. Geneva: World Health Organization; 2011.

26. Wister A, Loewen N, Kennedy-Symonds H, McGowan B, McCoy B, Singer J. One-year follow-up of a therapeutic lifestyle intervention targeting cardiovascular disease risk. Can Med Assoc J. 2007 Oct 9;177(8):859–65.

27. Warner ET. Obesity Treatment for Socioeconomically Disadvantaged Patients in Primary Care Practice. Arch Intern Med. 2012 Apr 9;172(7):565.

28. Touger-Decker R, Denmark R, Bruno M, O'Sullivan-Maillet J, Lasser N. Workplace Weight Loss Program; Comparing Live and Internet Methods: J Occup Environ Med. 2010 Nov;52(11):1112–8.

29. Svetkey LP, Stevens VJ, Brantley PJ, Appel LJ, Hollis JF, Loria CM, et al. Comparison of strategies for sustaining weight loss: the weight loss maintenance randomized controlled trial. Jama. 2008;299(10):1139–1148.

30. Stumm G, Blaik A, Kropf S, Westphal S, Hantke TK, Luley C. Long-Term Follow-Up of the Telemonitoring Weight-Reduction Program "Active Body Control." J Diabetes Res. 2016;2016:1–7.

31. Shuger SL, Barry VW, Sui X, McClain A, Hand GA, Wilcox S, et al. Electronic feedback in a diet- and physical activity-based lifestyle intervention for weight loss: a randomized controlled trial. Int J Behav Nutr Phys Act. 2011 May 18;8:41.

32. Shrestha M, Combest T, Fonda SJ, Alfonso A, Guerrero A. Effect of an Accelerometer on Body Weight and Fitness in Overweight and Obese Active Duty Soldiers. Mil Med. 2013 Jan;178(1):82–7.

33. Sherwood NE, Jeffery RW, Pronk NP, Boucher JL, Hanson A, Boyle R, et al. Mail and phone interventions for weight loss in a managed-care setting: weigh-to-be 2-year outcomes. Int J Obes. 2006;30(10):1565–1573.

34. Polzien KM, Jakicic JM, Tate DF, Otto AD. The efficacy of a technology-based system in a short-term behavioral weight loss intervention. Obesity. 2007;15(4):825–830.

35. Pellegrini CA, Verba SD, Otto AD, Helsel DL, Davis KK, Jakicic JM. The Comparison of a Technology-Based System and an In-Person Behavioral Weight Loss Intervention. Obesity. 2012 Feb;20(2):356–63.

36. Park M-J, Kim H-S. Evaluation of mobile phone and Internet intervention on waist circumference and blood pressure in post-menopausal women with abdominal obesity. Int J Med Inf. 2012 Jun;81(6):388–94.

37. Orsama A-L, Lähteenmäki J, Harno K, Kulju M, Wintergerst E, Schachner H, et al. Active Assistance Technology Reduces Glycosylated Hemoglobin and Weight in Individuals With Type 2 Diabetes: Results of a Theory-Based Randomized Trial. Diabetes Technol Ther. 2013 Aug;15(8):662–9.

38. Oh JA, Kim HS, Yoon KH, Choi ES. A Telephone-Delivered Intervention to Improve Glycemic Control in Type 2 Diabetic Patients. Yonsei Med J. 2003 Feb 1;44(1):1–8.

39. Oh B, Cho B, Han MK, Choi H, Lee MN, Kang H-C, et al. The Effectiveness of Mobile Phone-Based Care for Weight Control in Metabolic

Syndrome Patients: Randomized Controlled Trial. JMIR MHealth UHealth. 2015 Aug 20;3(3):e83.

40. McConnon Á, Kirk SF, Cockroft JE, Harvey EL, Greenwood DC, Thomas JD, et al. The Internet for weight control in an obese sample: results of a randomised controlled trial. BMC Health Serv Res [Internet]. 2007 Dec [cited 2018 Jan 5];7(1).

41. Marcos MLT, Royo JMP, Herencia JAC, Domenech NR, Presas JA, López PJT. Efecto sobre los parámetros lipídicos de una intervención para reducir peso en pacientes con sobrepeso y obesidad. Clínica E Investig En Arterioscler. 2017;29(3):103–110.

42. Luley C, Blaik A, Reschke K, Klose S, Westphal S. Weight loss in obese patients with type 2 diabetes: Effects of telemonitoring plus a diet combination – The Active Body Control (ABC) Program. Diabetes Res Clin Pract. 2011 Mar;91(3):286–92.

43. Krukowski RA, Tilford JM, Harvey-Berino J, S. West D. Comparing Behavioral Weight Loss Modalities: Incremental Cost-Effectiveness of an Internet-Based Versus an In-Person Condition. Obesity. 2011 Aug;19(8):1629–35.

44. Izquierdo R, Lagua CT, Meyer S, Ploutz-Snyder RJ, Palmas W, Eimicke JP, et al. Telemedicine intervention effects on waist circumference and body mass index in the IDEATel project. Diabetes Technol Ther. 2010;12(3):213–220.

45. Huber JM, Shapiro JS, Wieland ML, Croghan IT, Vickers Douglas KS, Schroeder DR, et al. Telecoaching plus a portion control plate for weight care management: a randomized trial. Trials [Internet]. 2015 Dec [cited 2018 Jan 5];16(1).

46. Haugen HA, Tran ZV, Wyatt HR, Barry MJ, Hill JO. Using telehealth to increase participation in weight maintenance programs. Obesity. 2007;15(12):3067–3077.

47. Harvey-Berino J, West D, Krukowski R, Prewitt E, VanBiervliet A, Ashikaga T, et al. Internet delivered behavioral obesity treatment. Prev Med. 2010 Aug;51(2):123–8.

48. Goulis DG, Giaglis GD, Boren SA, Lekka I, Bontis E, Balas EA, et al. Effectiveness of home-centered care through telemedicine applications for overweight and obese patients: a randomized controlled trial. Int J Obes. 2004 Nov;28(11):1391–8.

49. Burke LE, Conroy MB, Sereika SM, Elci OU, Styn MA, Acharya SD, et al. The Effect of Electronic Self-Monitoring on Weight Loss and Dietary Intake: A Randomized Behavioral Weight Loss Trial. Obesity. 2011 Feb;19(2):338–44.

50. Bennett GG, Herring SJ, Puleo E, Stein EK, Emmons KM, Gillman MW. Web-based Weight Loss in Primary Care: A Randomized Controlled Trial. Obesity. 2010 Feb;18(2):308–13.

51. Bennett GG, Foley P, Levine E, Whiteley J, Askew S, Steinberg DM, et al. Behavioral Treatment for Weight Gain Prevention Among Black Women in Primary Care Practice: A Randomized Clinical Trial. JAMA Intern Med. 2013 Oct 28;173(19):1770.

52. Anderson DR, Christison-Lagay J, Villagra V, Liu H, Dziura J. Managing the Space between Visits: A Randomized Trial of Disease Management for Diabetes in a Community Health Center. J Gen Intern Med. 2010 Oct;25(10):1116–22.

53. Allen JK, Stephens J, Dennison Himmelfarb CR, Stewart KJ, Hauck S. Randomized Controlled Pilot Study Testing Use of Smartphone Technology for Obesity Treatment. J Obes. 2013;2013:1–7.

54. Jakicic JM, Davis KK, Rogers RJ, King WC, Marcus MD, Helsel D, et al. Effect of Wearable Technology Combined With a Lifestyle Intervention on Long-term Weight Loss: The IDEA Randomized Clinical Trial. JAMA. 2016 Sep 20;316(11):1161.

55. Thomas JG, Raynor HA, Bond DS, Luke AK, Cardoso CC, Foster GD, et al. Weight loss in Weight Watchers Online with and without an activity tracking device compared to control: A randomized trial: Weight Watchers Online. Obesity. 2017 Jun;25(6):1014–21.

56. González C, Herrero P, Cubero JM, Iniesta JM, Hernando ME, García-Sáez G, et al. PREDIRCAM eHealth Platform for Individualized Telemedical Assistance for Lifestyle Modification in the Treatment of Obesity, Diabetes, and Cardiometabolic Risk Prevention: A Pilot Study (PREDIRCAM 1 >. J Diabetes Sci Technol. 2013 Jul;7(4):888–97.

57. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Tudor-Locke C, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc. 2011 Aug;43(8):1575–81.

58. Global recommendations on physical activity for health. Genève: WHO; 2010.

59. Estruch R, Ros E, Salas-Salvadó J, Covas M-I, Corella D, Arós F, et al. Primary Prevention of Cardiovascular Disease with a Mediterranean Diet. N Engl J Med. 2013 Apr 4;368(14):1279–90.

60. Documento de consenso sobre “recomendaciones nutricionales y de educación alimentaria en la diabetes”: ACD 2003. Associació Catalana de Diabetis; 2003. 90 p.

61. Camelon KM, Hådell K, Jämsén PT, Ketonen KJ, Kohtamäki HM, Mäkimatilla S, et al. The Plate Model: a visual method of teaching meal

planning. DAIS Project Group. Diabetes Atherosclerosis Intervention Study. J Am Diet Assoc. 1998 Oct;98(10):1155–8.

62. Bandura A. Health Promotion by Social Cognitive Means. Health Educ Behav. 2004 Apr;31(2):143–64.

63. Bandura A. Self-efficacy: Toward a Unifying Theory of Behavioral Change. :25.

64. WHO | STEPS Manual [Internet]. WHO. [cited 2018 Mar 13]. Available from: http://www.who.int/chp/steps/manual/en/

65. Wallace TM, Levy JC, Matthews DR. Use and abuse of HOMA modeling. Diabetes Care. 2004;27(6):1487–1495.

66. Beato Fernández L, Rodríguez Cano T. [Attitudes towards change in eating disorders (ACTA). Development and psychometric properties]. Actas Esp Psiquiatr. 2003 Jun;31(3):111–9.

67. Wadden TA, Anderson DA, Foster GD, Bennett A, Steinberg C, Sarwer DB. Obese women's perceptions of their physicians' weight management attitudes and practices. Arch Fam Med. 2000 Oct;9(9):854–60.

68. Alcántara-Aragón V, Rodrigo-Cano S, Lupianez-Barbero A, Martinez MJ, Martinez C, Tapia J, et al. Web Support for Weight-Loss Interventions: PREDIRCAM2 Clinical Trial Baseline Characteristics and Preliminary Results. Diabetes Technol Ther. 2018 May;20(5):380–5.

