

Health Monitoring Web Platform for Real-Time Expert-User Interaction

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Abstract—Mobile health tracking applications are in abundance over the last years, with applications such as fitness tracking, photo diet tracking for weight loss and diet reporting applications. These applications are used for self-assessment, dynamic feedback and motivation of the users, while some more recent studies revealed that the data from these applications can be beneficial for experts in advising their clients. In this work, a real-time nutrition and fitness tracking web platform is proposed that enables experts to track the progress of their clients (even) in real-time or based on their work schedule, so as to establish a more holistic view of clients' progress. The platform aims to support experts in providing the best guidance and advice on a nutrition and fitness plan. The web platform was developed, used and evaluated by both clients and experts, which showcased the importance of this real-time expert-user interaction.

Keywords—health tracking applications, real-time interaction, health monitoring, web platform, nutrition, fitness, diet plan.

I. INTRODUCTION

Many health problems today are due to overweight and lack of exercise. This leads people to consult *Registered Dietitian Nutritionist (RDN)*, who can guide them with regards to a healthy diet. Yet, this is not enough, as a healthy diet needs to be complemented with physical activity, in order to maintain or improve one's personal health [1]. Also, RDNs cannot accurately know the amount of physical activity that their clients do on a daily basis, which is a problem, since it can aid experts to gain a holistic view of the client's health.

Mobile health tracking devices support users in monitoring and self-assessing their health. In addition to mobile health tracking devices, there are also many smartphone applications on the market, i.e., S-Health, Apple Health, MyFitnessPal, which can be used for the same purpose. Self-monitoring has become easier with the use of such applications, since user input is significantly reduced. Users can therefore track and record a wealth of data relating to their physical activity, fitness, diet, pulses, etc., with less effort than ever before [2].

However, it is difficult for users to continue using mobile health tracking applications for extended periods of time [3]. This indicates abandonment towards these applications usage. Abandonment maybe attributed to several reasons and requires further investigation for each particular situation [3]. Possible

reasons could be though the loss of enthusiasm that existed at the early stage of use, users have achieved the targets that they had set at the start of usage, external user life obligations that have interrupted usage, cannot use the entire set of features of the device/application effectively or to their fullest capabilities.

Taking into consideration the aforementioned, in this work a health monitoring web platform for real-time expert-user interaction is developed and presented. It has two components: i) web application for experts and ii) Android mobile application for users. This web platform supports real-time nutrition and fitness tracking of the users' health data by the experts. This includes data like steps walked, distance covered and calories burnt. Furthermore, users (clients) are able to share their diet health data with expert RDNs. By having access to this data, RDNs are able to draw important conclusions about the overall health and progress of their clients. Specifically, RDNs can even interact in real-time with clients (if needed) by sending them messages regarding their progress for providing them with advices and remarks. Based on the results of this work it is shown that this can be highly beneficial and motivational.

Mobile devices are considered the most successful ubiquitous device to date, with the population of mobile device owners to be very high and constantly on the rise. Exploiting also this fact, this work aimed towards the development of a mobile application, together with the support of a web application that would enable clients to interact with RDNs, in an effort to promote "quantified-self" (tracking daily living related information via technology usage) fitness and nutrition, but also receive expert guidance and advice. Together, the web application aimed at RDNs and the mobile application aimed at the clients, refer to an integrated web platform. This platform, as the key contribution of this work, supports real-time interaction and expert guidance on nutrition and fitness.

Using this platform, RDNs are able to interact with their clients in real-time. In specific, clients can manually upload their health data to the platform through the mobile health tracking application. Then, with clients' consent, RDNs can have access to the physical activity records of their clients, are able to monitor whether their expert diet guidance and advice

is being followed correctly and can also send messages to their clients for further guidance and motivation in real-time.

II. RELATED WORK

The "quantified self" movement considers the assistance of technology to measure all aspects of daily living [4]. Wearable devices can be used to collect data that will increase the understanding people have of themselves, their surrounding environment, and which could even benefit their health. In most cases users do feel motivated to wear wearables to track their activities for health and fitness purposes for a while - best scenario a few months - before stop using them. Research work indicates abandonment of health tracking applications [3, 5, 6, 7, 8]. This can be attributed to various reasons, e.g., users achieved the targets, everyday obligations interrupted applications usage, or lack of motivation simply because they do not see the benefit. This subject requires further investigation for each particular situation [3, 5]. In fact, various research works have been performed on health behaviour change approaches, e.g., gamification and social connections, to avoid technology abandonment.

