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Activity-based nutrition management model for healthcare using similar group analysis

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Abstract.
BACKGROUND: Due to environmental factors such as nutrient intake imbalance, lack of exercise, and increased stress, it is necessary to control nutrition in order to prevent diseases and provide treatment in terms of healthcare.
OBJECTIVE: This study proposes the activity-based nutrition management model with the use of the cluster analysis of similar group for healthcare.
METHODS: The proposed method is to conduct the cluster analysis of similar group for nutrition management and to develop the real-time activity information based nutrition management algorithm with the use of big data in order to improve the quality of healthcare management service. It is to re-process an existing nutrition database and add voice recognition function in line with the service so as to improve convenience of intake-food inputs. In addition, the Bluetooth Low Energy (BLE) communication based standard collection of bio signals occurring in real-time is developed. This study also proposes the method of improving an existing algorithm of drawing a daily recommended allowance with the use of real-time activity information, and the proposed service provides the essential information of nutrition management with the use of public big data.
RESULTS: To verify the developed technology and service model and its effectiveness, the nutrition management service system is designed and developed with human interface.
CONCLUSIONS: The developed health model helps to solve the obesity problem, save medical costs, and address the issue of national health.

Keywords: Big data, algorithm, ICT, nutrition management, healthcare service

1. Introduction

Ageing population and westernized eating habits lead to continuous rises in chronic diseases, which cause an increase in the social burden of medical cost. In Korea, the medical cost for chronic diseases reached 19 trillion Won, and increases 9.2% annually on average. The prevalence rate of male adults' obesity (the rate of those with BMI 25 or more), which is a cause of chronic diseases, is on the constant rise. Male adults' obesity prevalence rate calculated in 2019 was 42.3%, which is on the constant increase [1]. Such an increase is caused by living habits, such as genetic factors, stress, lack of physical activity, excess drinking, and smoking. Dietary factors including fat, sugar, and sodium intakes are highly

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related to obesity. As such, obesity is one of the critical causes of chronic diseases, and it is attributable to nutrient intake imbalance. In terms of nutrition intake of each age group, young adults have more intake of nutrients related to obesity, and the intake trend is on the rise [2]. When young adults begins to have physical ageing and reducing muscles, they can have obesity and they can easily be exposed to many different diseases due to their abdominal obesity. As their obesity remains long, it can develop into chronic diseases. As the preemptive measures to prevent aged persons' chronic diseases, nutrition management of young adults is of very importance. Young adults are the main group of economic activity so that they face environmental restrictions, such as space, time, and economy, in order for their nutrition management. For this reason, by utilizing information communication technology, it is necessary to provide them with the activity- based nutrition management service which is aimed at inducing young obese patients to have a desirable dietary habit, to eat balanced nutrients, and keep healthy weight. An existing nutrition management service is mainly based on offline service. The information system based service fails to be activated because of the absence of Information and Communication Technology (ICT) based technology use and inaccuracy of nutrition management algorithm. Since such system and service are developed on the basis of suppliers, users' satisfaction is found to be low. With the constant development of ICT, the field of healthcare has faced paradigm change [3]. The convergence of ICT and an industry makes it possible to implement healthcare regardless of environments. For this reason, the health service expands to wellness based prevention or healthcare beyond treatment [4–7]. Nevertheless, in the nutrition management area, the ICT based technology for nutrition management is not so much developed and applied as it is commercialized, and the algorithm of creating and offering information has low accuracy. In addition, a demander based service model needs to be developed. The nutrition management system for obesity, which emerges as a social issue, is introduced at home and abroad, and its clinical effect is announced. There have been a lot of investments and studies on the development of devices and solutions which can be used regardless of time and space. In the healthcare area, the world sees the change of dietary life, over-nutrition, and lack of exercise. As a result, cardiovascular diseases, dyslipidemia, arteriosclerosis, and heart disease occurred more often [8].

In this study, an activity-based nutrition management system is developed to improve online and offline nutrition management service fundamentally, and its service effectiveness is verified. In order for the system to be applied to users and service in reality, an intake amount is converted into the unit of a paper cup and a nutrition analysis database is reestablished. The established database is applied to establish the model of the voice recognition system, and to build the voice recognition engine which is used to recognize a variety of food and an amount of intake as continuous voice. For the mobile healthcare service, the ICT based method of transmitting and changing the standard data is developed to collect real-time bio data. In addition, the algorithm of calculating a calorie of daily intake with the use of activity information is developed, and the nutrition management system provides the information created after the process of public health big data. The requirements of members of nutrition management service are applied to draw a commercial service model which is applied to system design for development. The developed system is verified in terms of function and effectiveness.