69. Appel LJ, Clark JM, Yeh H-C, Wang N-Y, Coughlin JW, Daumit G, et al. Comparative Effectiveness of Weight-Loss Interventions in Clinical Practice. N Engl J Med. 2011 Nov 24;365(21):1959–68.

70. Moroshko I, Brennan L, O'Brien P. Predictors of dropout in weight loss interventions: a systematic review of the literature: Dropout in weight loss interventions. Obes Rev. 2011 Nov;12(11):912–34.

71. Weinstock RS, Teresi JA, Goland R, Izquierdo R, Palmas W, Eimicke JP, et al. Glycemic Control and Health Disparities in Older Ethnically Diverse Underserved Adults With Diabetes: Five-year results from the Informatics for Diabetes Education and Telemedicine (IDEATel) study. Diabetes Care. 2011 Feb 1;34(2):274–9.

72. Hannon TS, Saha C, Carroll AE, Palmer KNB, O'Kelly Phillips E, Marrero DG. The ENCOURAGE Healthy Families Study: A Comparative Effectiveness Trial to Reduce Risk for Type 2 Diabetes in Mothers and Children. Pediatr Diabetes [Internet]. 2018 May 20 [cited 2018 May 22].

73. Tanaka M, Adachi Y, Adachi K, Sato C. Effects of a Non-Face-to-Face Behavioral Weight-Control Program Among Japanese Overweight Males: A Randomized Controlled Trial. Int J Behav Med. 2010 Mar;17(1):17–24.

74. Maruyama C, Kimura M, Okumura H, Hayashi K, Arao T. Effect of a worksite-based intervention program on metabolic parameters in middle-aged male white-collar workers: A randomized controlled trial. Prev Med. 2010 Jul;51(1):11–7.

75. Rafiei N, Gill T. Identification of factors contributing to successful self-directed weight loss: a qualitative study. J Hum Nutr Diet [Internet]. 2017 Nov 21 [cited 2018 May 29].

76. Bally L, Dehais J, Nakas CT, Anthimopoulos M, Laimer M, Rhyner D, et al. Carbohydrate Estimation Supported by the GoCARB System in Individuals With Type 1 Diabetes: A Randomized Prospective Pilot Study. Diabetes Care. 2017 Feb;40(2):e6–7.

77. Anthimopoulos M, Dehais J, Shevchik S, Ransford BH, Duke D, Diem P, et al. Computer Vision-Based Carbohydrate Estimation for Type 1 Patients With Diabetes Using Smartphones. J Diabetes Sci Technol. 2015 May;9(3):507–15.

78. Bayu MZ, Arshad H, Ali NM. Nutritional Information Visualization Using Mobile Augmented Reality Technology. Procedia Technol. 2013;11:396–402.

79. Vasiloglou MF, Mougiakakou S, Stanga Z. GoCARB accuracy on carbohydrate estimation versus visual estimations by dietitians. :1.

80. Karpischek S. Mobile barcode scanning applications for consumers: Application development and the quality of product master data [Internet]. ETH Zurich; 2012 [cited 2018 Jun 1].

81. Laing BY, Mangione CM, Tseng C-H, Leng M, Vaisberg E, Mahida M, et al. Effectiveness of a Smartphone Application for Weight Loss Compared With Usual Care in Overweight Primary Care Patients: A Randomized, Controlled Trial. Ann Intern Med. 2014 Nov 18;161(10_Supplement):S5.

82. WORLD HEALTH ORGANIZATION. GLOBAL DIFFUSION OF EHEALTH: making universal health coverage achievable. Geneva: World Health Organization; 2017.

83. WHO Global Observatory for eHealth. MHealth: new horizons for health through mobile technologies. Geneva: World Health Organization; 2011.

84. Jong CC de, Ros WJ, Schrijvers G. The Effects on Health Behavior and Health Outcomes of Internet-Based Asynchronous Communication Between Health Providers and Patients With a Chronic Condition: A Systematic Review. J Med Internet Res. 2014;16(1):e19.

85. de la Haye K, Robins G, Mohr P, Wilson C. How physical activity shapes, and is shaped by, adolescent friendships. Soc Sci Med. 2011 Sep;73(5):719–28.

86. McPherson M, Smith-Lovin L, Cook JM. Birds of a Feather: Homophily in Social Networks. Annu Rev Sociol. 2001 Aug;27(1):415–44.

87. Smith LH, Holm L. Social class and body management. A qualitative exploration of differences in perceptions and practices related to health and personal body weight. Appetite. 2010 Oct;55(2):311–8.

88. Valente TW. Network Interventions. Science. 2012 Jul 6;337(6090):49–53.

89. Merolli M, Gray K, Martin-Sanchez F, Lopez-Campos G. Patient-Reported Outcomes and Therapeutic Affordances of Social Media: Findings From a Global Online Survey of People With Chronic Pain. J Med Internet Res. 2015;17(1):e20.

90. Hutchesson MJ, Rollo ME, Krukowski R, Ells L, Harvey J, Morgan PJ, et al. eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis: eHealth interventions for obesity in adults. Obes Rev. 2015 May;16(5):376–92.

91. Baker R, Bateman I, Donaldson, C, Jones-Lee M, Lancsar E, Loomes G, et al. Weighting and valuing quality-adjusted life-years using stated preference methods: preliminary results from the Social Value of a QALY Project. Health Technol Assess [Internet]. 2010 May [cited 2018 Jun 3];14(27).

92. Drummond M, Tarricone R, Torbica A. Assessing the Added Value of Health Technologies: Reconciling Different Perspectives. Value Health. 2013 Jan;16(1):S7–13.

93. Harris T, Kerry SM, Limb ES, Furness C, Wahlich C, Victor CR, et al. Physical activity levels in adults and older adults 3–4 years after pedometer-based walking interventions: Long-term follow-up of participants from two randomised controlled trials in UK primary care. Basu S, editor. PLOS Med. 2018 Mar 9;15(3):e1002526.

94. Sharma AM, Padwal R. Obesity is a sign - over-eating is a symptom: an aetiological framework for the assessment and management of obesity. Obes Rev. 2010 May;11(5):362–70.

95. Kristensen ST, Køster A. Contextualising eating problems in individual diet counselling. Health Interdiscip J Soc Study Health Illn Med. 2014 May;18(3):319–31.

96. Carr LJ, Bartee RT, Dorozynski C, Broomfield JF, Smith ML, Smith DT. Internet-delivered behavior change program increases physical activity and improves cardiometabolic disease risk factors in sedentary adults: Results of a randomized controlled trial. Prev Med. 2008 May;46(5):431–8.

97. Cadmus-Bertram L, Wang JB, Patterson RE, Newman VA, Parker BA, Pierce JP. Web-based self-monitoring for weight loss among overweight/obese women at increased risk for breast cancer: the HELP

pilot study: Web-based weight loss among women at increased risk of breast cancer. Psychooncology. 2013 Aug;22(8):1821–8.

98. Cradock KA, ÓLaighin G, Finucane FM, McKay R, Quinlan LR, Martin Ginis KA, et al. Diet Behavior Change Techniques in Type 2 Diabetes: A Systematic Review and Meta-analysis. Diabetes Care. 2017 Dec;40(12):1800–10.

Supplementary materials

Supplementary tables and figures

Table S1. Weight-loss and weight-maintenance results of telemedicine intervention groups compared to usual care intervention groups

Telemedicine intervention groups that lost significantly more weight than usual care intervention groups				
Reference	**N**	**Duration (Months)**	**Results [a]**	**Type of data analysis: 95% CI / p [b]**
Huber JM et al, 2015, USA [45]	90	6	WL: ETE -2.3kg	**Intention to treat:** / 0.013
Oh B et al, 2015, South Korea [39]	422	24	WL: -2.21 vs -0.77 kg	**Intention to treat:** / < 0.001
Bennett GG et al, 2013, USA [51]	194	18	WL: MD −1.4kg	**Intention to treat:** −2.8 to −0.1kg / 0.04
Orsama AL et al, 2013, Finland [37]	48	10	WL: -2.1 vs -0.4kg	**Completers only:** / 0.021
Park MJ et al, 2012, South Korea [36]	67	3	WC: -3.0 vs +0.9cm WL: -2.0 vs +0.7kg	**Completers only:** /0.001 /0.001
Warner et al, 2012, USA [27]	365	24	WL: MD -1.03kg BMI: MD -0.38kg/m^2	**Intention to treat:** -2.03 to 0.03kg /..... -0.75 to 0.004kg/m2 /.....
Luley C et al, 2011, Germany [42]	70	6	WL: -11.8 vs -0.3kg BMI: -4.1 vs -0.1 kg/m^2	**Intention to treat** /0.000 /0.000
Burke LE et al, 2011, USA [49]	210	6	PP5%: 63 vs 46%	**Intention to treat:** /0.05
Izquierdo R et al, 2010, USA [44]	890	24	WC: -1.2 vs +1cm+	**Intention to treat:** / 0.02
Bennet GG et al, 2010, USA [50]	101	3	WL: MD -2.56kg	**Intention to treat:** -3.6 to -1.53kg /.....
Svetkey LP et al, 2008, USA [29]	1032	36	WL: MD -1.2kg	**Intention to treat:** CI −2.1 to −0.3; / P=.008
Polzien KM et al, 2007, USA [34]	57	3	WL: -6.2 vs -4.1kg	**Intention to treat:** /0.04
Goulis DG et al, 2004, Greece [48]	122	6	WL: -11.8 vs -2.0kg	**Intention to treat:** /0.05
Telemedicine intervention groups with no significant differences in weight loss compared to usual care intervention groups				
Reference	**N**	**Duration (Months)**	**Results [a]**	**Type of data analysis: 95% CI / p [b]**
Tárraga-Marcos ML et al, 2017, Spain [41]	180	12	WL: −4.3 kg vs −5.6kg BMI -1.5 vs −2.0 kg/m^2 WC -3.5 vs −3.6cm	**Intention to treat:** NS