On the basis of the above approaches an abundance of smartphone applications has been created, and exist in the market today covering diverse aspects: (i) *Calorie Counter* - MyFitnessPal, MyNetDiary and Fooducate are smartphone applications that mainly track diet and exercise to determine optimal caloric intake and nutrients for achieving users' goals and uses gamification elements to motivate users. (ii) *Fitness Tracking* - Google Fit and S-Health are applications that track steps and fitness. In overall, with these applications users can track their fitness and analyze their stats to see how to improve. (iii) *Digital Tutors* - An example is Pocket Yoga that includes different sessions based on the level of expertise and experience with listed poses, images and videos.

Apart from health tracking applications, several research works have been performed to address the above issues. In [9], the development of the user interfaces of a multi-device digital coaching service is presented, which aims to provide tailored feedback to users concerning their physical activity level and medication intake. It examines user preferences regarding the situation, device and timing of feedback they would like to receive from their personal attentive digital coach. In specific, this work shows that creating meaningful and effective attentive personal systems implies that these systems provide support taking the context of the user into account, and empower users to take control of their lifestyle. The goal is to support users in daily life, and offer timely and meaningful feedback to empower users to adopt a certain (more healthy) behaviour [9].

The mobile fitness coach (i.e., GymSkill) is an application for comprehensive physical exercising support, from sensor data logging, activity recognition to on-top skill assessment, using the phone's built-in sensors [10]. The researchers used principal component breakdown analysis and criteria-based scores for individualized and personalized automated feedback on the mobile phone. The goal of this research is to track training quality and success and give feedback to the user, as well as to engage and motivate regular exercising [10].

Automatic generation of real-time tailored messages in a behaviour change application is also addressed in [11]. The authors present a comprehensive and practical framework that addresses the basic aspects of motivational messages that are time, intention, content and presentation. The targets are (i) to define a Model of Motivational Messages encompassing the above concepts relevant to the topic of motivational message generation, and (ii) to develop a practical framework for automatically generating effective physical activity promotion messages in a real-time setting. The paper focus is on physical activity promotion, but the model and framework are used in the broader scope of behaviour change support.

The above research works address the aspect of timely, personalised, context-aware and automated feedback to the user. This aims to promote self-management, motivate the client and inject behaviour change to avoid health tracking applications abandonment. More recent research work begins to acknowledge the need for a more interactive relationship between the client and experts. In specific, an integrated system and method is patented in [12]. It permits coaches to maintain contact with multiple clients, update clients' activities, motivate clients to attain their goals and continue training without the physical presence of the coach.

This work is heavily related to the above system. It aims to enable interactive communication between RDNs and clients, in an analogous way as the coach and clients communication in [12]. This is enabled even during periods when there is no personal contact, i.e., during scheduled appointments with the RDN, to foster a continuous relationship and provide accountability and engagement in order to maximize the effectiveness of the diet, fitness and coaching program. In order to implement such a platform, the research model is formulated and presented in the next section.

III. RESEARCH MODEL

Research work in [13] defines a framework for discussing key areas in which such activity tracking applications can be improved. It considers four properties (see Fig.1): *intention, timing, content, and representation*. The authors define intention to be: either inform about the benefits of physical activity, or provide information on the user's daily progress towards a goal. Timing defines the moment at which the system chooses to initiate an interaction, while content consists of the chosen words in a verbal communication, or values displayed in a graphical representation of progress. Given these properties, the goal of tailoring is to increase the system's likelihood of conveying its intention by matching the properties to the user in a specific context and situation.

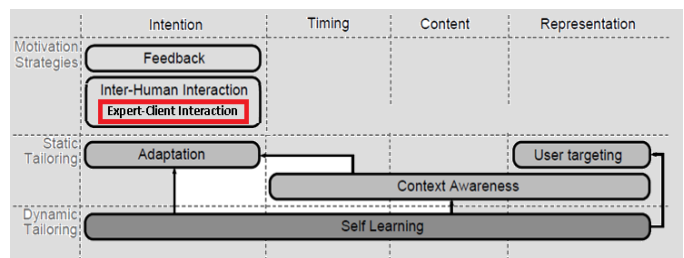


Fig. 1. Focused Research Model - adapted from [13].

