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Feasibility for the enhancement of an online support system for persons with metabolic syndrome, aimed at applications for ischemic heart disease and heart failure

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Abstract— **Previously, we developed of an online support system for persons with metabolic syndrome. In this study, we investigated the possibility of enhancing our system for applications in ischemic heart disease (IHD) and heart failure (HF). The main causes of IHD are obesity, hypertension, arteriosclerosis, hyperglycemia and other metabolic disorders. These conditions are related to lifestyle issues, such as diet and exercise. Dietary management becomes more difficult as the patient's condition worsens. We primarily focused on behavior changes. To raise the user's awareness of food intake, we improved a number of functions of the developed system: an entry of the user's lifestyle information, a calculation of the total calorie intake and a reference of food model pictures in 80 kcal standard quantities. IHD encompasses many of the causes of HF. Management tools appropriate for HF are few. We describe the main functions of our system and promote self-management as a requirement for IHD and HF. We expect that the framework of our system is applicable to the management of patients with chronic HF.**

I. Introduction

The World Health Organization reported that ischemic heart disease (IHD) is the most common cause of death worldwide, having caused 7.25 million deaths in 2008 [1]. IHD comprises many of the causes of heart failure (HF). The main causes of IHD are obesity, hypertension, arteriosclerosis, hyperglycemia and other metabolic disorders. These conditions are related to lifestyle issues, including diet and exercise. Thus, patients should be self-managed, focusing their attention on lifestyle improvements at home. We developed a system to support the self-management of patients using a personal digital assistant (PDA), focusing on diabetes mellitus (DM) [2]. In 2009, we published an outline of the system, which was evaluated by 20 volunteers [3]. We then constructed a support system for the health instructions as a tool to support the specific instructions given to persons with metabolic syndrome in 2010 [4]. However, diet management becomes more difficult as the patient's condition worsens. We primarily focused on "behavior changes" [5]. Both self-management and behavior changes by a person in the pre-symptomatic stage are needed to prevent lifestyle-related diseases. To raise the user's awareness of food intake, we improved the functions of our system. IHD encompasses many of the causes of HF. There are very few management tools for the management of heart failure.

In this paper, we studied the feasibility of enhancing our system, aimed at applications for IHD and HF. We describe the primary functions of our system and promote self-management as a requirement for chronic HF.

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II. Configuration of our System

A. System architecture

Our system consists of a web server installed in the medical institution, a personal computer (PC) operated by a physician and a patient PDA. The system has three functions: entry of user lifestyle information, calculation of total caloric intake and a reference containing food model pictures of 80 kcal standard quantities. We constructed the system using JSP (JavaServer Pages), MySQL and VBA (Visual Basic for Applications) technologies. A schematic of the system configuration is shown in Figure 1.

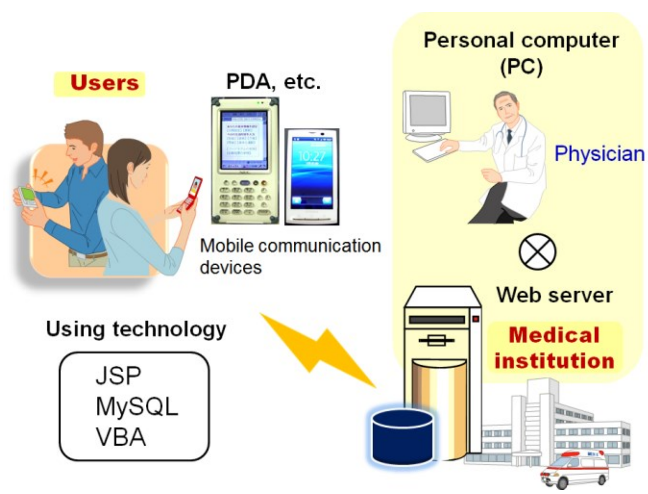

Figure 1. System configuration

B. Outline of the main functions before and after evaluation

Based on the feedback from the evaluators, we improved the system (TABLE I). A group of 20 volunteers evaluated the system from the user interface side, focusing on the functions

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of the food model pictures and information input; the results of these evaluations have been previously reported [2]. In addition, 14 medical staff members evaluated the full functionality of the system from the health instructors' side to investigate whether the system can be used during health examinations. This chapter provides an overview of the main features concerning diet and improvements in the program. The opinions from 14 medical staff members are described at the end of this chapter.