2. Activity-based nutrition management technology

2.1. Establishment of nutrition analysis database for nutrition management service

Three thousand six hundred and fifty-seven food products and 1,821 food types of Food Product and Food Nutrients Database of Korean Nutrition Society [9], 203 food products and 1,819 food types are reprocessed by Dietetic Institute [10] in the order of the highest consumption and highest frequency food

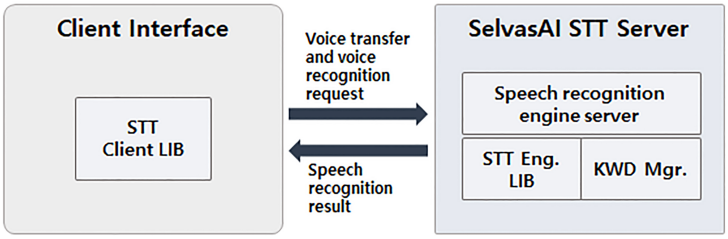


Fig. 1. Voice recognition process.

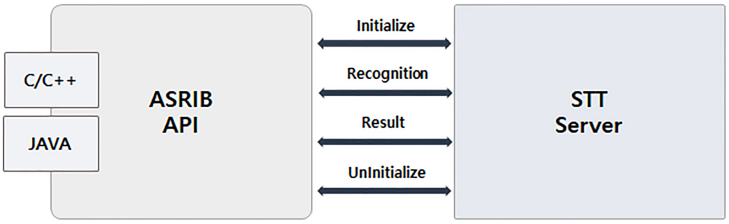


Fig. 2. Recognition server interface.

types of adult Koreans. As a unit of a paper cup, there are 0.25 (1/4 cup), 0.5 (1/2 cup), 0.75 (3/4 cup), and 1 (1 cup) types on the basis of the paper cup of 180 ml. The food product and food amounts of the Korean Nutrition Society database are converted into the paper cup amounts of portion sizes (g) so as to establish the nutrition analysis database for nutrition management service. The items with large errors of weight (g) and volume (ml) are actually measured. In terms of the items that include soup and solid ingredients, the paper cup unit conversion formula for the items is developed and applied.

2.2. Automatic food product recognition technology using voice recognition

Voice recognition is the computer technology of analyzing voice language and converting data into characters. A voice is the means of communication naturally used in everyday life and does not need any expensive device in voice input and transmission. Voice recognition technology is divided into speaker-dependent technology and speaker-independent technology. The speaker-dependent technology is able to recognize a specific speaker depending on recognizable persons. Voice recognition technology is able to recognize voice according to a pronunciation type and the number of vocabularies. In terms of recognition based on pronunciation types, there are the keyword detection methods able to detect and recognize isolated words, connected words, continuous sentences, and conversational continuous sentences, and specific words. In terms of recognition based on the number of vocabularies, there are smalls size (ten to hundreds of words) recognition technology and large size (tens of thousands of words) recognition technology. In case of the voice recognition with complex structure, the final recognition result is drawn through the language model based language processing.

Figure 1 illustrates the voice recognition procedure using STT server of SelvasAI [11]. For the voice recognition to be applied to nutrition management system, the voice recognition system of SelvasAI is used. For the recognition of unspecified speakers' diverse food name and utterance sentence, the speaker-independent and large size continuous speech recognition technology is applied. The nutrition database established in the system development process is applied to newly refine the sound model and language model suitable for nutrition management service and optimize the DNN based voice recognition engine.

Depending on service models, the sound model in diverse environments is established. The model established on the basis of nutrition analysis database is applied to continuous speech voice recognition system for Korean language so as to develop the voice recognition function fitting the activity-based nutrition management system.

As shown in Fig. 2, recognition server interface is developed and established to receive a recognition result in real time regardless of a type of voice information transmission. When the request of voice recognition is given to Server with the use of the functions defined in ASRLIB API, its recognition result is sent to a client program. With the uses of Initialize and UnInitialize functions, the connection information (IP, Port) used for API are set up, and released. If additional connection information is needed, it is possible to set up the information. Recognition and Result functions are used to send voice information, and a recognition result is sent back after Server recognition is completed.

