2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) | 978-1-6654-6493-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/HNICEM57413.2022.10109490

Virtual Dietitian as a Precision Nutrition Application for Gym and Fitness Enthusiasts: A Quality Improvement Initiative

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***Abstract*—The *Virtual Dietitian* (VD) application is a nutrition knowledge-based system that generates personalized meal plans in accordance with the one-size-does-not-fit-all concept of precision nutrition. A subset of the population that was not involved in its four-part developmental study was gym and fitness enthusiasts despite them being important target users. As part of our quality improvement (QI) plan, we initiated a two-phase user testing to inform modifications to VD. We recruited a total of 30 users with prior experience in nutrition applications. In phase 1, they used the current version of VD for a week and answered a mixed-form questionnaire afterward. We used the same questionnaire from our previous study, which is composed of System Usability Scale (SUS) items and open-ended questions. After months of system modification, the same set of users evaluated again the new VD version after another week of use. A paired-sample t-test showed a statistically significant difference in SUS scores before (SUS = 79) and after (SUS = 82) modifying VD based on the suggestions of the participants ($p = 0.005$). Some new features include water tracker and reminder modules, Google Fit integration, and other nutrition support services (e.g., teleconsultation with registered dietitians). Although further refinements to VD are still needed, we were able to incorporate a QI initiative typically employed by healthcare organizations into software development for a better and improved personalized nutrition application.**

Keywords*—*Nutrition Research, Quality Improvement, Precision Nutrition, Dietetics, Knowledge-Based System, Fitness

I. Introduction

The field of nutrition has been increasingly interested in how food affects human health and well-being [1-3]. Founded upon the one-size-does-not-fit-all concept, one relatively new area of study is precision nutrition (PN). According to the proposed definition by the American Nutrition Association, PN (sometimes referred to as personalized nutrition or individualized nutrition) is a field that "*leverages human individuality to drive nutrition strategies that prevent, manage, and treat disease and optimize health*" [4]. Therefore, one of the ultimate goals of PN is to develop effective, dynamic, and tailored nutritional recommendations that conform to inter-individual variability (e.g., food preferences and eating behaviors, deep phenotyping, physical activity, gut microbiome, genetic profile, and social determinants of health) in response to nutrition [5-8]. Figure 1 illustrates this variability in the PN plate [9]. Unfortunately, PN as a field of research is still in its infancy and not many studies have been conducted in this area [10].

In physical fitness, adequate nutrition plays an irreplaceable role in the effective performance of exercise [11]. The balance of nutritional needs and intake is critical for conditioning, avoidance of injury, recovery from fatigue after exercise, muscle repair, and the overall improvement of athletic performance. With the close relationship between physical fitness and energy intake [12], gym and fitness enthusiasts (i.e., people who exercise regularly) must be familiar with their macronutrient requirements and the effects of intake before, during, and after exercise. Diet choices are also considerable and various factors influence these decisions. Some variables include nutrition knowledge, attitude, culture, religious beliefs, affordability, availability, dietary restrictions, preference, social environment, and more [13-16]. Unfortunately, gym-goers were found to have a low level of nutrition knowledge, especially when compared with athletes [17]. Following the PN concept, it is insufficient to follow any generic dietary plans since an optimal macronutrient distribution compliant with the total daily energy expenditure is critical to achieving fitness goals [12, 18-20].

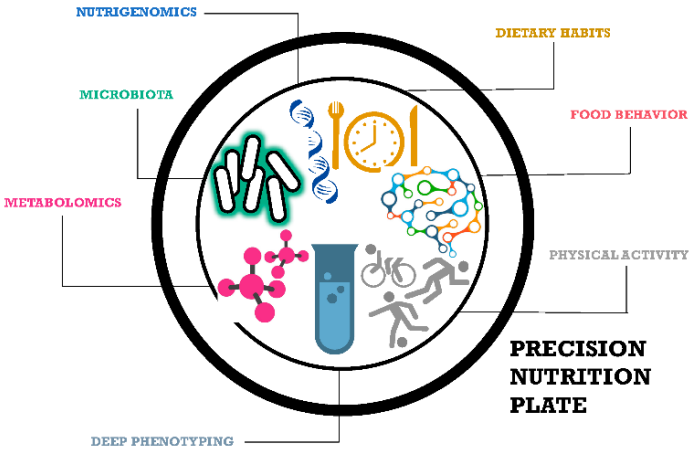

Fig. 1. The Precision Nutrition Plate. Adopted from [9].

