Development of an Integrated Obesity Management Waist Belt System Composed of Calorie Tracking and Waist Circumference Measuring Module for Long Term Monitoring

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Abstract— **A waist belt type simple device was designed to monitor the individuals who are obese and want to maintain their consumed calories and waist circumference changes. Relatively long term monitoring with this device could help them maintain their health conditions. This devised system is composed of calorie tracking and waist circumference module. This study suggests feasible and meaningful results. If users' data are collected largely with this developed system, we can reveal the relationship between obesity and daily life pattern.**

I. INTRODUCTION

OBESITY has increased alarmingly in the past 20 years, reaching epidemic proportions. Nowadays we are mainly consuming junk foods that have high calories as a result of our hectic lifestyles and these foods which are being more readily available. The most common causes of obesity are improper lifestyle and unhealthy diet. Sedentary lifestyle and living on fast foods are the most common causes. Recent statistics have shown that 16% of US children are suffering from obesity symptoms. Early diagnosis can help to eliminate obesity in children. The most genuine causes of obesity in children are their food habits and lifestyle [1]. Being obese increases the risk of diseases and health conditions. Obesity can cause many serious health conditions such as diabetes, heart diseases, hypertension and cancer [2]. The life span of human beings is decreasing due to obesity and the health conditions that arise from it. In general, to decide whether or not someone has a weight problem, the most important factor is waist circumference.

In [3], researchers showed that increased waist size was a predictor of heart failure even when measurements of body mass index (BMI) fell within the normal range. In addition, others have indicated that the waist circumference and the ratio of waist circumference to height are strong indicators for management of weight than the classic BMI, and also the ratio is a strong predictor of intra-abdominal fat [4].

Thus, if we can measure and record waist circumference in daily life for a long time, it would be helpful for management of overweight and obese individuals, because these patients could be motivated for losing weight by checking it regularly. One of the factors of energy expenditure which is an important aspect of weight loss is the calories burned from exercise. To prevent obesity, regular exercise is good option to burn the layers of fat which is deposited inside the body. Exercises are extremely helpful in eliminating the excess fat that leads to obesity. Overweight individuals must follow a regular weight loss program under guidance. Healthy individuals also need to prevent obesity by means of the fact that intake of energy should be in balance with energy expenditure to keep optimal body weight.

However, one of the major difficulties in dealing with overweight individuals participating in exercise programs is identifying and prescribing exercise intensity and determining the number of calories burned during exercise. Accordingly, estimating the amount of calories burned during exercise or in daily life is required for the effective management of obesity.

To realize this goal, this study focuses on the development of a device that measures not only waist circumference but also calorie expenditure automatically in daily life as the device is embedded into a waist belt. The information of waist circumference and calorie expenditure could be very helpful to overweight individuals suffering from obesity.

II. MATERIALS AND METHODS

A. Backgrounds

To know about individuals' health condition for energy metabolism, we should monitor one's food intake and energy expenditure, because the imbalance of incoming and outgoing calorie causes weight change. Once people gain overweight they have difficulties in losing weight, because to keep calorie balance is not so easy. There are many

commercial tools to help weight loss for such people, but many people of them fail to weight management. In this study, we suggest more effective tool to help them. The devised belt system can measure one's daily activity level and waist circumference by just putting this belt on during daily life. No more annoying procedure is needed such as finding out pedometer, paying attention to measure waist circumference with measuring tape, and so on. Moreover, these kinds of measurements are not recordable so we cannot retrieve data from anywhere but one's memory. This devised belt could be more helpful to who live a busy modern life.

B. Materials

The system is composed of 2 major parts. One of the components is calorie tracking module, so called activity monitor, which measures the amount of activity in daily life. The other component is waist circumference measuring module which is belt type. These 2 modules are integrated into the single waist belt system depicted in Fig.1. The buckle of the belt has electronic board inside in which 2 modules are implemented. The buckle could be open to show the measurement results on LCD window. Both parts are briefly described in Table 1.

(a)

(b)

Fig.1. The appearance of devised belt system. The buckle part is not painted mock-up which is made of ABS resin.
(a) The whole vision of belt system. Working electronics are put in the buckle part and a lot of magnets are inserted into leather belt part.
(b) The open view of buckle part. The buckle part has LCD window, 4 operating buttons, and exposed MR sensors(seen as 2 black dots) to be close to the passing magnets.