2.3. Ambient device interaction technology using bio-signals

In a telecommunication environment, ambient intelligence technology has been developed. In the circumstance, smart devices using wearable sensors are used to analyze bio data in everyday life. A lot of investments and studies have been made on the customized healthcare service which makes it possible to monitor one's own condition through telecommunication [12–15]. As an example, there are smart devices capable of measuring activity or heart rate, such as glasses, bands, shoes, and belts [16–19]. Smart shoes and bands use IMU sensor including accelerator and gyroscope in order to measure bio data such as a user's movement, motion, and heart rate, and record position data in everyday life through GPS sensor. Based on these collected data, personal activity pattern and heart rate pattern are analyzed so as to provide the customized healthcare service [9].

For an ambient intelligence based healthcare, it is possible to utilize ISO/IEEE 11073-20601 protocol in which the data exchange between a smart device for measuring personal bio data and a gateway is defined. IEEE 11073-20601 protocol consists of Domain Information Model, Service Model, and Communication Model [20]. Bluetooth Low Energy (BLE), which is a typical communication protocol of bio signal measurement devices and smartphones, is also called Bluetooth Smart. For lightweight classic Bluetooth version, a part of Bluetooth 4.0 was announced. BLE provides Bluetooth wireless connectivity for an inexpensive small battery based device that needs several months to several years of battery lifespan. BLE technology contributes to the scalability of the healthcare service, since it is applied to watches, Proximity tags, sports and appropriate fitness sensors, healthcare sensors and remote controllers. In the activity-based nutrition management system, InBodyBAND2 of Inbody, PWB-100, 200, and 250 of Parton, Ribbon Device of Uracle, and UA-651BLE of A&D interact with BLE over IEEE 11073 protocol.

3. Similar group analysis and activity-based nutrition management

3.1. Development of nutrition management algorithm reflecting each stage of activity

Calorie control based nutrition management is an issue of present-day's people. Most systems propose a target intake calorie or recommend food menu or diet. An advanced nutrition management system implements the daily recommended calorie intake formula which is used offline nutrition management service in a software type and offers nutrition management service. Unlike the offline nutrition management service, the system uses a user's fixed activity information or does not collect information

Table 1
Definition of physical activity levels

Category of activity	Low active level	Active level	Very active level
Level of physical activity	1.50 (1.40 $\sim$ 1.60)	1.75 (1.60 $\sim$ 1.90)	2.00 (1.90 $\sim$ 2.20)
Everyday life	Static activity of sitting most of the time	Mostly sitting; some standing work, commuting, product buying, household work, and light exercise	Mostly standing work or exercise; active leisure activity

automatically so that it fails to provide a daily recommended intake calorie accurately. A calorie generated in the body for a certain time is referred to as metabolism. As a unit, there are calorie (cal) and kilo calorie (kcal). Humans consume energy for their basic activity even in their sleep in order to keep their body temperature and heart rate. In other words, basic energy is consumed in the body without any movement, which is called basal metabolism. A basic metabolic rate accounts for a great deal of daily consumed energy so that it is of importance. Energy expenditure other than that is mostly made for body movement activities. All body 'activities', such as exercise, singing, and dancing, lead to energy expenditure, which is called activity metabolism. In terms of a degree of obesity, a weight can be evaluated with Body Mass Index (BMI). Of the indexes based on weight and height, BMI is the most widely applied one. It is calculated in the way of dividing one's weight (kg) by the square (m^2) of its height. A standard weight is calculated in either Broca formula or modified Broca formula. If a standard height is 161 cm or more, Broca formula is applied; if 160 cm or less, modified Broca formula is applied. Information on muscle mass and body fat percentage is helpful for nutrition judgment. Such judgment is better than the judgment only with BMI. In terms of a daily recommended intake calorie, a daily energy requirement can be calculated differently depending on general adults, obesity, and low weight. Other nutrition requirements are calculated generally on the basis of the official 'Dietary Reference Intakes for Koreans'. For instance, according to 2015' Dietary Reference Intakes for Koreans, the physical activity of male and female adults aged 20 to 49 was 1.55 ± 0.19 and 1.46 ± 0.17, respectively, which means 'low active ($1.4 \leqslant \text{PAL} < 1.6$). If one is allowed to select its own physical activity level (low active, active, very active) in its physical information record, in terms of the estimated energy allowance for low activity, women can have 1.12 of PA (Physical Activity) and men 1.11. Accordingly, by applying PA differently depending on a activity level (low active, active, and very active), it is possible to calculate an estimated energy requirement. In case of obesity, an estimated energy requirement can be calculated as shown in the below Eq. (1).