In this work we believe that, apart from the mobile application that aims to use Inter-Human interaction to motivate users, e.g., using social connections, a very important and critical motivational strategy is “Expert-Client” interaction. This work therefore aims and focuses, as highlighted in red in Fig. 1, in the “Expert-Client” interaction, proposes, designs and implements a web platform that enables this motivational strategy. This is performed throughout this work based on the input of expert RDNs used during requirement analysis for the design and implementation of the platform (see section IV), but also during the evaluation of the platform (see section V).

TABLE I. RDN REQUIREMENTS FOR WEB PLATFORM

Web Application Requirements	Android Mobile Application Requirements
Use system from different computers	Instant communication with client
Add personal client information	Daily tracking of client progress
Create a new diet plan	Client can record quantity of beverages consumed
Client can complete first-visit questionnaire	View foods consumed by client View graphs of client progress

IV. PLATFORM IMPLEMENTATION

A. Requirements from Registered Dietitian Nutritionist

Face-to-Face interviews were conducted with four RDNs during requirements analysis, to identify needs and aspirations in terms of the design and development of the web platform. Two sets of requirements were determined: (i) for the web application of the clients and (ii) for the Android application of the RDNs. These requirements are presented in Table I.

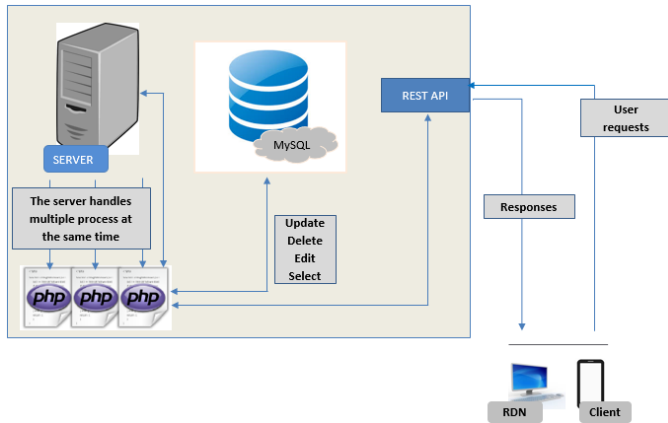


Fig. 2. The architecture of the web platform.

B. Architecture

The architecture for the Web Platform for Real-Time Expert-User Interaction employs the client-server model (see Fig. 2). Specifically, an Apache Web Server and MySQL were used to develop the web-platform and database respectively. PHP was used for the development to facilitate the exchange

of data to/from the server. A key advantage of the adopted architecture is the REST API, which has been adapted accordingly to make the web platform accessible to web users (RDNs), as well as mobile users (clients). The REST protocol enables separation of concerns, separating the user interface from the server functionality. Moreover, the REST API allows for cross-platform communication, extensibility and scalability.

Through the Android mobile application, users can connect to the Apache Web Server and MySQL database, enabling them to retrieve, store and modify data in the database.

C. Enabling Real-Time Interaction: Web Application

Using the web application, the RDN can create a profile for a new client: i.e., input personal data, biographical data (e.g. weight, height, BMI). Specifically prepared diet plans can also be created by the RDN and added to the client’s profile. With all the available data, the VO2max (fitness level) of the client can even be calculated and monitored. Clients registered by the RDN are listed in the “Customers” page (see Fig. 3).

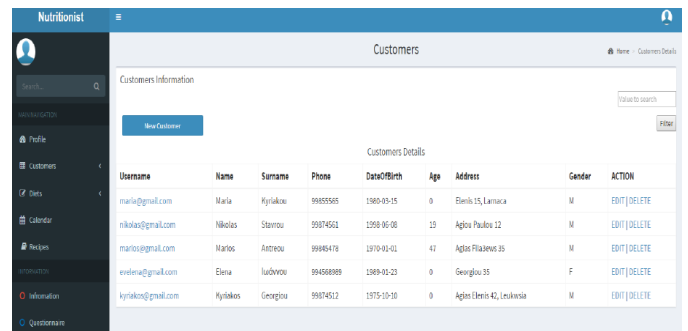


Fig. 3. List of clients that are registered on the web application.

At first, the RDN can create an account for each client that uses the web platform. Once the client has gained access to the system through the mobile application (see subsection D), he/she will need to complete the first-visit questionnaire and submit it electronically. A RDN can select a client and view his/her individual profile page (see Fig. 4). As can be seen in Fig. 4, the RDN will also be able to access this questionnaire from the client’s “Profile” page.