In recent years, there have been growing studies looking into the development and utilization of computer systems and mobile applications to improve nutrition behavior [e.g., 18]. According to a systematic review [21], nutrition applications are associated with increased nutrition knowledge, and using various platforms (e.g., computer, mobile, smartphone, and internet technologies) promotes the attainment of diet and weight goals. One example is the two-arm parallel randomized controlled trial with a three-month intervention and six-month maintenance program called "TXT2BFiT" [22]. The primary strategy is to send motivational text messages to nurture behavior transformation around weight maintenance. This multi-component lifestyle program conforms with PN by personalizing coaching calls as well as text messages according to gender and stage of change. After the trial period, it was found that participants prefer self-monitoring applications capable of personalizing nutrition services. Thus, it is noticeable that modern nutrition applications attempt to incorporate the PN concept. For instance, the Virtual Dietitian (VD) application was designed to generate meal plans based on users' preferences and restrictions [23]. The core functionality uses a forward chaining algorithm as a method of reasoning to filter thousands of recipes based on the nutritional values of all foods and ingredients. VD also distributes the macronutrients and micronutrients tailored to the needs of users. Despite the advancements and many nutrition applications, there is a concern that their usage in dietary health can promote negative habits and unhealthy eating behavior [24]. Thus, continuous quality improvement of nutrition applications should be the ethos of any nutrition policy and public health.

In healthcare, quality improvement (QI) is an important part of quality management to ensure high-quality care for patients. It offers an opportunity to evaluate and optimize current tools for more comprehensive and effective healthcare services. Nutrition research likewise utilizes QI initiatives [25-27]. Following the call for further exploration of nutrition applications in improving diet and health [21], we commenced a two-phase QI initiative with the target subset of the population (i.e., gym and fitness enthusiasts). This QI study was performed on VD – a nutrition application that follows the conception of PN [23]. As a generic tool, the sample in this study was not consulted during the development stage of VD despite their low level of nutrition knowledge indicating the potential value of such an application for them [17]. The primary goal of this study was to determine nutrition application features needed by this sample and modify VD to serve their needs. To the best of our knowledge, this is the first QI analysis undertaken with a nutrition application grounded on PN. We hope to provide further evidence in the existing thread of discussions not only in nutrition research but also in application development.

II. Materials and Methods

This paper is a sequel to a four-part developmental study that started with the construction of a nutrition application prototype called Plan-Cook-Eat (PCE) [18]. Following the growing trend of PN, we developed PCE to generate tailored dietary prescriptions based on a person's total daily energy expenditure. PCE ensures that there is an optimal distribution of macronutrients (protein, fat, and carbohydrate) in meals throughout the day. Despite the overall positive ratings, registered dietitians mentioned that PCE lacked more nutrition-related features that integrate evidenced-based dietetics while application users demanded more flexibility in generating their daily meal plans (e.g., incorporating personal food preferences and restrictions). These shortcomings led to a mixed-methods needs analysis for a larger and smarter nutrition application [28]. Accordingly, it was learned that people generally lack the essential nutrition knowledge and dietary compositions to make smarter food choices. Nonetheless, they expressed their willingness to embrace a healthier lifestyle with the assistance of a nutrition application. This confirmation initiated the design and development of VD to assuage the inadequate nutrition problems [23]. Inspired by a knowledge-based information system, VD uses a forward chaining algorithm to generate personalized meal plans tailored to individuals' nutritional needs, goals, preferences, and restrictions. Unlike PCE, VD is strictly anchored on the Nutrition Care Process, which is used by nutrition professionals to assess, diagnose, treat, and monitor their patients. This final version was evaluated by experts and users in terms of quality, acceptability, and usability [29]. Various features have been recommended for future versions although a series of testing and evaluations have already been conducted. The most recent evaluation is evidence that there are remaining refinements to be done in VD.