$$662 - 9.53 \times \text{Age (years)} + \text{PA}[15.91 \times \text{Adjusted weight (kg)} + 539.6 \times \text{Height (m)}] \quad (1)$$

For example, if an obese man of 170 cm in height and 76 kg in weight aims to reach 72 kg (BMI 24.9), his estimated energy requirement is 2153 kcal. If he takes 2400 kcal, he needs to do more physical activity so as to burn (2400–2153) kcal. It is desirable to determine PA on the basis of daily living patterns, rather than occupations. It is possible to refer to the below Table 1, where inactive levels can be treated equally as in basal metabolic rate.

A user of nutrition management app selects a level of physical activity in the Table 1 when information input is displayed on the initial screen of the app. Based on the initially input information, the system provides nutrition management guidelines and a daily recommended intake calorie. The user is able to perform its own nutrition management after receiving the guidelines from the system. If its different activity information depending on situations is not entered accurately and manually, it is hard for the system to provide a daily intake calorie accurately. With the use of the bio signal measurement device interaction technology developed in this study, activity information is received from a variety of

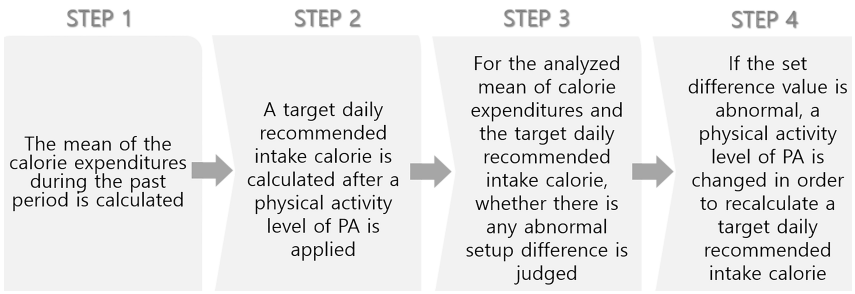


Fig. 3. Nutrition management activity level change process.

wearable devices and is applied to a nutrition management algorithm. The activity information of wearable devices includes walking, stair climbing, running, and other motion information. After three-week activity analysis, a user's average calorie expenditure is calculated. If a user's use period continues, the calorie expenditure information of a similar group is applied so as to draw a user's average calorie expenditure. In the system, an energy requirement is calculated in consideration of a level of physical activity (inactive level, low active level, active level, and very active level). If the already set difference value exceeds positively (+), an activity level goes up. If it is negative (−), the level goes down. If a user's daily energy requirement provided by the system has the difference of +300 Kcal and more from the activity information (average calorie expenditure) drawn from the app, the system goes up the actual activity level entered by the user (e.g., low active → active) when calculating and suggesting the user's calorie requirement. If the difference is −300 Kcal, the system goes down the actual activity level entered by the user (e.g., low active → inactive) when calculating and suggesting the user's calorie requirement. If the difference is ±600 kcal and more, it is possible to go up or down two levels. Wearable devices can be used in connection with mobile phones, waist belts, wrist bands, hair bands, glasses, and necklaces. A target daily recommended intake calorie is determined after at least one of weight adjustment target, age, weight, height, sex, and activity level is applied. Weight adjustment target is categorized into weight maintenance, weight reduction, and weight increase. The steps of daily recommended intake calculation using a physical activity level of PA are presented in Fig. 3.

As shown in Fig. 3, the activity-based nutrition management is able to correct a level of physical activity according to real-time activity, to draw a daily recommended intake calorie, and to provide nutrition management information accurately.