Stumm G et al, 2016, Germany [30]	70	24	WL -8.9kg vs -9.8 WLM: +2.8kg vs +4.4kg	**Intention to treat:** NS
Allen JK et al, 2013, USA [53]	68	6	WL: -5.4 vs -2.5kg	**Completers only:** NS
Shrestha M et al, 2013, USA [32]	20	6	WL: -0.1 kg vs. +0.3 kg	**Completers only:** NS
Pellegrini CA et al, 2011, USA [35]	51	6	WL: −8.8 vs −3.7kg	**Intention to treat** NS
Shuger SL et al, 2011, USA [31]	197	9	WL: -6.59 vs -1.86 kg	**Intention to treat:** NS
Touger-Decker R et al, 2010, USA [28]	113	6,5	WL: -2.6 vs -1.7kg	**Completers only:** NS
Anderson DR et al, 2010, USA [52]	295	12	BMI: MD +0.19 kg/m^2	**Intention to treat:** NS
Haugen HA et al, 2007, USA [46]	87	6	WL: -0.6 vs -0.5kg	**Intention to treat:** NS
Wister A et al, 2007, Canada [26]	315	12	WC: -2.8 vs -2.3cm BMI:-0.47 vs -0.33kg/m^2	**Intention to treat:** NS
McConnon A et al, 2007, UK [40]	221	12	WL: -1.3 vs -1.9kg	**Completers only:** NS
Sherwood NE et al, 2006, USA [33]	1801	24	WL: -1.0 vs -0.6kg	**Intention to treat:** NS
Jeong-Ah Oh et al, 2003, South Korea [38]	50	3	BMI: +0.3kg/m2 vs +0.2kg/m2	**Completers only:** NS
Usual care intervention groups that lost significantly more weight than Telemedicine intervention groups.				
Reference	**N**	**Duration (Months)**	**Results [a]**	**Type of data analysis: 95% CI / p [b]**
Krukowski RA et al, 2011, USA [43]	323	6	WL: -5.5 vs -8.0kg	**Intention to treat:** .... / <0.01
Harvey-Berino J et al, 2010, USA [47]	481	6	WL: -6.0 vs -8.0kg	**Intention to treat:** / <0.01

a. Results were converted to SI units, and are expressed as a mean difference or as a comparison of weigh-loss results between the telemedicine intervention group and the control group.
b. For studies with more than 2 arms: the p is from the comparison between the most effective telemedicine intervention and the usual care control intervention at study completion.
+ This difference was found to be significant only for women.
CI: Confidence interval, **WL:** Weight-loss, **MD:** Mean difference, **ETE:** Estimated treatment effects using analysis of covariance (ANCOVA), **WC:** Waist Circumference, **WLM:** Weight-loss maintenance, **BMI:** Body Mass Index, **PP5%:** Percent of participants who had 5% weight-loss, **NS:** Non-significant difference.

Figure S1. User experience

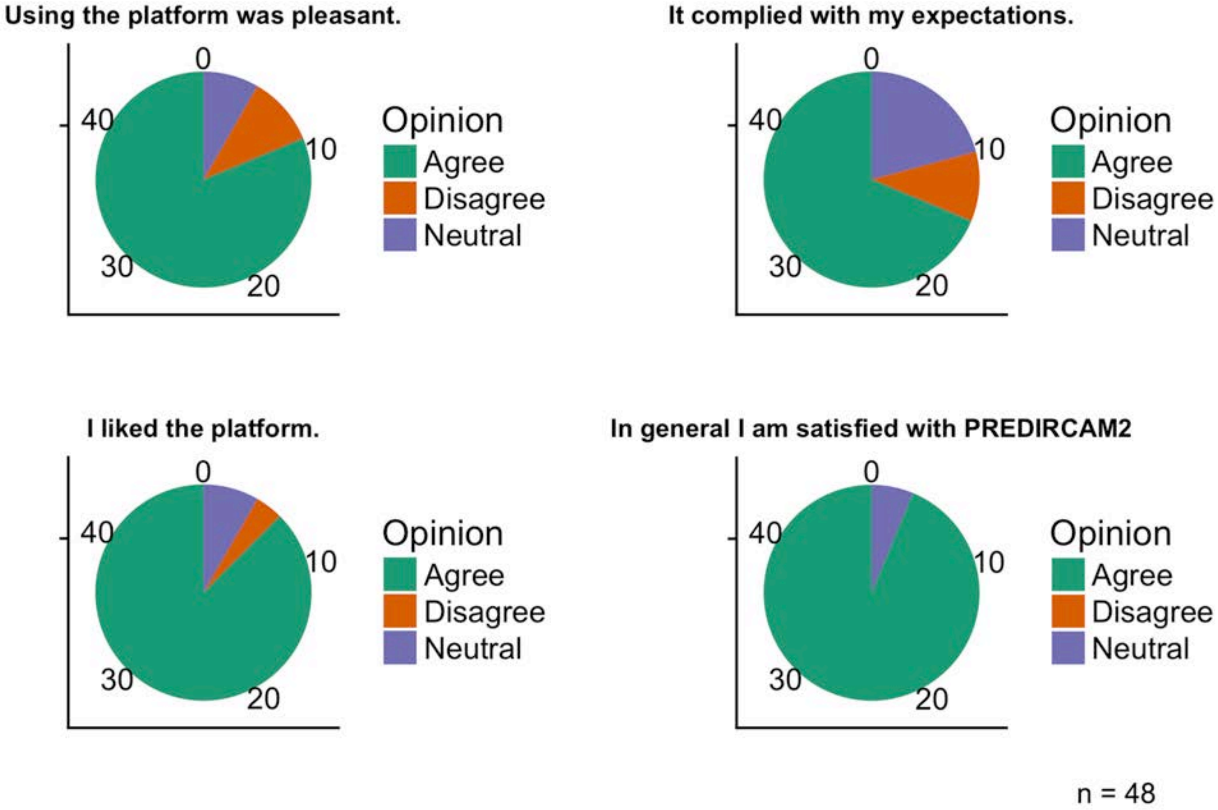


Figure S2. General usability of PREDIRCAM2 platform.