TABLE I. IMPROVED FUNCTIONS AND FEEDBACK

Improved functions	Feedback
Entry of user lifestyle information a) Contents of food intake:	14 medical staff members (health instructors' side)
Calculation of total caloric intake	
References of food model pictures of 80 kcal standard quantities	20 volunteers (interface side)

C. *Entry of user lifestyle information*

a) Contents of food intake: Food intake was entered using pull-down menus and buttons to simplify the input process. The meal menu is selected by a procedure involving major classifications (staple foods, main dishes, side dishes and soup dishes) → intermediate classification → menu for convenience (example: staple food → rice → curry and rice). This method is based on Japanese-style meals, e.g., "1 bowl of soup and 3 dishes" is considered a well-balanced meal. This function provides 600 items available for selection, focusing on home-cooked dishes. All menu items are based on a professional guidebook [6] and analysis by a nationally registered dietitian. For example, in the staple food selection procedure, the original menu allowed a choice of only rice, bread or noodles. The improved version allows the selection of two staple items (rice, bread and/or noodles), as shown in Figure 2.

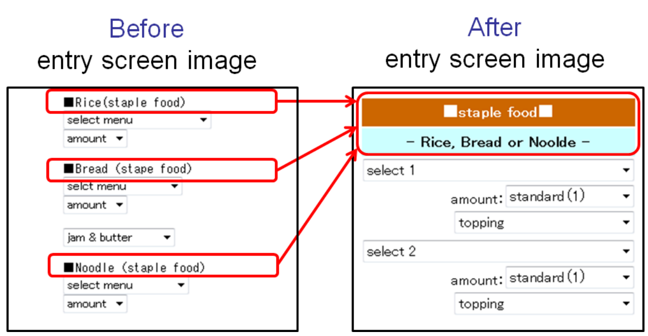

Figure 2. Menu selection method (for staple foods)

b) Contents of exercise: We based the exercise data entry on the energy consumption (kcal) measured with a pedometer because walking is generally recommended as a therapeutic exercise. We set the entry item of 5 rates of perceived exertion (RPE): very light, fairly light, somewhat hard, hard and very hard. We based this on the Borg scale, which is commonly used worldwide as a measure of exercise intensity.

D. *Calculation of total caloric intake*

The total caloric intake per meal is automatically calculated using VBA in Microsoft Excel. It is possible to examine the food intake on the reference form using simple button operations. The improved reference form includes 6 color-coded areas (Figure 3). Area 1 shows the examinee ID, the meal time and the date of entry. Area 2 shows staple foods, such as rice, bread and noodles. Area 3 shows main dishes, such as fish, meat, eggs, bean curd-based dishes and one-pot dishes. Area 4 shows vegetable-based items/salad, miso soup/other soups and fruit/desserts. Area 5 shows soft drinks and alcohol. Area 6 provides a space for text entry, the calories consumed at each meal and total calorie consumption; this is a newly added function. However, for maximum benefit, users should understand standard food sizes and increase their awareness of their own food intake.

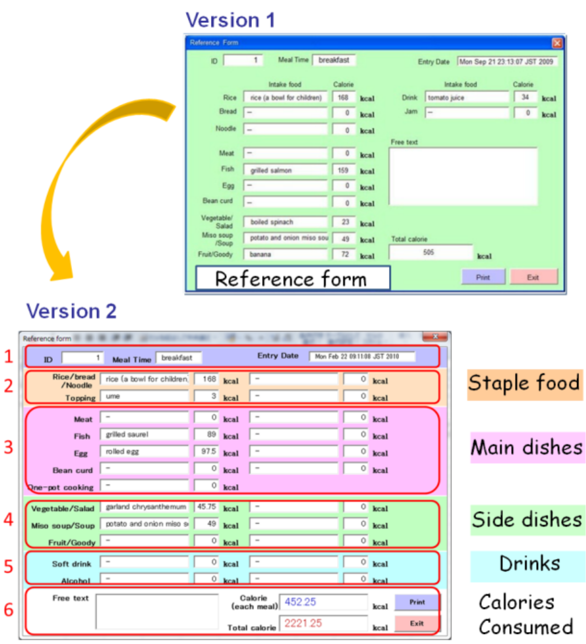

Figure 3. The improved reference form consists of 6 color-coded areas.