TABLE I
COMPOSITION OF THE DEVISED SYSTEM

Module	Function	Sensing Difference
Calorie tracking module	Estimation of calorie consumption and activity data logging	Accelerometer
Waist circumference measuring module	Waist circumference measuring and storing measured data	Magnets and Magneto-Resistive sensor

The first module, calorie tracker, utilizes 3-axis accelerometer. If users put the belt system on their waist during daily life, their body movement generates 3-axis acceleration signals. Then generated signals are processed by the calorie tracker module with sampling, AD converting, and calculation by MCU(MSP430F5437, TI, USA). The processed data is shown on LCD window with the type of 24 hour history of today and daily history of 24 days with respect to steps and calorie, respectively. All of the activity data are stored in flash memory in the belt system.

On the other part, the second module, waist circumference measuring module, utilizes magnet and magneto-resistive sensor (MR sensor, DM-106B, SONY, JAPAN). Magnets are studded in leather part of belt with regular distance, and MR sensor is located in the buckle part of the belt which is facing the magnet of the leather part. The waist circumference measuring module was implemented in previous study [5]. In brief, MR sensors detect the passing magnets which are arranged with alternative polarity and regular distance and MCU calculates the user's waist circumference. Besides, the direction of belt, saying fastening or unfastening direction, could be detected so that exact waist circumference is provided by arranging 2 MR sensor's gap difference with 3/4 of distance of magnets. In this case, the MR sensor gap difference is 0.75cm, and the distance of magnets are 1cm. All of the waist circumference
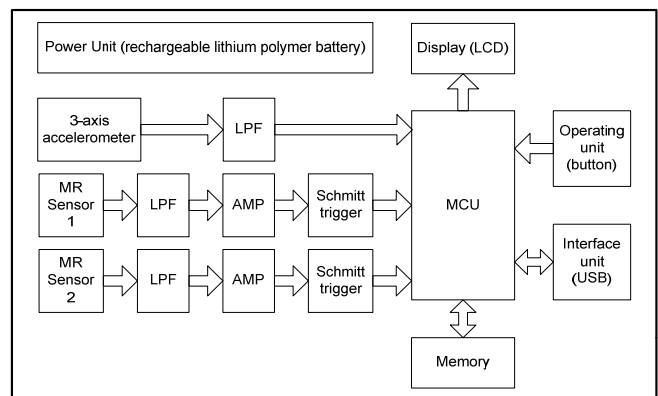

Fig.2. Block diagram of devised belt system. This figure shows the whole hardware components at a glance. The input stage of calorie tracking module is composed of accelerator, filter, while the input stage of waist circumference module is composed of two MR sensors, and filter, amp, Schmitt trigger for each sensor. All signals flow to MCU to be processed, and the result is shown at LCD window and stored in flash memory. Moreover, stored data may be uploaded to a terminal through USB interface unit.

data is stored in flash memory in the belt system. Fig.2 shows the whole hardware configuration, which covers the entire belt system.

C. Methods

The devised belt system is applicable for users who want to know their daily activity level and waist circumference change through relatively long period. Users are just required to put this belt system on and live one's real life. Calorie tracker is working at every moment to collect user's activity signal and waist circumference is working in the moment of putting this belt on. This belt system is tested by a subject who was healthy male in his middle 30's during several days for initial study. Usually the subject worked at his desk sedentarily and walked a little, and so on, during the period.

The generated 3-axis acceleration signals while moving are sampled at 40Hz, digitized, and processed by MCU, and also measured waist circumference data is processed by MCU after passing through some hardware components. All of the processed data are stored in memory the capacity of which is large enough to contain about 340 days' data. The belt system has a interface unit which can communicate with external terminal such as PC, PDA, etc. with USB

communication. Thus stored data could be transferred to the terminal and the reporting program could generate reporting page for selected period.

III. RESULTS

This devised belt system gives the results in forms of instant monitoring and long term trend analysis from accumulated data. The instant monitoring is available in LCD window inside the buckle of the belt system. A few kinds of information from user's activity could be shown such as consumed calories and walking steps in 24 hour range of today's data and in 24 days history range that is selected by button operation. Fig.3 shows the results on the LCD screen as well as the relevant activity report generated visualized in a personal computer.