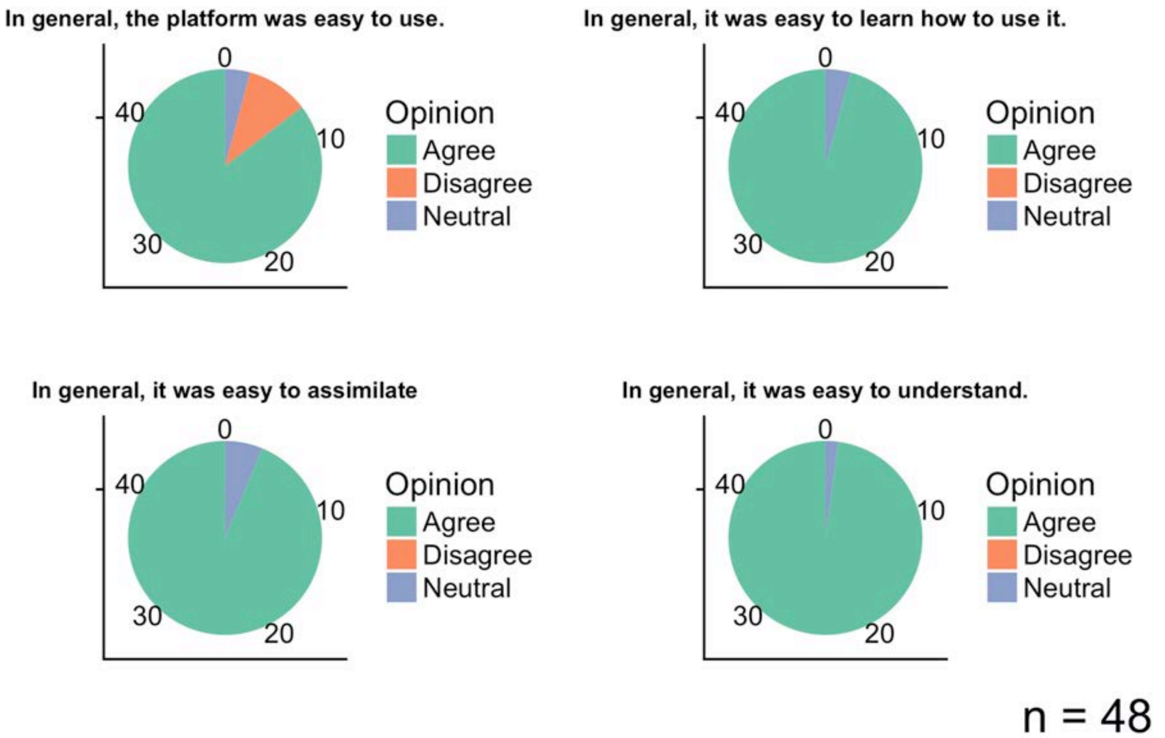


Figure S3. Satisfaction with PREDIRCAM2's exercise module

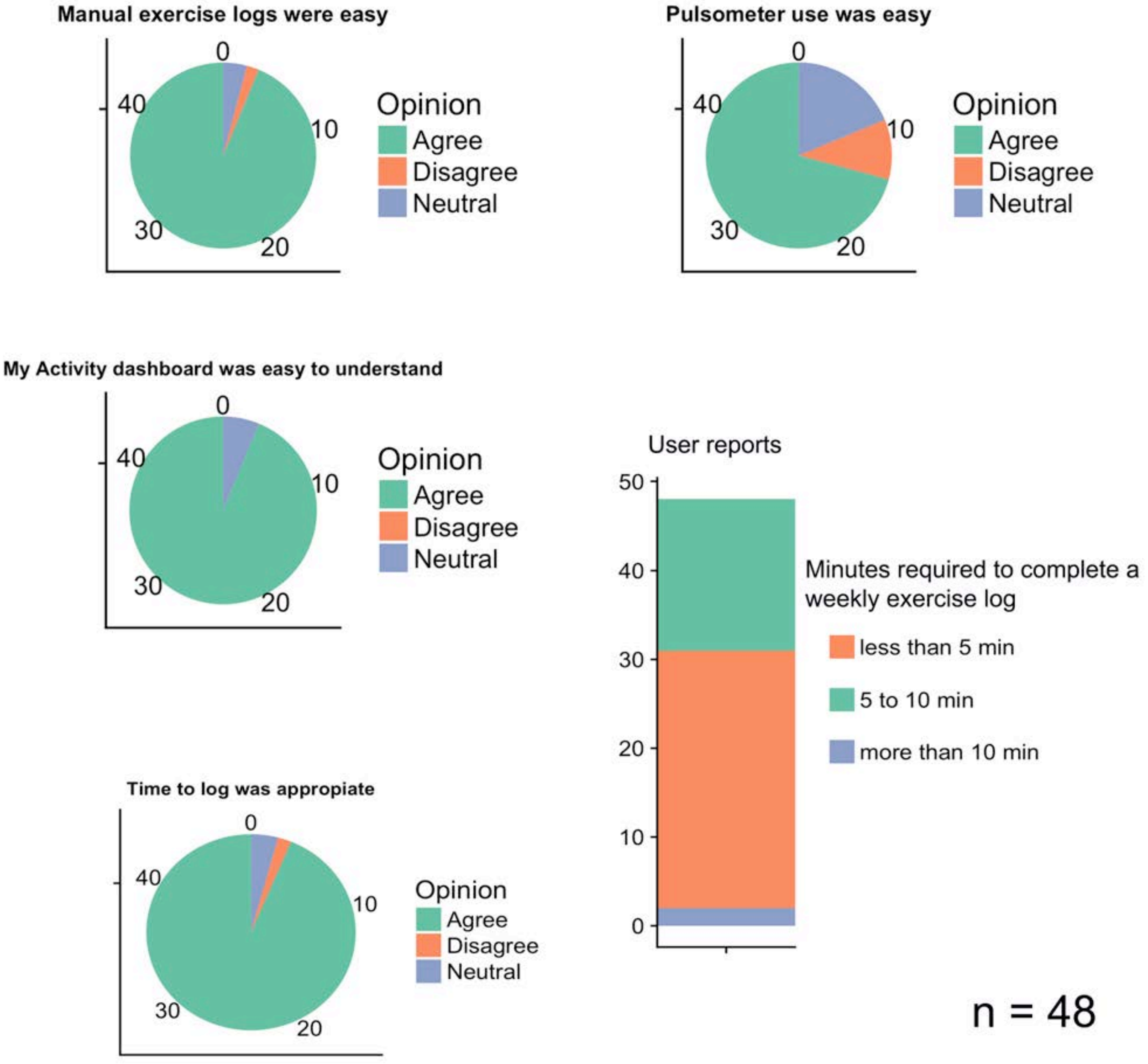


Figure S4. Satisfaction with PREDIRCAM2's dietary module

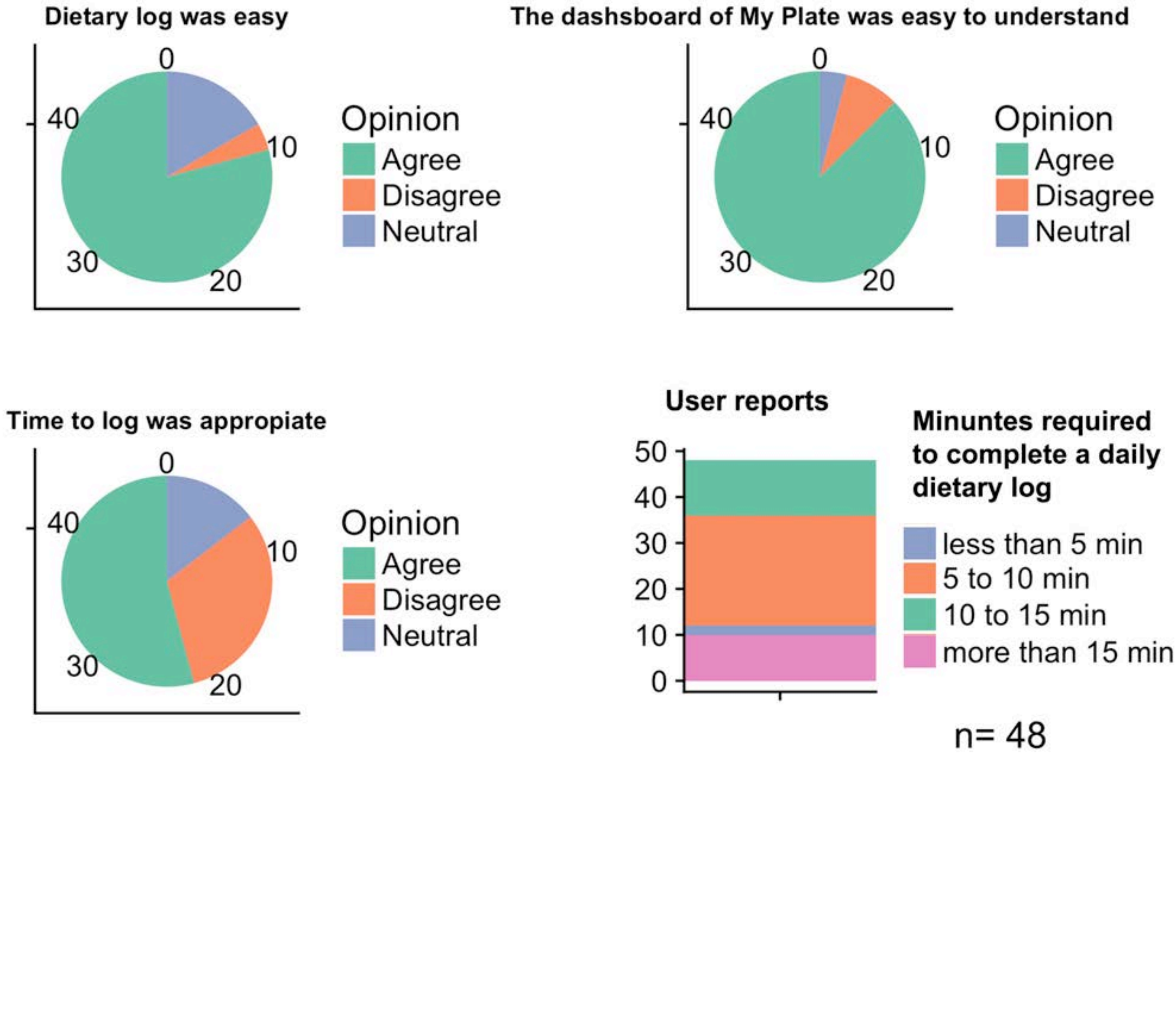


Figure S5. Users satisfaction with PREDIRCAM2's anthropometry module

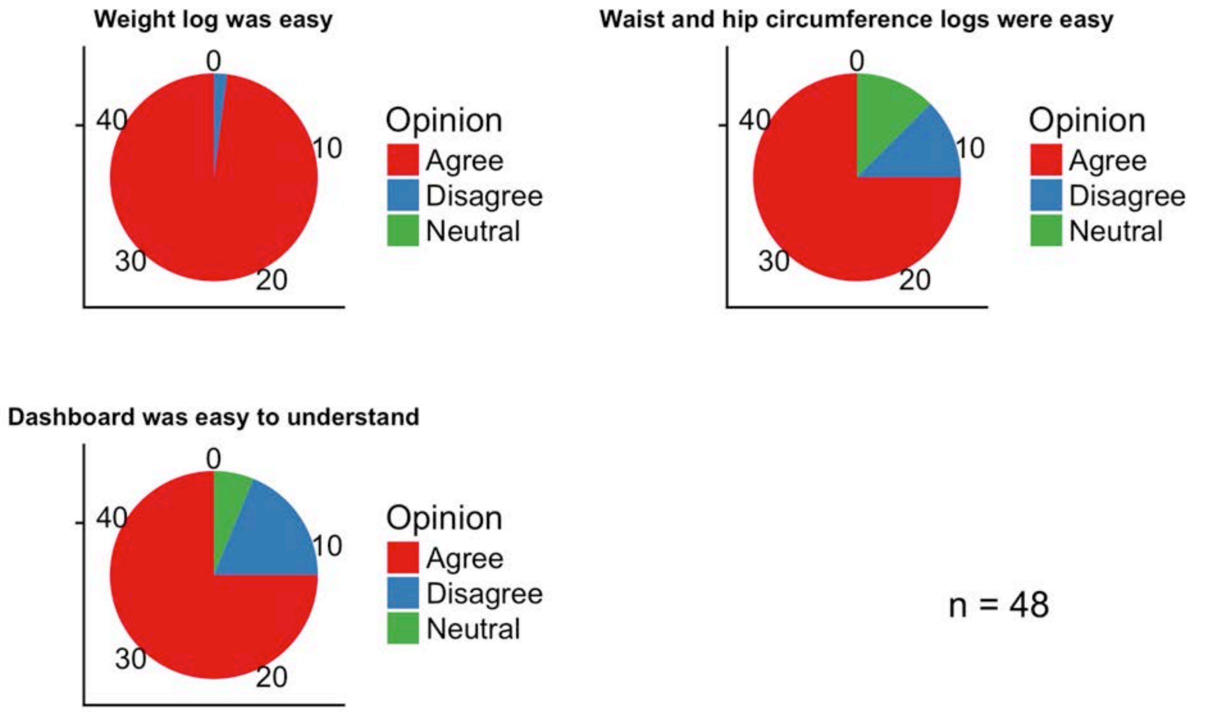


Figure S6. Satisfaction with PREDIRCAM2's messaging and notifications

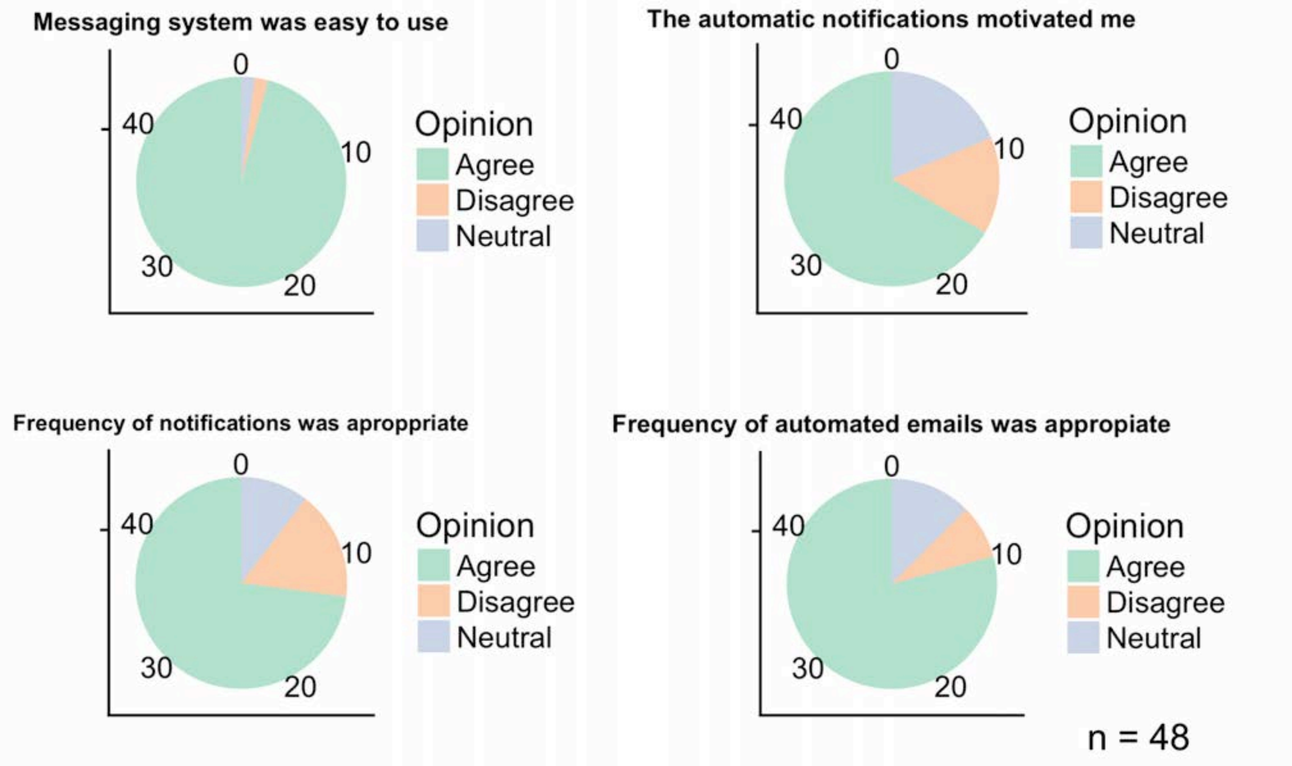
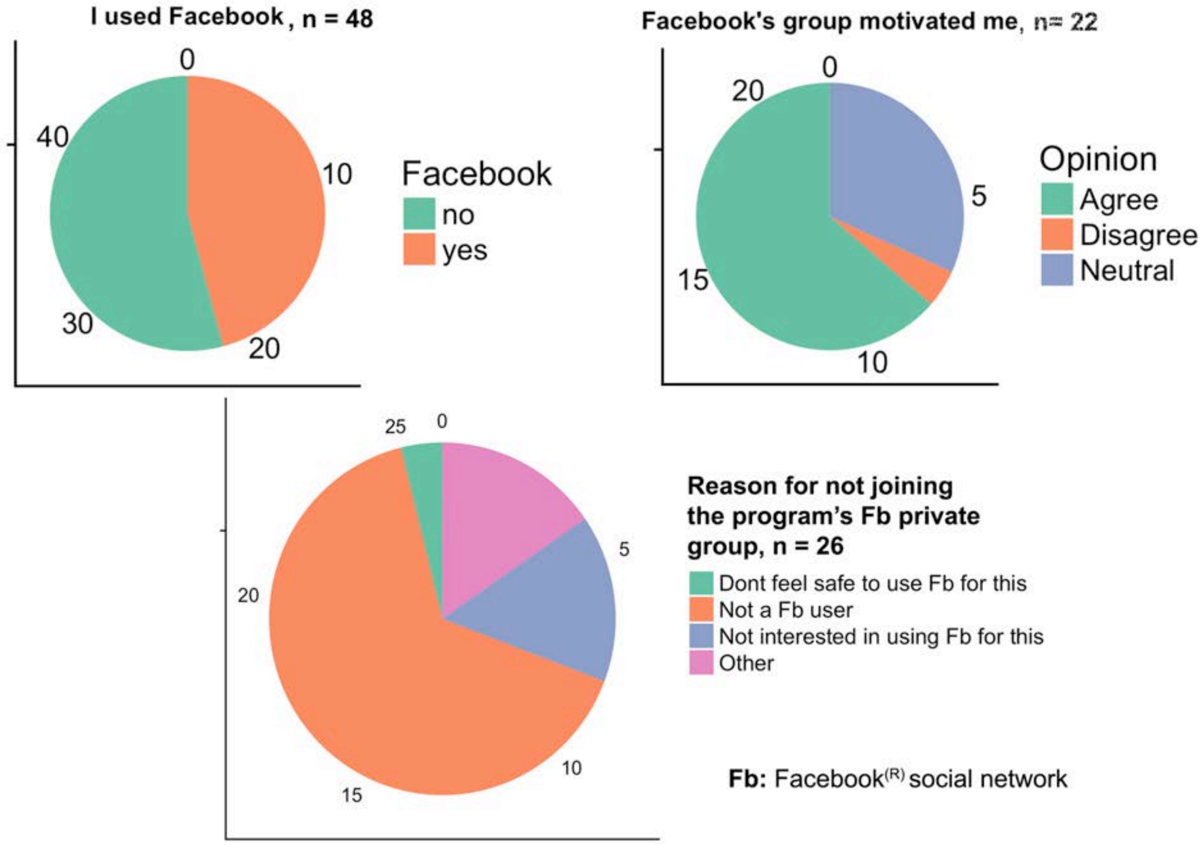


Figure S8. Users' satisfaction with the use of a Fb private group, and reported reasons for not joining.



Publications related to this work

Title: Web support for weight-loss interventions: PREDIRCAM2 clinical trial baseline characteristics and preliminary results.

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BRIEF REPORT

Web Support for Weight-Loss Interventions: PREDIRCAM2 Clinical Trial Baseline Characteristics and Preliminary Results

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Abstract

An ongoing clinical trial is testing the efficacy of web telematic support in a structured program for obesity treatment and diabetes prevention. Participants were recruited from two tertiary-care hospitals and randomized to receive either a telematic intervention (TI) supported by PREDIRCAM2 web platform or a non-telematic intervention (NTI). All receive 1-year follow-up. Both interventions consist of tailored dietary and exercise prescriptions, based on a Mediterranean dietary pattern and general WHO exercise recommendations for adults. At 6 months, both groups have received 7 contacts, 3 exclusively telematic for the TI group. This is a preliminary result intention-to-treat analysis. One hundred eighty-three participants were recruited, with a mean body mass index of $34.75 \pm 2.75\,kg/m^2$. General dropout rate at 6 months was 26.8%. Weight changes were statistically significant at months 3 and 6 compared to baseline, -2.915 ± 0.24 kg, -3.29 ± 0.36 kg, respectively ($P < 0.001$), but not statistically significant between the 3- and 6-month time points -0.37 ± 0.21 kg ($P = 0.24$). Mean group differences showed that the TI group lost 1.61 ± 1.88 kg more than the NTI group ($P = 0.39$). Waist, waist/hip ratio, resting heart rate, blood pressure, HbA1c, and low-density lipoprotein cholesterol also showed statistically significant changes at 6 months, with no significant differences between groups. Weight loss in the TI group shows similar results as the usual care NTI group for weight loss and control of obesity comorbidities. At completion of the clinical trial, these results will be reevaluated to assess the potential role of web support in weight-loss maintenance and its cost-effectiveness.

Keywords: Telemedicine, Obesity, Metabolic syndrome, Lifestyle modification.

Background