As part of our mission to continuously improve the usefulness and quality of VD, we performed a two-phase QI study following the protocol used in a web-based health application for nutrition therapy in primary care [25]. Our target participants were fitness and gym enthusiasts who were invited via social media platforms using snowball and purposive-convenience sampling techniques. Unlike the basis of the protocol which had two separate samples, our QI study relied on the same participants for both phases. An instructional guide was sent to the participants after submitting an informed consent form. To begin the first phase, participants were asked to use VD daily for seven days to assess the usability of the current version and recommend missing features that they require for a nutrition application. On a side note, they were not mandated to follow the personalized meal plans generated by VD. A mixed-form questionnaire was delivered within the application after a seven-day trial period. This questionnaire sought to assess the system usability of the current version of VD and identify new potential features based on the viewpoints of the target sample. Similar to the last two sprints of VD [23, 29], we used the System Usability Scale (SUS) and open-ended questions such as "*Which features of VD do you like?*" and "*What feature(s) would you like to see added in VD?*". All evaluations from Phase 1 were completed on March 31, 2022, with a total of 30 participants. Despite a low number of participants, it is still more than the acceptable sample size (n = 20) for usability testing with a quantitative analysis [30]. Given our sample size, we sorted all responses to the open-ended questions manually according to the most requested features and reported by at least three participants. As undertaken by another QI study, we included representative quotations to improve the credibility of the findings [25]. In terms of SUS, we calculated the scores of this ten-item questionnaire according to the published instruction [31]. Accordingly, the range of scores is 0 to 100 and the acceptable score is higher than 70. Afterward, we considered all responses and conducted a series of sprints for three months to modify VD (June 1 to August 1, 2022). In Phase 2, we recruited the same set of participants and presented the modified VD that complies with some of their recommendations. Participants were instructed to use VD daily again for another week and assess its usability. We completed the Phase 2 on August 19, 2022. Finally, we utilized a paired sample t-test to test the statistical difference of SUS scores between Phase 1 and Phase 2.

III. Results and Discussion

All participants (n = 30) provided feedback on both phases. Most of them were 21 to 30 years old (n = 19, 63.33%) and living with family (n = 22, 73.33%) in an upper middle-income class (between ₱76,669 to ₱131,484; n = 20, 66.67%). Their physical activity was active (daily or intense exercise 3-4 times/week; n = 14, 46.67%) and their nutritional status was overweight (BMI $\geqslant$ 25 and < 30 kg/m^2; n = 19, 63.33%). Although all participants have experience with three to four nutrition applications (n = 25, 83.33%), only four participants use them regularly (13.33%).

A. *Which features of VD do you like?*

When asked which VD features they like, most participants selected the meal plan diary and generator (n = 23, 76.67%). As shown in Figure 2, this two-in-one feature tracks what users eat and generate daily meal plans according to several variables: (1) preferences such as diet plans, cooking techniques, and cuisines; (2) restrictions such as food allergies and dietary practices based on religion; (3) body image goals such as losing, maintaining, or gaining weight; and (4) food-based dietary guidelines. A regular exercise routine complemented by healthy eating is fundamental to maintaining good health and well-being [11, 12]. In terms of treatment options for weight loss, exercise with a healthy diet is better than exercise or diet alone [32]. For beginners who are not financially capable of consulting with registered dietitians, this feature offers a free opportunity in promoting healthy eating and exercising. Nutrition application users are better at maintaining dietary and physical activity behaviors than non-users [33]. The remaining participants (n = 7, 23.33%) favored the flexibility of the automated meal planner augmenting the personalized dietary recommendations (see Figure 3 for the settings module). Some of the excerpts from the qualitative feedback are as follows:

- *The app is great because it not only allows you to track what you eat but also recommends meal plans. I do not need to consult with dietitians often.* [P6]
- *I like the feature of the meal planner that allows me to select my preferred cuisines. I would not probably eat the meals if they are not to my taste.* [P22]