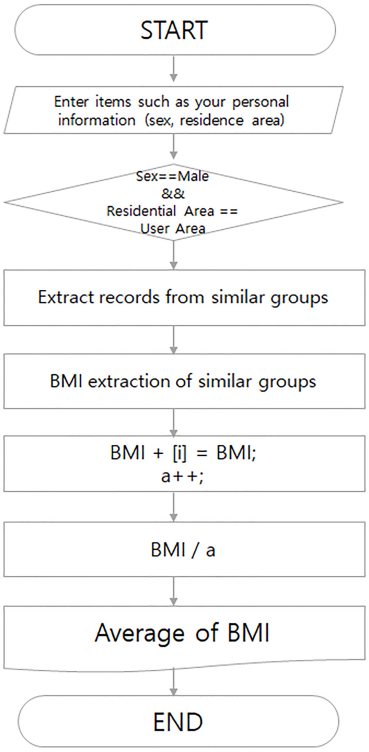
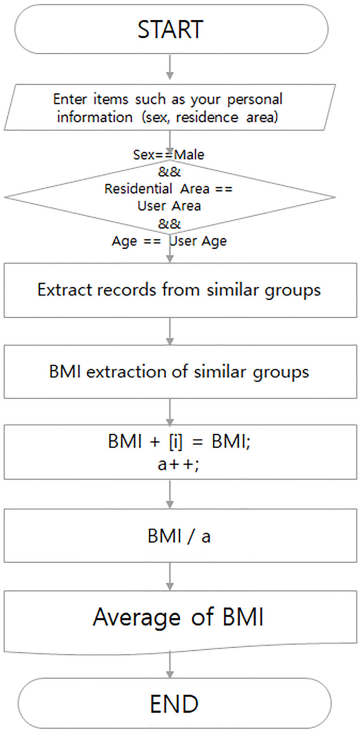
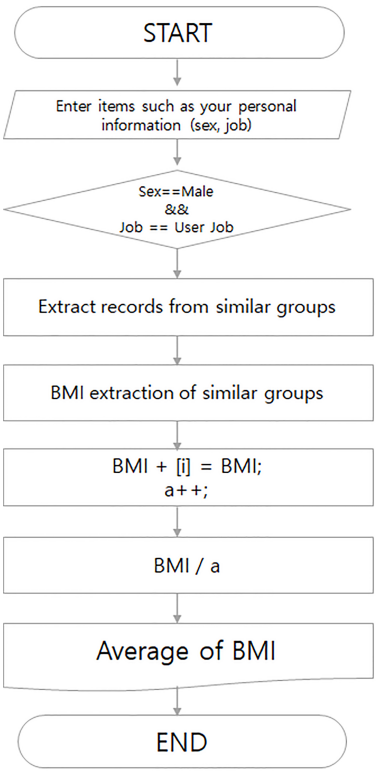
3.2. Similar group analysis algorithm using big data

The activity-based nutrition management system provides big data analysis information through a user's mobile device app. For the analysis on similar group, National Health Insurance Public Data is used. In other words, the average BMI of particular subjects and general men in similar residential area, the average BMI of general men in all areas, the average BMI of the age group in residential area, the average BMI of the age group in all areas and a particular person's BMI are analyzed. With the use of the National Health Insurance Public Data, the average BMI of general men similar to particular subjects by income quintiles, the average BMI of general men by activity time, the average BMI of general men by occupations, and a particular person's BMI are displayed in graph on app. In this way, the correlation between subjects and unspecified many persons similar to the subjects is intuitively offered in terms of obesity information. Therefore, the development purpose of the proposed algorithm is to improve the quality of nutrition management service and induce the continuous use of the app. For big data analysis,

Table 2
Similar group analysis factors and target values for obesity and nutrition management

Category	Factor value	Result value
User BMI	Height, weight	User BMI
The mean of general men in residential area	Height, weight, sex, residential area	The average BMI of all similar group and user BMI position
The mean of general men in all areas	Height, weight, sex, all areas	
The mean of the age group in residential area	Height, weight, sex, residential area, age	
The mean of the age group in all areas	Height, weight, sex, all areas, age	
The mean of general men by income quintiles	Height, weight, sex, income quintiles	
The mean of general men by activity time	Height, weight, sex, activity time	
The mean of general men by occupations	Height, weight, sex, occupation	

Table 3
Similar group analysis flow

The average of the average male in the residential and whole area	Age range average for residential and local area	Income/activity time/average of normal men by occupation
		

of 34 National Health Insurance raw data of National Health Insurance Corporation, 10,000 items are analyzed. As the analysis result, the factors most related to obesity-height, weight, sex, residential area, and age-are drawn from a similar group. In addition, of 756 National Health and Nutrition Examination Survey items of Korea Centers for Disease Control and Prevention, 8,000 data are analyzed so as to draw the factors related to nutrition management, which are height, weight, sex, income quintiles, activity time, and occupation. Table 2 shows the analysis results according to the drawn factors, and Table 3 presents the system process flow for similar group analysis.