Obesity and its comorbidities are the pandemic of our age. Despite the proliferation of health promotion programs, the prevalence of obesity has not declined and is yet continuing to rise in specific populations.[1] Intensified treatments have proven to be effective for weight loss and diabetes treatment and prevention. Unfortunately, they remain unavailable in most countries given their elevated cost. In the battle against obesity and its comorbidities, telemedicine

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could offer cost-effective tools to facilitate intensified treatments. In our setting, telematic interventions (TIs) offering continued support and self-monitoring for conditions such as sleep apnea, or gestational diabetes, have shown to be useful and potentially cost-effective.[2–5]

PREDIRCAM2 is a web platform designed for promotion of healthy lifestyles, weight loss, weight-loss maintenance, and cardiometabolic risk prevention.[6] There is an ongoing clinical trial designed to assess the potential benefit of using web support in a structured treatment program for obesity and prevention of its comorbidities: Individualized telemedical assistance for lifestyle modification in the treatment of obesity and cardiometabolic risk prevention (NCT 01919372). Recruitment has been completed and all active participants have completed the 6-month follow-up.

Materials and Methods

In accordance with the Declaration of Helsinki, the participant institutions bioethics committee approved the study protocol. Participants were recruited at the Nutrition and Endocrinology Departments of two tertiary-care hospitals. They were derived by their primary care physicians or by the hospitals' occupational health departments. Eligibility criteria were as follows: adults 18 to 65 years, body–mass index between 30 and 39.9 kg/m^2, no severe illnesses, no pregnancy, and not receiving medications for glucose, lipid, blood pressure, or weight control. A randomization list was generated at https://www.sealedenvelope.com/ to allocate participants in two groups.

Program structure

In the first appointment, participants underwent evaluation of inclusion criteria with medical history anamnesis and provided their signed informed consent. Blood testing and anthropometry were performed in the second appointment. In the third appointment, participants were informed of their randomization to receive either a TI supported by the PREDIRCAM2 web platform or a non-telematic intervention (NTI). All participants will receive 1-year follow-up and treatment. Both interventions consist of tailored exercise and dietary prescriptions based on a Mediterranean dietary pattern and general WHO exercise recommendations for adults. TI group participants receive a heart rate monitor watch at baseline to estimate their physical activity intensity and energy expenditure (Polar RS400). Both groups have access to the same informative material and are asked to log their food intake; TI group through the web platform and NTI group on paper. At the 6-month follow-up, the NTI group had received treatment in 7 in-person contacts, while the TI group received 4 in-person contacts, 3 telematic contacts, and continued web support. Blood testing was performed again at the 6-month follow-up.