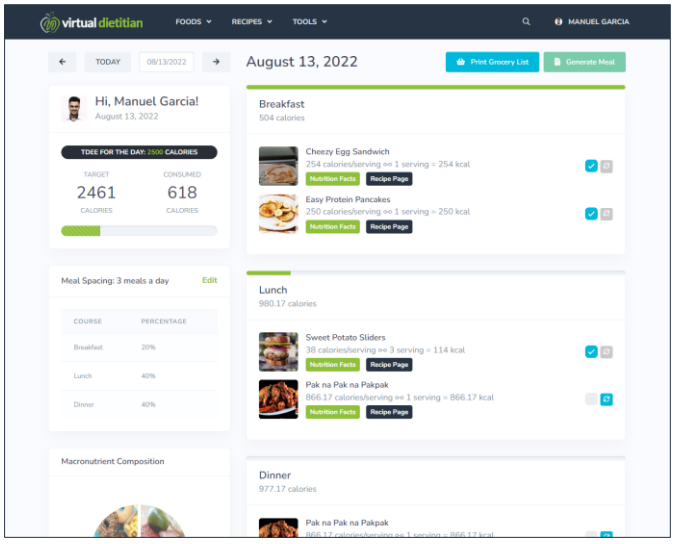

Fig. 2. Meal Plan Diary and Generator

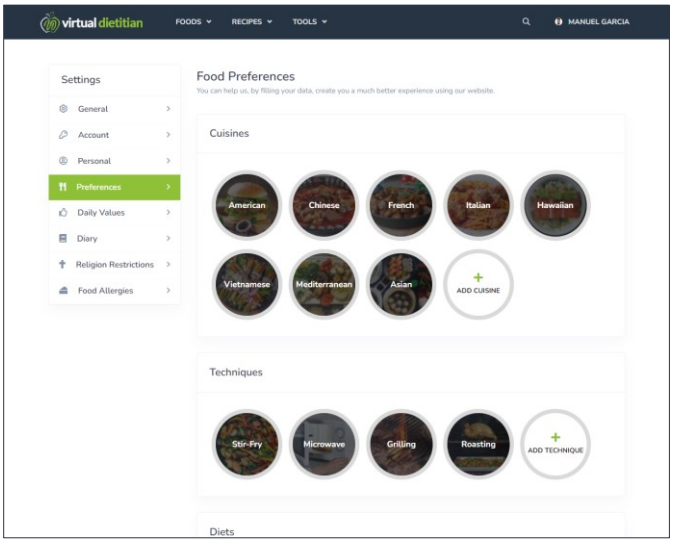

Fig. 3. Food Preferences Settings: Cuisines, Techniques, Diet Plans

B. *What feature(s) would you like to see added in VD?*

Feedback from Phase 1 opened opportunities to enhance the functionality and applicability of VD. We tagged each response manually and ranked it according to the most requested feature. However, we did not include all the suggested features because some of them were out of the scope of VD. For example, seven participants (23.33%) asserted that the "*combination of nutrition and workout application would be more useful*" [P12]. Although we acknowledge that this is a good feature idea, particularly for this sample (i.e., gym and fitness enthusiasts), we concluded that we should stick with features that every user could benefit from. More importantly, we believe that adding "*daily routine workout guides*" [P19] deviates far from the primary goal of VD (i.e., to create personalized meal plans for any individual).

Nutrition Coaching (Teleconsultation)

The most requested feature was remote nutrition coaching or teleconsultation (n = 22, 73.33%). This suggestion is consistent with what has been found in a randomized controlled trial where participants valued phone coaching calls the most, and that text and email messages were found helpful in achieving their goals [22]. In the nutrition literature, there is already well-established evidence supporting the acceptability, usefulness, and benefits of remote consultation [34-36]. One possible reason behind this suggestion is the current COVID-19 pandemic. This feature idea is also a reminder that no technology can replace human experts like registered dietitians. Although we modified VD to have this feature, it is still unclear how to invite and compensate dietitians. Some of the feedback regarding this feature are as follows:

- *Regardless of the countless available nutrition apps on the market, I still prefer talking to real experts.* [P2]
- *My friend who is a dietitian does not provide me with a lot of meal options unlike this website. Still, I would like to consult him regarding the calories and nutrients and doing it within the app seems a good idea.* [P25]
- *With COVID and other diseases going around now, an online consultation feature would be useful.* [P26]