4. Development of activity-based nutrition management health model

4.1. Activity-based nutrition management health model

With the extended human life and westernized eating habits, more nutrition management has been needed, and all age groups have been more interested in nutrition management. In this circumstance, it is necessary to provide the activity-based nutrition management health service which makes it possible to manage nutrition easily and continuously in social life and personal life [21–24]. To draw the essential functions for nutrition management, 150 subjects who used or use a nutrition application are selected. They are asked to use three nutrition management service applications for 10 days and more, and to evaluate the importance and performance of each function on the 5-point scale. The service functions that have a significant difference in terms of analysis values and are considered important for nutrition management by general consumers, and work well in nutrition management applications are drawn. Based on the drawn service functions, a level of requirement of nutrition management service functions is analyzed with 400 general consumers. The differences in a level of requirement are analyzed depending on age groups (20–30 years of age group, 40–50 years or more of age group) and whether to have a disease. In the survey of nutrition management service function requirement, the items that a high requirement value in all age groups are categorized into high, middle, and low types, and the items that have a high requirement value are categorized according to whether diseases are included [25,26]. Through the meeting of experts including nutrition expert, service expert, clinical medical doctor, exercise expert, and development expert, the basic functions of nutrition management are drawn as shown in Table 4.

Based on the drawn basic functions of nutrition management service, a nutrition management health model is developed. The developed service model uses the interactive voice recognition technology for obese patients so as to take into account their use convenience. Through the activity-based sensing data collection, their activity is accurately analyzed. The quality of the health service is improved in the way of establishing a nutrition database and using a nutrition management algorithm. Figure 4 illustrates the conceptual diagram of the activity-based nutrition management health service model.

4.2. Activity-based nutrition apps and web systems

Based on the developed nutrition management analysis database and service model, a nutrition management database with total of tables is developed. In the code system of food type database, a category has two digits, a division 1 digit, and a section three digits. In the code system of food product database, a category has two digits, a division 1 digit, a section three digits, subsection two digits, and blank 1 digit. Through the implemented interaction with bio measurement devices, the developed system collects and analyzes body fat and activity information (step count and calorie expenditure) in interaction with InbodyBand2 in order to provide the analyzed information to users. Figure 5 shows the screen of device interaction for measuring an activity with the use of InbodyBand2.

The nutrition management system provides such functions as eating record, band interaction, and nutrient evaluation, and side menu is developed in order to search for use history. The web screen is designed for nutritionists to find and analyze members' eating records, menu, nutrients, and calories all at once. In the nutrition management screen, the activity data collected in connection with nutritionists' guidelines, weight management, eating records, and InbodyBand2 are displayed. These data are analyzed by the system so as to display such information on a daily intake calorie and proper nutrition balance, which are needed for a user's nutrition management. Eating records can be made by a manual way or by

Table 4
The basic functions of nutrition management information service

Function	Category	Details	Level of requirement
Personal information input	Basic physical condition information	Personal information input (e.g., sex, age, weight, height)	High
	Dietary information	Input of breakfast, lunch, and dinner menu	Middle
		Input of breakfast, lunch, and dinner meal size	Middle
		Whether to request a manager to add the menu which is not found in menu search	High
		Input of snack intakes	Middle
	Goal setting	Target weight loss setting (obesity, dietary habit improvement)	High
		Target daily exercise (e.g., step count, exercise time) setting	High
Customized information offering	Customized basic physical condition information	Offering of BMI based obesity level	High
		Offering of the information as to whether there is the danger of high blood pressure	Middle
		Offering of the information as to whether there is the danger of diabetes	Middle
		Offering of daily recommended intake calorie	Middle
	Customized dietary information	Offering of the calorie for the described meal size	High
		Display of the ratio of carbohydrate, protein, and fat for the described meal size	Middle
		Display of the sodium amount for the described meal size	Middle
		Display of the nutrient balance for the described meal size	Middle
		Offering of essential nutrients after the nutrition analysis on the described meal	High
		Recommendation of proper food products and food types after the nutrition analysis on the described meal	High
General information offering	Food nutrition	Offering of food recipe	High
		Offering of the latest news about food nutrition	Middle
		Offering of daily recommended menu	Middle
		Offering of the recommended menu for each disease	High
		Offering of the nutrient contents of each food type	High
		Offering of the nutrient contents of each food product	High
		Offering of the one-time provision size of each food product	High
	Symptoms and diseases	Offering of obesity management information	Middle
		Offering of high blood pressure information	High
		Offering of diabetes information	High
		Offering of the latest news about diseases	Middle
	Physical activity and exercise	Offering of the latest news about physical activity and exercise	Middle
		Offering of the video of each exercise type	High
		Offering of living information	Middle
Communication	Expert	Personal coaching of nutrition expert	Middle
		FAQ with application developer or administrator in case of app problem	High
	Community	Community of app users	Middle
Other functions	Entertainment function	Points saving through attendance check	High
	Online shop	Purchase of health and nutrition food products	High
	Additional functions	Additional functions in connection with other equipment	Middle