Description of the web platform

The PREDIRCAM2 web platform (http://limbhad.gbt.tfo.upm.es:8080/) was designed as an educational tool that allows healthcare providers to tailor dietary and physical activity goals, and users to assess and progressively adjust their lifestyles.[6] The exercise module receives input from the Polar RS400 heart rate monitor and also through direct manual registry from the user. The dietary module feeds on a dynamic database that grows according to the users' requests and allows them to save personal ingredient combinations. The platform provides feedback when logging dietary intake and physical activity, and also through general automatized notifications. A messaging system integrated into the

Table 1. Baseline Characteristics of the Study Population

	General, n = *183*	*TI group,* n = *91*	*NTI group,* n = *92*	P
Age (years)	44.5 ± 10.8	43.9 ± 11.2	44.6 ± 11.5	0.6688
Females (%)	83.6	86	82	0.4437
High education level (%)	54	61	47	0.0446
Smokers (%)	16	18	13	0.3271
Ex-smokers (%)	28	27	30	0.7081
Hypertension (%)	5	5.4	5.5	0.9859
Type 2 diabetes mellitus (%)	2	4.4	0	0.0449
Dyslipidemia (%)	11	11	12	0.8386
BMI (kg/m^2)	34.75 ± 2.75	34.5 ± 2.7	35 ± 2.8	0.2293
Weight (kg)	94.17 ± 12.68	93.2 ± 12.1	95.1 ± 13	0.2987
Waist (cm)	105.93 ± 9.5	104.71 ± 9	105.87 ± 10.1	0.4129
WHR	0.912 ± 0.08	0.911 ± 0.08	0.913 ± 0.09	0.8737
RHR (bpm)	73.2 ± 12.1	74.1 ± 11.4	74.2 ± 11.8	0.9149
SBP (mmHg)	128.85 ± 14.6	129.4 ± 14.4	127.5 ± 14.4	0.3647
DBP (mmHg)	83.81 ± 9.18	84.3 ± 8.9	82.4 ± 8.4	0.1386
HbA1c (%)	5.47 ± 0.36	5.44 ± 0.40	5.41 ± 0.33	0.5149
Insulin (pmol/L)	88.42 ± 42.75	94.33 ± 47.74	92.26 ± 49.94	0.7796
LDL cholesterol (mg/dL)	120.4 ± 29	120.8 ± 26.4	123.7 ± 31.5	0.5031
Non-HDL cholesterol (mg/dL)	138.98 ± 32	140.97 ± 31.02	142.98 ± 33.6	0.6764
HDL (mg/dL)	55.24 ± 14	54.4 ± 13	53.4 ± 14	0.6275
LDL/ApoB	1.21 ± 0.21	1.22 ± 0.2	1.21 ± 0.2	0.7594
Triglycerides (mg/dL)	93.71 ± 36	104.03 ± 61.50	99.41 ± 46.33	0.5683
HOMA-IR	2.93 ± 1.57	3.09 ± 1.68	3.04 ± 1.74	0.8673

BMI, body mass index; DBP, diastolic blood pressure; HDL, high-density lipoprotein; HOMA-IR; LDL, low-density lipoprotein; NTI, non-telematic intervention; RHR, resting heart rate; SBP, systolic blood pressure; TI, telematic intervention; WHR, waist/hip ratio.

platform enables the users to communicate with healthcare providers. Also, the platform includes a link to a private group on Facebook®, where users interact among themselves and with healthcare providers.

Statistical analysis

Sample size was determined to be 111 participants per group, with an α unilateral error of 5% and power of 80%, for a tolerated difference of 2 kg and standard deviation of ±6 kg. The dropout of a third participating center limited our total sample size to 183 participants. Normal distribution was assessed by box-plot evaluation. Two-way ANOVAs were performed to assess the effect of group and time on our study variables: weight, waist, waist/hip ratio (WHR), HbA1c, resting heart rate (RHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), insulin, homeostatic model assessment for insulin resistance (HOMA-IR), and blood lipids. There was homogeneity of variances, as assessed by Levene's test of homogeneity. The Greenhouse–Geisser correction was applied whenever we encountered sphericity violations for the two-way interactions. To deal with missing data, three types of analyses were performed: completers only per protocol (PP) analysis and two intention-to-treat (ITT) analyses. The strategies for ITT analyses were last-observation-carried-forward (LOCF) and multiple imputation (MI). Values of $P < 0.05$ were considered significant. Imputation process and statistical analysis were performed using SPSS package (version 23.0 for Mac OS; SPSS, Inc., Chicago, IL).

Results

Table 1 shows the baseline characteristics of the study population ($n = 183$). There were no significant differences between groups at baseline, except for education level and type 2 diabetes mellitus (T2DM) diagnosis. A larger percentage of participants in the TI group had a high education level, 61.5% having at least one higher education degree compared with 46.7% of the NTI group ($P = 0.0446$). All participants diagnosed with diabetes were in the TI group (4.4% vs. 0%, $P = 0.0449$). Their primary care physicians had diagnosed them before recruitment, following the American Diabetes Association's diagnosis criteria. The general dropout rate was 11.5% at 3 months and increased to 26.8% at 6 months. Dropout differential rates at 6 months were 34% for the TI group and 19.6% for the NTI group. The most frequently reported reason for dropout for both groups was finding the intervention too time-consuming, followed by a self-reported lack of motivation, and family issues. For detailed information on participant flow in the study (Supplementary Fig. S1; Supplementary Data are available at http://online.liebertpub.com/suppl/doi/10.1089/dia.2017.0456). Figure 1 shows weight by group from three different types of analyses. Table 2 shows the effect of time on study variables.

Completers only: PP analysis

Weight changes were statistically significant at 3 and 6 months compared to baseline, –4.0 ± 0.27 kg and –4.5 ± 0.47 kg, respectively ($P < 0.001$); but not statistically significant between

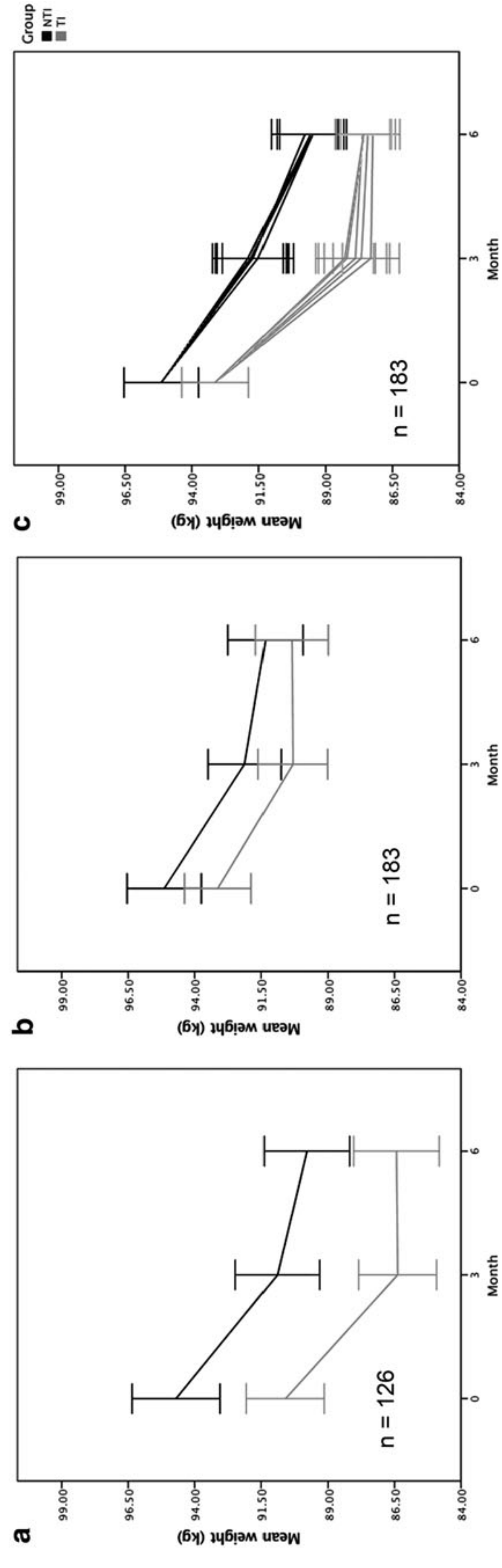

FIG. 1. Weight by group at 0, 3, and 6 months. **(a)** Completers only, **(b)** last-observation-carried-forward, **(c)** multiple imputation. NTI, non-telematic intervention; TI, telematic intervention.

Table 2. The Effect of Time on Study Variables

Type of analysis	Completers only, n = 126			Last-observation-carried-forward, n = 183			Multiple imputation, n = 183		
Time points (months)	0–3	0–6	3–6	0–3	0–6	3–6	0–3	0–6	3–6
Weight (kg)	−4.0 ± 0.27**	−4.5 ± 0.47**	−0.53 ± 0.30	−2.915 ± 0.24**	−3.29 ± 0.36**	−0.37 ± 0.21	−4.32 ± 0.49**	−5.6 ± 0.61**	−1.28 ± 0.44*
Waist (cm)	−4.34 ± 0.46**	−5.9 ± 0.60**	−1.6 ± 0.59	−3.45 ± 0.35**	−4.5 ± 0.46**	−1.1 ± 0.41*	−4.32 ± 0.48**	−6.17 ± 0.57**	−1.85 ± 0.49**
WHR	−0.018 ± 0.04**	−0.024 ± 0.004**	−0.006 ± 0.004	−0.016 ± 0.003**	−0.019 ± 0.003	−0.003 ± 0.003	−0.018 ± 0.005**	−0.025 ± 0.005**	−0.007 ± 0.005
RHR (bpm)	−3.19 ± 0.87 **	−3.56 ± 1.0bpm*	−0.37 ± 0.88	−2.5 ± 0.65**	−2.9 ± 0.75**	−0.47 ± 0.61	−4.1 ± 0.92**	−4.2 ± 0.84**	−0.138 ± 0.96
SBP (mmHg)	−3.78 ± 1.03**	−2.53 ± 1.06	−1.25 ± 0.71	−3.0 ± 0.74**	−2.0 ± 0.78*	−1.04 ± 0.71	−2.6 ± 0.98*	−1.47 ± 1.04	−1.14 ± 0.93
DBP (mmHg)	−1.64 ± 0.58*	−1.6 ± 0.70	−0.039 ± 0.64	−1.4 ± 0.42*	−1.3 ± 0.51*	−0.031 ± 0.45	−2.09 ± 0.71*	−1.8 ± 0.68*	−0.27 ± 0.77
HbA1c (%)	—	−0.07 ± 0.021*	—	—	−0.048 ± 0.015*	—	—	−0.044 ± 0.023*	—
Insulin (pmol/L)	—	−3.87 ± 3.64	—	—	−2.84 ± 2.61	—	—	−8.14 ± 3.44*	—
LDL cholesterol (mg/dL)	—	−4.21 ± 1.6*	—	—	−2.84 ± 1.15*	—	—	−6.67 ± 1.89**	—
Non-HDL cholesterol (mg/dL)	—	−2.85 ± 2.21	—	—	−2.03 ± 1.54	—	—	−5.73 ± 2.25*	—

**$P < 0.001$, *$P < 0.05$.

the 3- and 6-month time points −0.53 ± 0.30 kg ($P = 0.24$). Mean group differences showed the TI group ($n = 55$) lost a mean of −3.99 ± 2.23 kg more than the NTI group ($n = 71$); this difference, however, was not statistically significant ($P = 0.075$). Mean differences between groups were not statistically significant for waist, WHR, HbA1c, RHR, SBP, DBP, HbA1c, HOMA-IR, and blood lipids, and no significant changes were detected on high-density lipoprotein (HDL), non-HDL cholesterol, low-density lipoprotein (LDL)/ApoB index, triglycerides, insulin, or HOMA-IR at 6 months (data not shown).