IV. DISCUSSION AND FUTURE WORK

The main point of this belt system is integrated hardware which includes calorie tracker and waist measuring module.
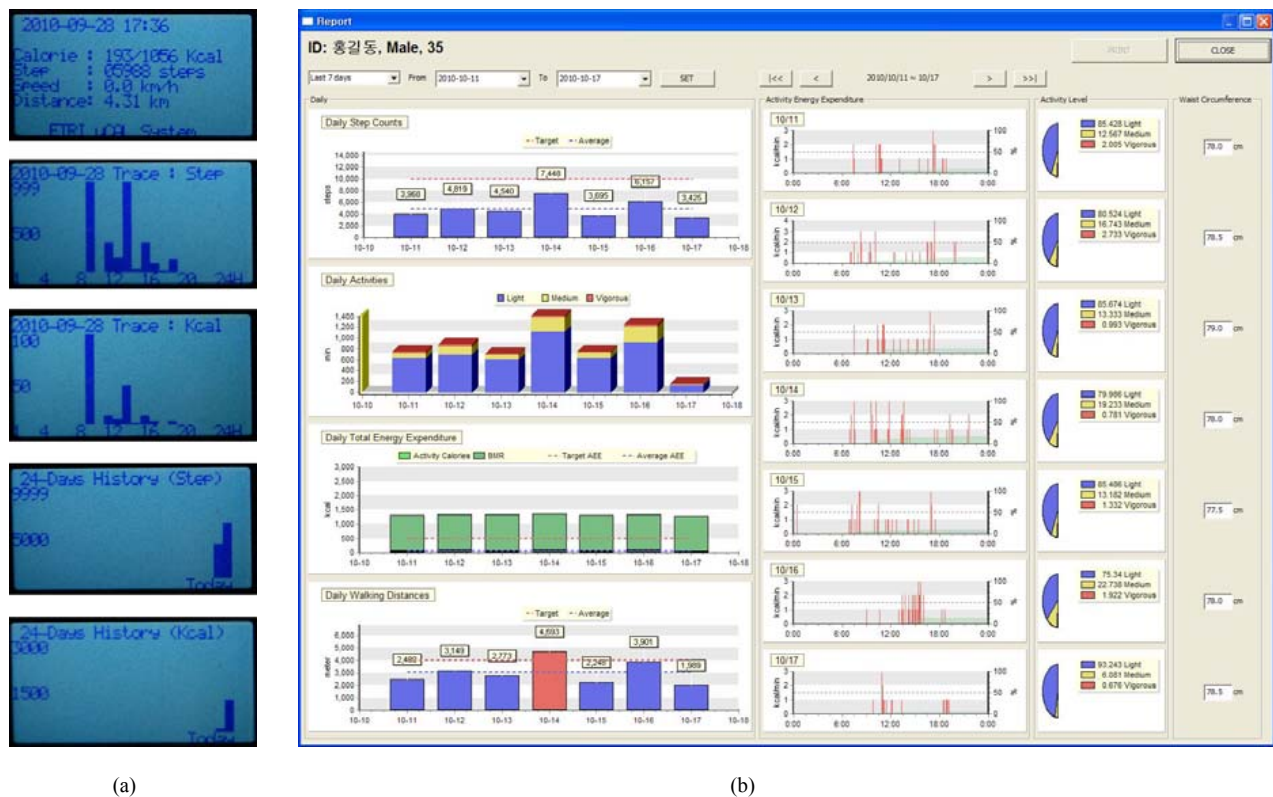

(a) (b)

Fig. 3. The examples of result screen on LCD window and report form of PC program.
(a) 5 example screen views(1st to 5th) are shown here. 1st : Total result of today's calorie, steps, distance, and current moving speed. 2nd and 3rd : today's hourly history of steps and consumed calories, respectively. 4th and 5th : 24 days history of steps and consumed calories, respectively.
(b) The example of report form from PC analysis software. The leftmost column shows daily data such as step counts, activities, total energy expenditure, and walking distance during selected period. The second column shows daily expended energy by activity (exclude the basal metabolism, etc.). The third column shows daily activity level which is separated to 3 levels like light, medium, and vigorous. The last column shows daily average waist circumference.

Besides, the calorie calculating algorithm is very accurate compared to the reference system which is gas exchange analyzer, K4b^2.

The devised belt system could be helpful for long term monitoring of daily activity pattern and user's waist circumference change. The transferred and accumulated data in terminal, for example PC, could make valuable information when it compared to the medical data. For instance, assume that large data from lots of users are collected and we have their medical data in various age groups. This dataset might give us very potent clue on which medical data comes out of which daily living pattern. The concatenated relationship between user's data and their medical examination results could be drawn quantitatively. The health care provider can give them exact and optimized advices for their health which are based on the measured data and health records.

The current system has no wireless interface unit like Bluetooth^{TM}. This system, however, should include that unit. If it has the ability to communicate with smartphone through wireless interface such as low power Bluetooth^{TM}, the measured data in the belt system could be uploaded without constraints. When the smartphone can play a role of terminal and gateway system at the same time, this system would be more powerful tool at the view of health care providing.

V. CONCLUSION

Obesity is one of the strongest threats of our health condition because it might cause many complications. We should make an effort not only to cure obesity but also to prevent obesity. In this point of view, the devised belt system could be very helpful to those who want to prevent or cure obesity. If a long term monitoring data of consumed calories and waist circumference change is analyzed and meaningful information is deduced, large population could get important information about the relationship between obesity and daily life pattern. Moreover, wireless connection with smartphone would enable to be a more comfortable and useful tool.

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