E. *References of food model pictures of 80 kcal standard quantities*

To raise the user's awareness of food intake, we contrived web-based visual contents that show 80 kcal portions of various foods. We compiled photographs of food portions equivalent to 80 kcal in an online database. The 80 kcal standard quantities are based on "The Food Exchange Table for Diabetes Treatment", edited by the Japanese Diabetes Society [7]. This book is often used for dietary instruction for patients with lifestyle-related diseases in Japan. The food model pictures can be accessed from the food classification screen → database inspection screen → pictures page. The volunteers provided feedback, such as "a white plate should be shown against a black background" and "disposable chopsticks should be shown as a scale bar". Based on these results, we devised new photography conditions and produced new photographs. As a tool to help show the actual sizes of the foods, food models are photographed together with a measuring tape, disposable chopsticks and a standard-sized plate. Examples are shown in Figure 4.

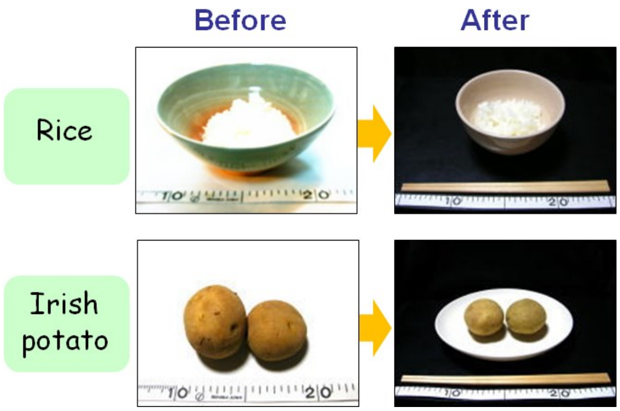

Figure 4. Food models are photographed with a measuring tape, disposable chopsticks and a standard plate based on the suggestions of the 20 volunteers.

F. Opinions of 14 medical staff members

For the improvements mentioned above, we conducted an experiment to verify the usefulness of our system in cooperation with the National Cerebral and Cardiovascular Center Hospital. Fourteen medical staff members evaluated the full functionality of the system using a questionnaire survey (five-grade evaluation: excellent, good, fair, poor and bad) based on a brief test. The staff members entered their lifestyle information and referred to pictures of 6 foods using a PDA (Pocket@iEX) by the NEC Corporation. Additionally, we conducted a hearing including several diagnosing physicians. TABLE II shows the age groups and experience of the evaluators with evaluations using a PC, mobile phone and PDA.

TABLE II. AGE, SEX AND EXPERIENCE IN USING A PC,A MOBILE PHONE AND A PDA OF THE EVALUATORES

Staff No.	**Age-group**	**Sex**	**Job category**	**Experience**		
				PC	***Mobile phone***	***PDA***
1	60~64	Female	Medical technologist	△	△	×
2	50~59	Female	Clinical nurse	△	△	△
3	30~39	Female	National registered dietitian (graduate student)	△	△	×
4	50~59	Female	Clinical nurse	×	△	×
5	30~39	Female	Dental hygienist	△	○	×
6	30~39	Female	Other	△	△	×
7	50~59	Female	Other	×	×	×
8	30~39	Female	Clerical staff	△	△	×
9	40~49	Female	Medical technologist	×	△	×
10	40~49	Female	Other	△	△	△
11	40~49	Female	Secretarial assistance	○	○	×
12	50~59	Female	Clerical staff	△	△	×
13	40~49	Female	Clerical staff	△	△	△
14	30~39	Female	Clerical staff	△	△	×

○excellent, △fair, × poor

For the entry of exercise information, 9 evaluators answered “it is easy to review my exercise”, and 6 evaluators answered “strength can be conscious”. The operation of the food menu selection method was rated as “excellent” by 1 evaluator, “fair” by 4 evaluators, “poor” by 4 evaluators and “bad” by 5 evaluators. The ease of finding menu data was rated as “excellent” by 1 evaluator, “good” by 1 evaluator and “poor” by 12 evaluators. Ten evaluators responded that “the review of food intake on the reference form by button operation is easy to understand”. Another 10 evaluators responded that the calculation of total amount of caloric intake “will become a measure of food intake in the future”. Regarding the food model reference pictures, 10 evaluators agreed that “this can be used as a patient instruction tool for dietitians”

Additionally, we tested the system with 3 volunteers (who were undergoing health checkup examinations) who entered their food intake using the system. Their data were compared with the estimated energy requirements in the “Dietary Reference Intakes for Japanese” [8], and the subjects received an explanation of the total caloric intake results from a physician.