ITT analysis: LOCF

ITT analysis with LOCF showed weight changes were statistically significant at 3 and 6 months compared to baseline, −2.915 ± 0.24 kg and −3.29 ± 0.36 kg, respectively ($P < 0.001$), but not statistically significant between the 3- and 6-month time points −0.37 ± 0.21 kg ($P = 0.24$). Mean group differences showed the TI group ($n = 91$) lost 1.61 ± 1.88 kg more than the NTI group ($n = 92$); this difference, however, was not statistically significant ($P = 0.39$). ITT analysis with LOCF showed no significant differences between groups for waist, WHR, HbA1c, RHR, SBP, DBP, HbA1c, HOMA-IR, and blood lipids. No significant changes were detected on HDL, non-HDL cholesterol, LDL/ApoB index, triglycerides, insulin, or HOMA-IR at 6 months (data not shown).

ITT analysis: MI

ITT analysis with MI showed weight changes were statistically significant at all time points. Between 3 and 6 months compared to baseline, −4.32 ± 0.49 kg and −5.6 ± 0.61 kg, respectively ($P < 0.001$); and between the 3- and 6-month time points: −1.28 ± 0.44 kg ($P = 0.011$). Mean group differences showed the TI group ($n = 91$) lost −2.66 ± 1.61 kg more than the NTI group ($n = 92$), however, this difference was not statistically significant ($P = 0.101$). ITT analysis with MI showed no significant differences between groups for waist, WHR, HbA1c, RHR, SBP, DBP, or blood lipids. HDL, triglycerides, LDL/ApoB index, or HOMA-IR did not show any significant changes at 6 months (data not shown).

Conclusions

Applied health technologies in lifestyle interventions for obesity have been tried in a wide variety of combinations to provide telematic support for weight loss in countries from North America, Australia, and Northern Europe.[7–11] To our knowledge, this is the first clinical trial of its kind to be held in a Mediterranean clinical setting.

The magnitude of weight changes at 6 months was similar to reports from other lifestyle interventions and to other technology-based weight-loss intervention programs.[12–14] Blood lipids and HbA1c changes were mild, however, this can be expected from a mostly nondiabetic population whose blood glucose and lipids were controlled without requiring any medications at recruitment.

Individualization, self-tracking, and e-coaching are key characteristics that have been related to improved health outcomes, usability, and adherence to e-health interventions.[11] The PREDIRCAM2 web platform integrates these key characteristics into a comprehensive lifestyle intervention. Weight, waist, WHR, HbA1c, and lipid changes were not significantly different between groups, suggesting that a substitution of 43% of the contacts with telematic support through the PREDRICAM2 web platform could be feasible. Continued web support could allow for both more contacts and an individualized approach.

The main limitation of this study is that it is underpowered to show significant differences between groups. High dropout rates are common in obesity intervention trials, limiting results and demanding for strategies to deal with missing data. Intensified intervention programs for obesity usually require frequent contacts with healthcare providers for reinforcement. Previous studies suggest that face-to-face contacts are required to provide clear instructions for implementation and engage patients in their therapy; therefore, not all the contacts can be substituted by any telematic strategy.[11] The amount of face-to-face contacts required by each individual may vary.[15] This may be a reason for the higher dropout rate seen in the TI group, since the use of technology in itself was not a frequently reported reason for dropout. Despite these limitations, the same trends were encountered for weight, waist, and WHR across all the analysis approaches.

Across the different strategies for dealing with missing data, the TI group exhibits the same weight-loss trend with an initial steep slope before the 3-month time point that tends to stabilize toward 6 months. Waist and WHR show similar trends. This trend may reflect the participants' motivation and adherence to treatment. There is a possible motivational effect in the use of technology that tends to wear off at 2 or 3 months, with consequent drops in adherence. The use of technologies in lifestyle interventions, such as webs, mobile applications, or physical activity trackers, has shown similar trends, with adherence rates tending to decline at 2 to 3 months of follow-up.[9,16,17]

The TI group shows similar preliminary results for weight loss and control of obesity comorbidities when compared to usual care. At the completion of the ongoing clinical trial, these results will be reevaluated to assess the potential role of web support for weight-loss maintenance as well as its cost-effectiveness.

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Author Disclosure Statement

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References

1. OECD: Obesity Update 2017 (OECD). www.oecd.org/els/health-systems/Obesity-Update-2017.pdf (accessed November 27, 2017).
2. Caballero-Ruiz E, García-Sáez G, Rigla M, et al.: A web-based clinical decision support system for gestational diabetes: automatic diet prescription and detection of insulin needs. Int J Med Inform 2017;102:35–49.
3. Galiano-Castillo N, Cantarero-Villanueva I, Fernández-Lao C, et al.: Telehealth system: a randomized controlled trial evaluating the impact of an internet-based exercise intervention on quality of life, pain, muscle strength, and fatigue in breast cancer survivors: telehealth system in breast cancer. Cancer 2016;122:3166–3174.
4. Isetta V, Torres M, González K, et al.: A New mHealth application to support treatment of sleep apnoea patients. J Telemed Telecare 2017;23:14–18.
5. Fuertes-Guiró F, Vitali-Erion E, Rodriguez-Franco A: A program of telementoring in laparoscopic bariatric surgery. Minim Invasive Ther Allied Technol 2016;25:8–14.
6. González C, Herrero P, Cubero JM, et al.: PREDIRCAM eHealth platform for individualized telemedical assistance for lifestyle modification in the treatment of obesity, diabetes, and cardiometabolic risk prevention: a pilot study. J Diabetes Sci Technol 2013;7:888–897.
7. Hutchesson MJ, Rollo ME, Krukowski R, et al.: eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis: eHealth interventions for obesity in adults. Obes Rev 2015;16:376–392.
8. Coons MJ, DeMott A, Buscemi J, et al.: Technology interventions to curb obesity: a systematic review of the current literature. Curr Cardiovasc Risk Rep 2012;6:120–134.
9. Lyons EJ, Lewis ZH, Mayrsohn BG, et al.: Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis. J Med Internet Res 2014;16:e192.
10. Sorgente A, Pietrabissa G, Manzoni GM, et al.: Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. J Med Internet Res 2017;19:e229.
11. Lentferink AJ, Oldenhuis HK, de Groot M, et al.: Key components in eHealth interventions combining self-tracking and persuasive eCoaching to promote a healthier lifestyle: a scoping review. J Med Internet Res 2017;19:e277.
12. De Luis DA, Izaola O, Primo D, et al.: Biochemical, anthropometric and lifestyle factors related with weight maintenance after weight loss secondary to a hypocaloric mediterranean diet. Ann Nutr Metab 2017;217–223.
13. Gepner Y, Shelef I, Schwarzfuchs D, et al.: Effect of distinct lifestyle interventions on mobilization of fat storage pools: the central MRI randomized controlled trial. Circulation 2017;pii: CIRCULATIONAHA.117.030501.
14. Haggerty AF, Hagemann A, Barnett M, et al.: A randomized, controlled, multicenter study of technology-based weight loss interventions among endometrial cancer survivors: technology-based weight loss and endometrial cancer. Obesity 2017;25:S102–S108.

15. Rafiei N, Gill T: Identification of factors contributing to successful self-directed weight loss: a qualitative study. J Hum Nutr Diet 2017. DOI:10.1111/jhn.12522.
16. Hermsen S, Moons J, Kerkhof P, et al.: Determinants for sustained use of an activity tracker: observational study. JMIR MHealth UHealth 2017;5:e164.
17. Cadmus-Bertram L, Marcus BH, Patterson RE, et al.: Use of the fitbit to measure adherence to a physical activity intervention among overweight or obese, postmenopausal women: self-monitoring trajectory during 16 weeks. JMIR MHealth UHealth 2015;3:e96.