the continuous voice based on voice recognition technology. By entering information on food type, food product, and a meal size in such ways, it is possible to improve users' convenience. A manager is able to find and manage service app users' information in the member management of nutrition management web. In terms of food type management function, it is possible to find the classification and code of food type and food product, nutrients of reprocessed database, and other information [27]. By analyzing app users' eating records and nutrients with the use of nutrition management function, a manager is able to provide nutrition guidelines to users directly. As contents, there is information on the guidelines for high

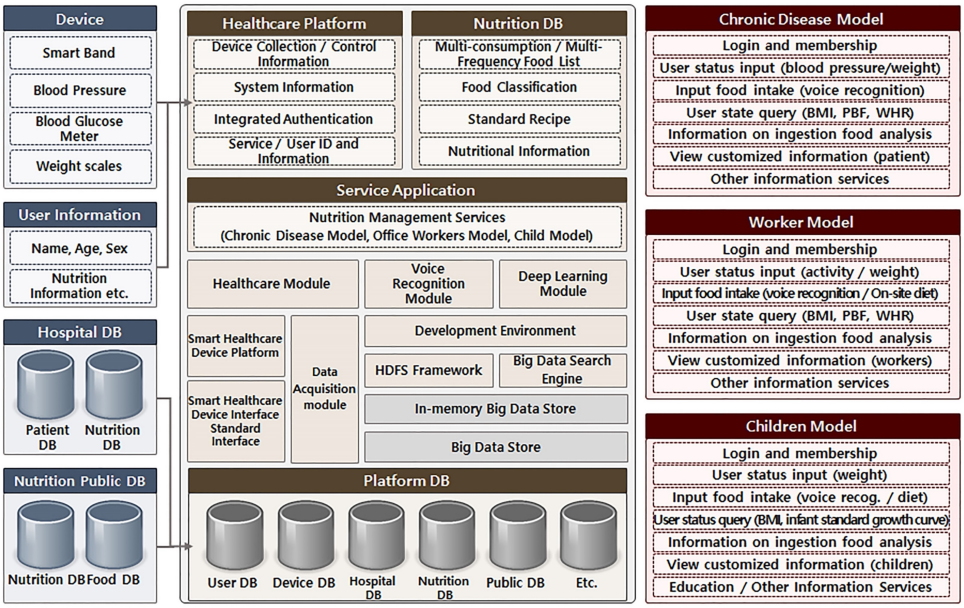


Fig. 4. Activity-based nutrition management health service model.