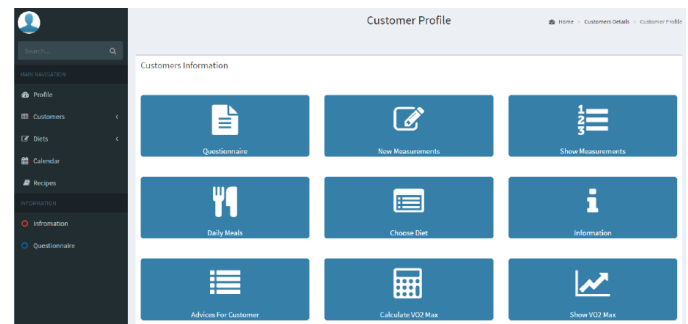


Fig. 4. “Profile” page of a client.

The client can upload photographs of daily meals and record the beverages (e.g. water, alcohol, caffeine) consumed

through the mobile application. This enables the RDN to monitor them more closely through the web application. In parallel, it is also possible to monitor the client's physical activities. The RDN can use graphs as well to aid the process of drawing conclusions and to monitor the progress of the client (see Fig. 5). The client has equally access to his/her recorded measurements and other personal information and can also view the graphs through the mobile application.

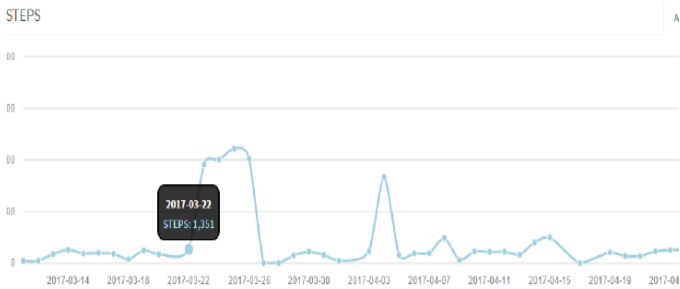


Fig. 5. Graph showing the steps walked by a client over several days from the web application (RDN side).

The most important attribute of the web platform is the fact that it facilitates interaction between RDNs and their clients. This differentiates it from other similar platforms since the interaction can contribute to better and faster results. By having all this data at their disposal, RDNs can take action instantly when needed by sending real-time expert advice to clients in the form of messages. Such messages can be motivational or corrective, in relation to users' individual nutrition and fitness plans.

D. Enabling Real-Time Interaction: Mobile Application

The client is provided with a username and password by the RDN to log-in to the Android mobile application. This happens after the RDN has registered the client on the web application. The mobile application runs on most platform versions (i.e. Android 6.x or later and Android 5.x or older). Depending on the platform version, the client may be requested to provide permissions to the mobile application.

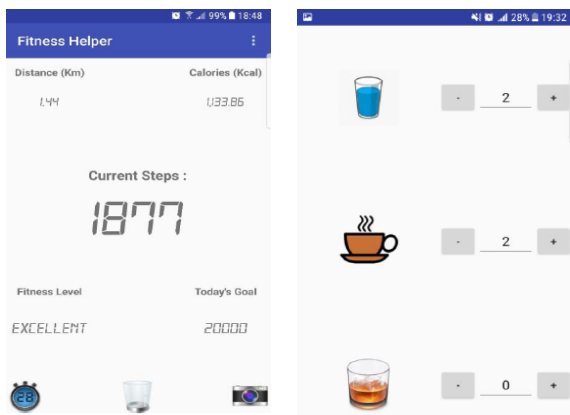


Fig. 6. "Home" and "Beverages" screens with tracked and inputted data.

Once the client has successfully logged-in to the mobile application, his/her data (e.g. weight, height, fitness level) will be automatically retrieved from the database. Some of this data is displayed on the "Home" screen (see Fig. 6). This data

is used to calculate the daily calories the client burns. An algorithm of the Google Fit API is used to do these calculations. As previously mentioned, personal client information are recorded on the web application during the client's first visit to the RDN. The client can use the camera of this/her mobile device to capture photographs of the meals consumed. These get stored on the device and are later sent to the RDN. Beverages consumed and physical activity done can also be recorded by the client.

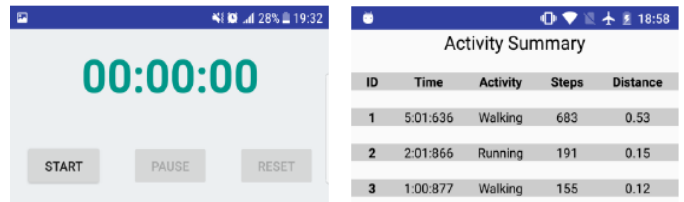


Fig. 7. "Stopwatch" and "Activity Summary" screens.