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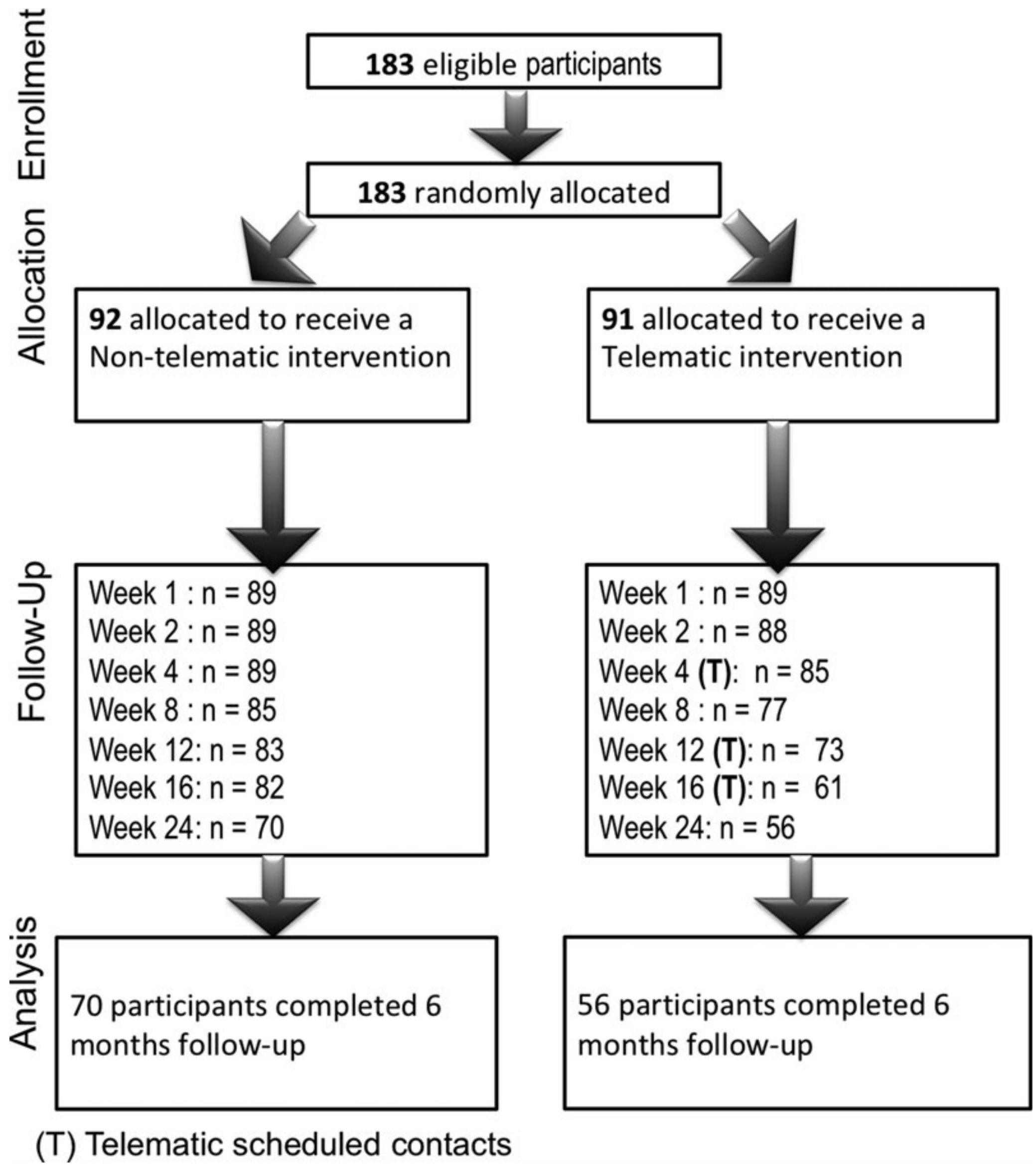
Supplementary Data



SUPPLEMENTARY FIG. S1. Flow of participants in the first 6 months of PREDIRCAM2 clinical trial. Telematic scheduled contacts are marked as **(T)**.

Title: Intensified telematic treatment for obesity – drop out rates and predictors at 6 months of Predircam2 web intervention.

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INTENSIFIED TELEMATIC TREATMENT FOR OBESITY - DROP OUT RATES AND PREDICTORS AT 6 MONTHS OF PREDIRCAM2 WEB INTERVENTION

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Table 1. Odds ratio for predictors of drop out at 6 months of the PREDIRCAM2 randomized trial

Variable	Whole sample analysis (n = 183)			Subgroup analysis: Non-technological internvention group (n= 92)			Subgroup analysis: Technological intervention group (n= 91)		
	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
Age (years)	0.9577	0.906 - 1.009	> 0.05	0.9190	0.835 - 0.997	= 0.05	0.9612	0.875 - 1.050	> 0.05
History of Obesity (years since diagnosis)	1.0100	0.979 - 1.042	> 0.05	1.0403	0.975 - 1.118	> 0.05	1.0053	0.966 - 1.047	> 0.05
HbA1c at baseline (%)	2.4441	0. 694 - 8.701	> 0.05	7.6712	0.426 - 231.6	> 0.05	1.8303	0.338 - 10.46	> 0.05
BMI baseline kg/m^2	0.3073	0.171 - 0.508	<0.001	0.4053	0.167 - 0.834	< 0.05	0.1855	0.064 - 0.428	< 0.001
BMI at 3 months kg/m^2	3.2093	1.728 - 6.849	<0.001	1.3165	0.351 - 5.081	> 0.05	5.6975	2.328 - 21.36	< 0.01
BMI at 6 months kg/m^2	1.0780	0.675 - 1.589	> 0.05	1.7905	0.686 - 5.332	> 0.05	1.0407	0.502 - 1.711	> 0.05
Dietary prescription at baseline (kcal)	1.0001	0.998 - 1.002	> 0.05	1.0010	0.998 - 1.005	> 0.05	0.9987	0.995 - 1.002	> 0.05
Physical activity prescription at baseline (kcal)	1.0006	0.999 - 1.001	> 0.05	1.0001	0.999 - 1.001	> 0.05	1.0007	0.999 - 1.002	> 0.05
Married (Yes)	0.6734	0.274 - 1.642	> 0.05	0.3749	0.068 - 1.811	> 0.05	0.9293	0.225 - 3.886	> 0.05
Fixed shift schedule (Yes)	0.9779	0.411 - 2.359	> 0.05	1.5370	0.333 - 7.950	> 0.05	0.5072	0.129 - 1.844	> 0.05
Personal history of depression (1)	1.7301	0.341 - 8.527	> 0.05	7.2825	0.226 - 171.1	> 0.05	1.023	0.118 - 9.409	> 0.05
Personal history of osteomuscular lesions (1)	3.3595	1.138 - 10.163	< 0.05	4.2157	0.617 - 30.31	> 0.05	5.0831	1.013 - 32.92	> 0.05
Previous treatments with technology/gadgets (1)	0.8508	0.307 - 2.269	> 0.05	1.003	0.169 - 5.438	> 0.05	0.4925	0.099 - 2.124	> 0.05
Reported anxiety towards food/eating (Yes)	1.2029	0.448 - 3.349	> 0.05	2.3893	0.424 - 18.34	> 0.05	1.1903	0.274 - 5.358	> 0.05

OR: Odds ratio calculated from coefficients of binomial logistic regression

Background and Aims: PREDIRCAM2 is a web-platform for obesity treatment and follow-up. A multicenter randomized-trial evaluates its effectiveness in obesity treatment and cardio-metabolicrisk prevention. Participants were randomized to an intensified technological-intervention (TI) supported by PREDIRCAM2, or a traditional non-technological face-to-face-intensified-intervention (NTI). Both groups receive one year follow-up, 12 appointments, 4 exclusively telematic in TI group. **Methods:** Drop-outs were counted from the first week of intervention until 6 months to assess global, diferential rates, and reported reasons. Binomial logistic regression was used to detect potential predictors for the sample as a whole and by subgroups. Analysis was performed using RStudio v1.0.153. **Results:** Overall drop-out rate is 24.6% (45/183), diferentials: 31.9% (29/91)TI, 17.4%(16/92) NTI. Most frequent drop-out reasons were: finding interventions too time consuming (5/16NTI, 7/29TI), followed by lack of motivation (4/ 16NTI, 6/29TI), and family issues (2/16NTI, 6/29TI). Four of twenty-nine drop-outs from TI group (14%) reported the reason to be unfriendly technology. Baseline BMI was a negative predictor (OR0.31, $p < 0.01$). Previous treatments using technology and having fixed working schedules were negative predictors of drop-out for the TI group (OR0.49, $p > 0.05$), while neutral(OR1.03, $p > 0.05$) and positive (OR 1.5, $p > 0.05$) respectively for NTI group (Table 1).

Conclusion: TI group had more drop-outs. Most frequently reported reasons were not directly related to technology. Adequate selection of participants and friendlier technology could improve TI adherence.

Title: Intensified telematic treatment for obesity using the web platform PREDIRCAM2, descriptive basal characteristics and preliminary results.

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INTENSIFIED TELEMATIC TREATMENT FOR OBESITY USING THE WEB PLATFORM PREDIRCAM2, DESCRIPTIVE BASAL CHARACTERISTICS AND PRELIMINARY RESULTS

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Background: PREDIRCAM2 is a web platform for obesity treatment and follow-up. It contains modules for: dietary prescription and registry with nutritional analysis based on individualized and mediterranean dietary goals, physical activity prescription and tracking with individualized targets, and anthropometric tracking. An ongoing multicenter randomized clinical trial evaluates the intervention's effectiveness in obesity treatment and cardio-metabolic-risk prevention.
Methods: Inclusion criteria: 18–65 years-old, BMI 30–39.9 kg/m2, no medication for type-2 Diabetes Mellitus (DM), dyslipidemia (DLP) or hypertension (HT). Randomization to intensified technological intervention (TI) supported by PREDIRCAM2 platform, or traditional non-technological face-to-face intensified treatment intervention (NTI). Both groups receive one year follow-up through 12 appointments with health-care professionals, 4 of which are exclusively telematic in the TI group.
Basal characteristics: 183 participants have been included, BMI 34.74±2.74, age 44.27±10.62, 84% female (31% postmenopausal, 6.5% history of gestational DM), 54% high education level, 54% married. Comorbidities: 2.2% type-2 DM, 5.5% HT, 11.5% DLP, 6.5% Depression, 2.7% diagnosed eating disorders. 56% received medication, most frequently antidepressants (24.5%) followed by vitamin D supplements (11.8%). 68% reported anxiety towards food, overeating in the form of: pecking 84.7%, binge-eating 35.5%, binge-and-vomiting 3.2%.
Preliminary results: 119 participants have completed 3-month follow-up: 60 TI, 59 NTI. Both groups have lost weight significantly ($P<0.0001$). 26.7% TI, and 25.4% NTI have achieved at least a 5% weight-loss ($P=0.88$). 81 participants have completed 6-month follow-up: 41 TI, 40 NTI. Both groups have lost weight significantly ($P< 0.0001$). 46.3% TI, and 32.5% NTI have achieved at least a 5% weight-loss ($P=0.20$). Both groups have achieved a reduction in HbA1c levels ($P<0.0001$), TI −0.81±1.9% and NTI −1.36±2.2% ($P=0.24$).
Conclusion: Our study population is mostly composed of highly educated females who report a high frequency of anxiety towards food and eating. PREDIRCAM2 shows to be a promising tool for obesity treatment and cardio-metabolic-risk prevention.

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