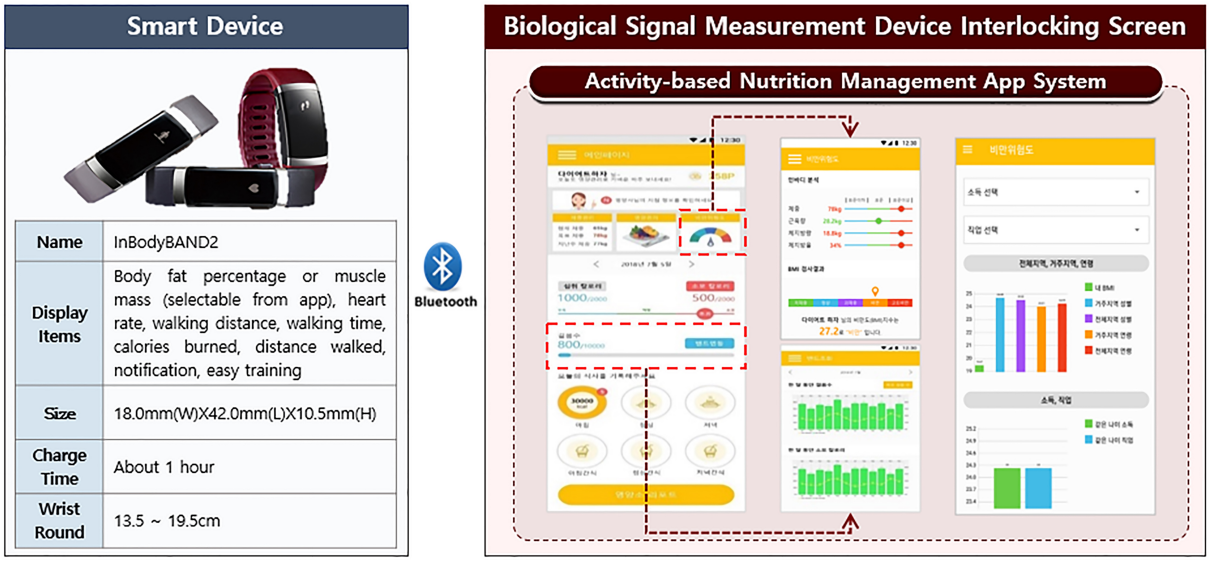


Fig. 5. Band linkage and activity measurement information output view.

sodium, high fat, and weight loss.

4.3. Performance evaluation

For the evaluation of the developed system, Institutional Review Board (IRB) approval is obtained from a general university hospital [21]. We provide online nutrition services to 50 people and offline nutrition services to 25 people. The performance of the system is evaluated for three months. Through the

Table 5
Service performance time differences between online and offline services

Service type	Consultation time	Nutrition judgment	Nutrition consultation	Evaluation and management
Online	15 minutes	Immediately	Immediately	10 minutes
Offline (conventional)	60 minutes	30 minutes	30 minutes	30 minutes (result sheet)

dietary life questionnaire, nutrition evaluation, and satisfaction survey, the effectiveness of the service model and system is analyzed. The comparison of online and offline services are made, and experimental application is implemented in order to verify the logical validity and effectiveness of the health model. According to the evaluation, the functional necessity of the system and the technical satisfaction were high, and the online service was better than an offline service in terms of service convenience, economy, and differentiation. Table 5 shows the service performance time differences between the activity-based nutrition management system and an existing offline nutrition management service. The online service shorten service times more than the offline service in the categories of consultation time, nutrition judgment, nutrition consultation, and evaluation and management.

As the result of the system and service evaluation, the online service of the activity-based nutrition management system has the following advantages:

If nutrition evaluation and consultation are made online, there are no temporal and spatial restrictions. Users are able to find in real time the analyzed calorie and nutrients of what they eat so that they can be aware of daily intake calories and control their calories. In addition, whenever they can have nutrition consultation, they can ask nutritionists questions freely. Through nutrition guidelines, they are able to recognize their dietary habits for weight loss and practice better eating habits in everyday life. In interaction with their smart bands, they are able to receive information on step count and calorie expenditure so that they can get motivation of doing exercise.

5. Conclusions

The obesity of young adults, which emerges as a social issue, is caused by living habits which fail to be managed due to environmental problems such as economic problem and time. In terms of the management of living habits important to prevent chronic diseases, obesity management is of significance, and obesity can be prevented and improved by nutrition management. Nevertheless, for the activity-based nutrition management system development, healthcare technology, algorithm, and service model are researched in the academic dimension. Proper food product treatment and nutrient adjustment help to treat diseases and prevent complications, through which it is possible to achieve healthcare. This study redesigned the nutrition analysis database which can be used practically and supports the nutrition management for diseases. For the improvement in users' convenience, continuous voice recognition technology was applied. In interaction with a variety of biometric devices, users' activity was measured depending on their situations. In the system developed in consideration of users' convenience and activity, an existing nutrition management algorithm is improved with the use of real-time activity information. Through the similar group clustering analysis, accurate attention information and measures are provided to users. In the thorough analysis of demands and requirements, human interface was developed so as to verify its effectiveness. In addition, the developed health model helps to solve the obesity problem, save medical cost, and address the issue of national health.

In the future research, it will be necessary to apply the 3D image recognition using status detection to the nutrition management system that draws a lot of public attention, and thereby to develop the

technology for giving a specialized service to each user. In addition, with the use of the knowledge base based context recognition multi-modal deep learning, it will be required to develop the knowledge processing technology of predicting the risk of obesity and creating diet success or fail information automatically.

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Conflict of interest

None to report.

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