A stopwatch (see Fig. 7) is available to the client for recording a physical activity. The client will first need to record the type of activity (e.g. walking, running) before using the stopwatch. A summary of all the daily physical activities can be viewed (see Fig. 7).

Using the accelerometer sensor of the mobile device, the mobile application is able to record data like the number of steps walked and distance covered. The client can therefore add personal targets (e.g. number of steps to walk on a specific day). Such goals will be determined in accordance to the expert guidance and feedback of the RDN. A client can also view the individual diet plan that was prepared for him/her by the RDN. If modifications are needed to this plan based on the client's progress or lack off, the RDN can implement these from the web application. As soon as these modifications are made, the updated diet plan will be accessible to the client through the mobile application.

Using graphs (see Fig. 8) the client can monitor progress achieved from the first visit to the RDN until the present day and also gain motivation. Graphs currently provided in the mobile application show: steps walked, beverages consumed, weight, distance covered, and daily calories burned. During evening hours, a JSON file is created with all the aforementioned data, which can then be sent to the RDN at a convenient time for the client.

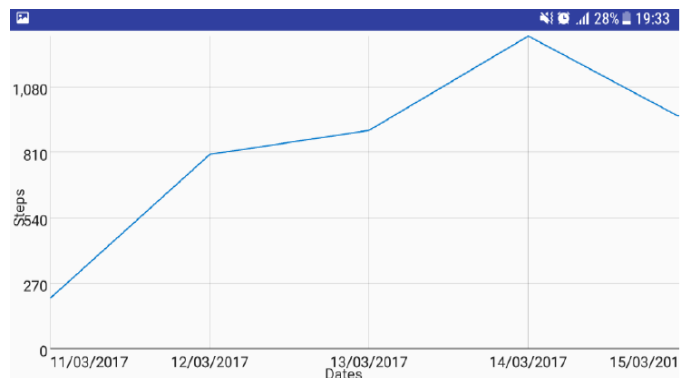


Fig. 8. Graph showing the steps walked by a client over several days from the mobile application (client side).

In the research study, it was emphasised that real-time interaction between RDN-client plays a pivotal role in adoption and long-term use of the web platform. With all this data, the RDN can draw more effective and accurate conclusions and take immediate action where necessary. Messages for motivation, progress updates and expert advice on corrective actions can be sent to the client (see Fig. 9).

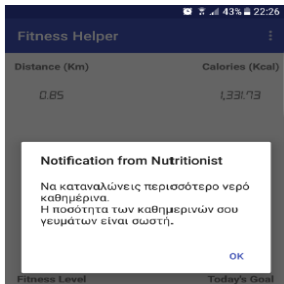


Fig. 9. Message received on the client’s mobile app from the RDN: “Drink more water daily. The quantity of your daily meals is correct”.

V. PLATFORM EVALUATION

The platform was evaluated by means of questionnaires that were provided to the two groups: end-users/clients (20 responses) and expert RDNs (20 responses). The first group of end-users, ages 20-30 years, were asked to watch a video, read a flyer for the platform and use the mobile application before answering the questionnaire. Then a holistic view of the web platform was presented to the second group via a demo video and presentation during the Cyprus yearly conference of RDNs, which were then asked to complete the questionnaire and provide oral feedback via the discussion conducted during the scheduled evaluation session at the conference. In the following paragraphs the key graphs and results are presented, which indicate the value of the web platform.

Question: Do you believe that your interaction using the platform with the expert RDN can help you in achieving your goal faster?

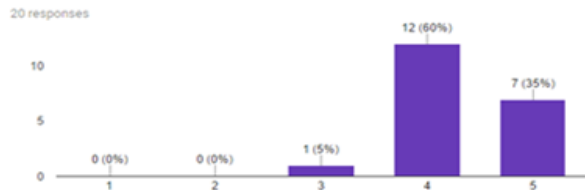


Fig. 10. Client study results - using the platform on a daily basis.

Initially, from the responses of the clients who participated in the survey, it was established that they were positive and open to the idea of consistently using the web platform in their daily lives (see Fig. 10 where 19 out of 20 responded Agree and Strongly Agree on the 5-point rating scale). This was particularly encouraging considering the fact that these users have used similar technologies in the past, but they did not tend to use them for extended periods of time and often abandon them. In fact, the results (see Fig. 10) show that clients believe that having their progress monitored and being able to receive real-time expert advice and feedback on their daily habits acted as supplementary motivation for them to continue using the mobile application and to better apply and adhere to the expert advice provided by RDNs. Clients stated

that this form of periodic interaction (e.g. daily, weekly, etc.) will enable them to achieve their goals more quickly since their daily data can be tracked and monitored by their RDN.