Water Tracker and Reminder

Next to teleconsultation is the water tracker and reminder (n = 19, 63.33%). In our defense, we did not include it in the initial version because plain water is calorie-free, which means that it will not affect the computation of total daily energy expenditure. Nevertheless, water is the main constituent of the human body, a participant in all biochemical reactions (e.g., digestion), and a vital component of nutrition [37]. In general, proper fluid intake is imperative for the human body to function at its very best. For people under intense exercise, the sweating that occurs leads to a loss of water that can then weaken thermoregulation as well as the circulatory system. Thus, water replenishment is essential to prevent a decline in athletic performance [11] and should always be part of the diet record [37]. In addition to the meal diary, we also included a reminder feature to notify users of when to drink water. Some of the participants noted the following:

- *If there is food, why there should be no water? I think it should be included in the application.* [P3]
- *I drink a lot of water during exercise but not on my rest days. A reminder to drink water is what I need.* [P14]

Wearable Technology Integration

Although not as many as the recommendations for the water tracker and reminder and teleconsultation, the next feature idea was integrating wearable technology (n = 8, 26.67%). Recently, there is an increasing interest in wearable activity trackers and a systematic review learned that they affect physical activity [38]. Since integrating different wearable technologies require a lot of time and resources, we agreed to focus on *Google Fit*. Following our position on mixing nutrition and workout applications, only metrics related to nutrition were included in the dashboard. The participants noted the following during their evaluation:

- *It would be helpful to possibly include the data from my smartwatch. I use Google Fit to track and record all of my data especially the calories burned.* [P20]
- *It would be nice to have a more informative dashboard where all health-related data are available. If possible, include data from wearable devices.* [P21]

Other Feature Idea Recommendations

Unlike the first three recommendations that were applied to the new VD version, there were other challenging feature ideas that we were not able to address but are good features to consider in the future. For instance, participant 21 urged a "*gamification feature to encourage people to eat healthy foods*". One idea is to award points for each kilogram people lose or gain. Nonetheless, integrating this feature demands a major application update and a proper gamification strategy. Another potential new feature is diet programs to be chosen as a "*package rather than generating meal plans daily*" [P13]. However, the completion of this feature requires the expertise of registered dietitians. Total daily energy expenditure may also be a barrier to creating meal packages. A 3000-calorie meal package is only valid for people that require the energy of around 3000 calories. Finally, two participants did recommend nutrition guides with visual examples [P2, P15]. In the next version of VD, we will be incorporating this feature to strengthen the dissemination of nutrition knowledge.

C. System Usability Scale: Before and After VD Modification

In Phase 1, participants rated VD with good usability scores (M = 79.20, SD = 4.103). This score is less than what was given by regular users in the previous evaluation [29]. However, it is expected since the needs of this study's sample were not taken into consideration. This suspected inadequacy is the reason why we initiated a QI study. In Phase 2, participants graded the latest version of VD with excellent usability scores (M = 83.16, SD = 2.249). Scores from Phase 2 were statistically higher than Phase 1, according to paired samples t-test: $t(29) = 3.095$, $p = .042$. It means that the modifications accomplished for the new version helped increase the application's usability. This finding implies that application developers may perform a QI study to improve their artifacts even though this methodology is only common in the field of healthcare. The primary strength of this paper is that VD has already been a subject of a series of evaluations. Future QI studies may have to perform a more extensive modification, especially for newly-developed applications. Nevertheless, the commitment to consistent software updates (e.g., fixing bugs or adding new features) is a vital process in software development.

IV. Conclusion

In this study, we initiated a two-phase QI initiative to improve VD and address the needs of gym and fitness enthusiasts. To our knowledge, this study was the first QI analysis undertaken with a nutrition application grounded on PN. Borrowing this process from the healthcare field allowed us to discover specific features needed by our target users. Additionally, it statistically improved the usability of VD after another sprint of system modification. It underlines the significance of involving users in the development lifecycle to guarantee the availability of necessary features. For a nutrition tool like VD that offers vital health services, continuous quality improvement should be the ethos of any nutrition policy.

Acknowledgment

The authors would like to express their gratitude to the FEU Institute of Technology for partially funding this paper and the participants for their valuable time and effort.

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