III. POSSIBILITY OF ENHANCING OUR SYSTEM

We examined whether the framework of our system would be applicable to various lifestyle-related diseases. We think our framework is suitable for diseases with the following features: the exacerbation of a disease state can be deterred when a patient self-manages their biological information, exercises, and diets at home.

TABLE III shows the lifestyle information considered to be required for the management of chronic HF and IHD. TABLE III also shows the supported and non-supported items in the current and future versions of our system. Management item is based on the hearing with the specialist, and the guideline for Japanese patients [9]. Management item is also necessary to consider the correspondence to the complications, such as DM.

TABLE III. CONSIDERED TO BE REQUIRED FOR THE MANAGEMENT OF CHRONIC HF AND IHD

Management item of chronic HF and IHD		**Our system (for metabolic syndrome)**	
		Currently version	***Future version***
Biological Data	Weight	○	○
	Body fat	○	○
	Blood pressure level	○	○
	Blood sugar level	○	○
	Urine sugar level	○	○
	Heart rate	×	○
Contents of exercise	Number of steps	○	○
	Exercise intensity	○	○
	Existence of fall	×	○
Contents of food intake	Calorie intake	○	○
	Total salt intake	×	○
	Total water intake	×	○
Prescription information	Compliance check	×	○

○supported, × non-supported

Overall, our system was able to calculate the total caloric intake. However, chronic HF patients also need to manage their amounts of salt and water intake. Future versions of our system should also calculate total salt and water intake.

Furthermore, patients with HF require strict weight management. To motivate self-management, it is necessary to add a function that is expected to raise awareness with regard to vital signs, not only diet. The management of the etiology of HF with medications, such as diuretics, hyperlipidemia, insulin, etc., is also an important factor.

IV. Discussion and Conclusion

Developing proper eating habits from an early age is very important. Irregular meal patterns, such as skipping breakfast, have been reported to be related to obesity in some epidemiological studies [10, 11]. Furthermore, a 2007 study in the journal "Metabolism" reported that healthy middle-aged adults who ate only 1 meal per day had higher glucose levels than those who ate 3 meals per day [12]. Health management systems, including meal planning systems, using mobile devices have been developed by several researchers and companies [13-17]. In almost all of these systems, the user photographs their meals, and the dietitian analyzes the dietary contents based on the photographs. Although diet education should include more than a nutrient analysis by dietitians, the practice of photographing meals can raise user awareness because users can visually check the contents of their meals. Here, as a simple input strategy, we adapted a button-operated selection menu method consistent with a Japanese style of well-balanced meal planning. In addition, we included visual references to raise user awareness of serving size. Based on suggestions regarding the health instructor's side of the entry function concerning diet, the entry of food intake information could be improved by simplifying the input process. The accuracy of food intake information should be improved by devising a new menu selection method and an intake amount correction function. As shown in TABLE II, few evaluators had experience using a PDA. Thus, the food menu selection method and ease of finding menu data might have been considered difficult because the evaluators were unaccustomed to the ten keys and cursor used with this device. The calculation of the total caloric intake was evaluated positively ("standard" or better) by 11 evaluators. Therefore, we considered its contents to be reasonable.

Thus far, we have assumed potential users of the system to be middle-aged. However, elderly patients are more likely to develop HF from IHD and other diseases. As the main intended lifestyle instruction represents most conventional systems, it is not suited to the pathophysiology of HF, which may be a limitation. Certain functions and interface specifications, e.g., the input of lifestyle information, may not be suitable for HF patients, especially the elderly. Our tool is provided on a PDA, which is considered a hybrid between a PC and a mobile phone in terms of portability and operability. However, smart-phones and tablet PCs may be more accessible and intuitive to operate. We are planning to move forward with an Android-based system that is suitable for use with smartphones, which are a more familiar communication tool than the current PDA platform. We will also develop a system that can be used by patients with chronic HF.

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