On the other side of the evaluation survey, RDNs indicated that they found the platform useful and are open to using such a system, which can create weekly or monthly reports grounded on the data shared by clients over a specific time periods. They further mention that it is not practical for them to view clients’ reports on a daily basis due to their busy working schedules, which is indicated by the results presented in Fig. 11.

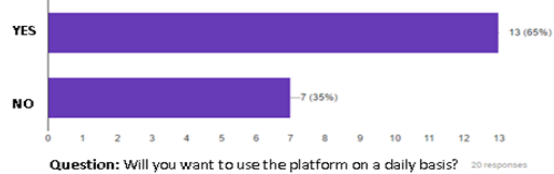


Fig. 11. RDNs study results - using the platform on a daily basis.

Still as they have pointed out they would like to use the platform for, e.g., creating profiles when setting appointments. As further explained to them, the platform does create reports and graphs that show clients’ progress on daily, weekly and monthly basis. Hence, RDNs can choose the periodic reports and graphs and can view them when they prefer based on their working schedules. It is important to note, as depicted in Fig. 12, that RDNs indicated their preference for monitoring and being updated of their clients’ progress on a weekly basis. Explicitly 17 out of 20 RDNs stated that they consider this to be important or very important.

Question: How important is to monitor and be updated on the clients progress on a weekly basis on the basis of the provided graphs?

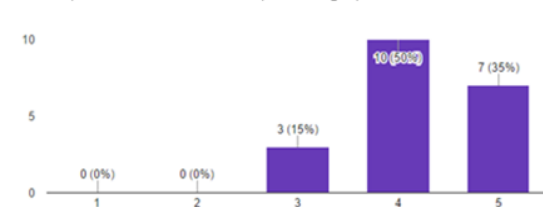


Fig. 12. Evaluation results - monitoring progress based on weekly graphs.

The preliminary results presented above (as part of the survey-based evaluation executed in this work), showcase the potential of the web platform, demonstrate its usefulness and provide initial insights as to the beneficial contribution it can have on improving clients’ health. The expert guidance that clients receive from the RDNs in the form of messages and by knowing that their progress is being monitored, acts as an additional important motivational strategy for them to do more physical activity and to adopt a more healthy diet.

Based on the results and comments received during the evaluation, recommendations provided were representative of both the client and RDN. In addition, from the analysis more areas for future research and improvements were determined:

- RDN should be able to evaluate the progress of a client on a weekly basis by assigning two ratings; one for the physical activity and the other for the diet.

- RDN should be able to send reminder messages to a client, using also SMS or e-mail, in order to do their physical activity in the case where it has been neglected.
- The client should be able to import his/her personal health data from other similar mobile applications that he/she may be a user of already.
- The client should be able to decide which data he/she will share with the RDN for monitoring purposes.
- An algorithm that automatically identifies the type of physical activity that the client is engaging in (e.g. walking, running, cycling), thus not requiring from him/her to add this information manually. This will also increase data integrity.
- An algorithm that calculates the amount of calories a meal contains based on its photograph, which was uploaded by the client. Details relating to the meals consumed over a period of time can be exported and presented in graphs, highlighting the daily calories consumed by the client. This will assist the RDN when drawing conclusions from the client's overall data.
- A knowledgebase of meals (e.g. database), with the amount of calories and nutrients defined for each. This will require several RDNs to collaborate and prepare this information. RDNs can then dynamically prepare a diet plan for a client by accessing the knowledgebase.

VI. CONCLUSIONS AND FUTURE WORK

The number of health and fitness platforms has increased drastically over the years, together with the people's desire to live more healthy lifestyles. This has led researchers and developers in designing platforms that attempt to dynamically motivate people to follow a healthy diet and do more physical activity. During the course of this research, a more interactive approach was used in order to combat early abandonment of the technology used (i.e. mobile application) and to help clients establish and maintain daily interaction with their RDNs. The preliminary results, obtained by clients and RDNs as part of the evaluation, indicate that constant client-RDN interaction motivates clients to continue doing physical activity and to follow a healthy daily diet. As future work, we plan to include users' comments received from the evaluation, listed in Section V. As the platform architecture enables extensibility, i.e., REST API, the features recommended can be developed and integrated in the web platform.

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