View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Kanazawa University Repository for Academic Resources

A fully automated health-care monitoring at home without attachment of any biological sensors and its clinical evaluation.

著者	Motoi Kosuke, Ogawa Mitsuhiro, Ueno Hiroshi, Kuwae Yutaka, Ikarashi Akira, Yuji Tadahiko, Higashi Yuji, Tanaka Shinobu, Fujimoto Toshiro, Asanoi Hidetsugu, Yamakoshi Ken-ichi
journal or publication title	Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference
volume	2009
page range	4323-4326
year	2009-09-01
URL	http://hdl.handle.net/2297/24319

31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

A Fully Automated Health-Care Monitoring at Home Without Attachment of Any Biological Sensors and its Clinical Evaluation

Kosuke Motoi, Mitsuhiro Ogawa, Hiroshi Ueno, Yutaka Kuwae, Akira Ikarashi, Tadahiko Yuji, Yuji Higashi, Shinobu Tanaka, Toshiro Fujimoto, Hidetsugu Asanoi, and Ken-ichi Yamakoshi, *Member, IEEE*

Abstract—**Daily monitoring of health condition is important for an effective scheme for early diagnosis, treatment and prevention of lifestyle-related diseases such as adiposis, diabetes, cardiovascular diseases and other diseases. Commercially available devices for health care monitoring at home are cumbersome in terms of self-attachment of biological sensors and self-operation of the devices. From this viewpoint, we have been developing a non-conscious physiological monitor installed in a bath, a lavatory, and a bed for home health care and evaluated its measurement accuracy by simultaneous recordings of a biological sensors directly attached to the body surface. In order to investigate its applicability to health condition monitoring, we have further developed a new monitoring system which can automatically monitor and store the health condition data. In this study, by evaluation on 3 patients with cardiac infarct or sleep apnea syndrome, patients' health condition such as body and excretion weight in the toilet and apnea and hypopnea during sleeping were successfully monitored, indicating that the system appears useful for monitoring the health condition during daily living.**

I. INTRODUCTION

THE requirement for home health care or health monitoring has been increasingly raised as an effective scheme for early diagnosis, treatment and prevention of lifestyle-related diseases such as adiposis, diabetes, cardiovascular diseases and other diseases, as well as for the reduction of medical expenses. It is also expected to perform monitoring of the health condition of a patient and/or outpatient with disorders during daily living. But, commercially available devices for health care monitoring at home are cumbersome in terms of self-attachment of biological sensors and self operation of the devices.

The concept of non-conscious physiological monitoring is based on the fact that it would be better if the monitoring could be done in a fully automated manner without the attachment of any biological sensors to the subject's body and any troublesome operations of measurement. Thus, the subject does not need to be aware of the measurement and the physiological data can be stored during ordinary daily living.

From this point of view, electrocardiogram (ECG) monitor in bathtub [1] and bed [2~4] without direct skin-contact, respiration and pulse monitor using air mattress sensor [5,6], body temperature and movement monitor using thermistor [7] and so on, were developed. We have also developed not only a body and excretion weight monitor which a high accurate weight measurement device installed in a lavatory floor around a toilet-bowl, but also a toilet-seat-installed blood pressure (BP) monitor [8~10]. Moreover, a respiration and cardiac beat monitor under pillow using vinyl tubes filled with silicon-oil also have been developed [11].

A drowning alarm in the bathtub is also well recognized as being important in the fields of health-care, elderly care, and so on. The previous ECG monitor in bathtub [1] could not measure the respiration required for detecting the drowning. We have designed a new system capable of simultaneously measuring ECG [12]. We have also developed a prototype health-care monitoring room which bathtub, toilet and under-pillow monitor mentioned above are installed, and evaluated the measurement accuracy of these devices by simultaneous recordings of biological sensors directly attached to the subjects' body surface, indicating that these monitors allow accurate measurements [12].

In order to investigate its applicability to the health condition monitoring, we have further developed a new monitoring system which can automatically analyze the data obtained from the sensors. We also installed the system at hospital room and firstly monitored the body weight of a patient with cardiac infarct in the toilet and the respiration of 2 patients with sleep apnea syndrome during sleeping.

II. MONITORING SYSTEM

Fig. 1 shows an overview of the fully automated health-care monitoring system without attachment of any biological sensors set up at the hospital room. All of the sensors are installed in the toilet space, the bed and the bathtub, and the obtained data are automatically analyzed and displayed using the monitor equipment which amplifier for the sensors, computer, memory, LCD and LAN module are installed. Analytical results of each sensor such as trend-chart are stored and displayed using the server equipment.

Fig. 2 shows the details of the sensor system installed at the

K. Motoi, M. Ogawa, A. Ikarashi, S. Tanaka and K. Yamakoshi are with Graduate School of Natural Science and Technology, Kanazawa University, Kanazawa, 920-1192 Japan (Phone & Fax: +81-76-234-4760; e-mail: motoi566@staff.kanazawa-u.ac.jp).

H. Ueno and H. Asanoi are with Imizu City Hospital, Imizu, Toyama, 934-0053 Japan (Phone & Fax: +81-766-82-8100; e-mail: hidetugu@med.u-toyama.ac.jp).

Y. kuwae, T. Yuji, Y. Higashi and T. Fujimoto are with Fujimoto Hayasuzu Hospital, Miyakonojo, 885-0055 Japan (Phone: +81-986-25-1313; e-mail: rehabili@fujimoto.or.jp).

toilet. A platform-type scale with a weight resolution of about 10 gf is placed around a toilet bowl. Four load sensors were used to support a load plate at four points, constructing a U-shaped weight-measuring platform like a force plate. The weight-measuring platform was placed on the floor adjacent to a toilet bowl and also supported a toilet seat using a seat-supporting stand. Total body weight could therefore be loaded on the weight-measuring platform in case of either standing in front of the bowl or sitting on the seat. The output signal from the sensors are led to the amplifiers and fed to the computer via a 16-bit A/D converter (sampling frequency of 100 Hz). Using the automated analytical program installed at computer, the total body weight before and after excretion can be accurately detected, therefore obtaining the excretion weight from the difference of the body weight.

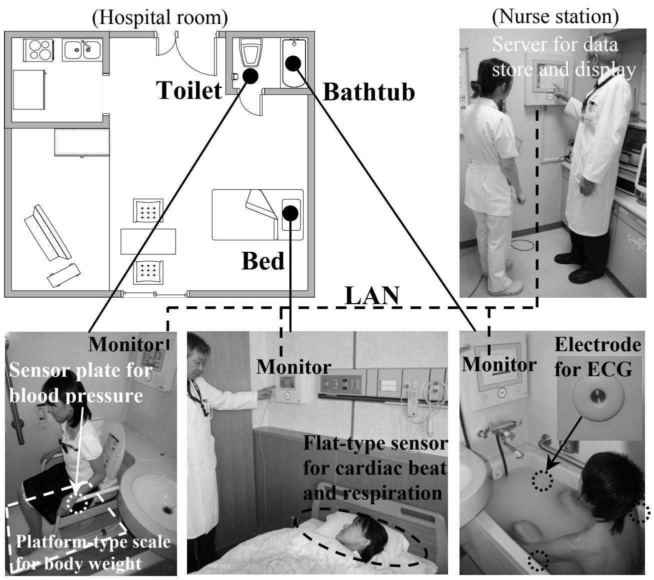

Fig. 1. Outline of the fully automated health-care monitoring system without attachment of any biological sensors set up at the hospital.

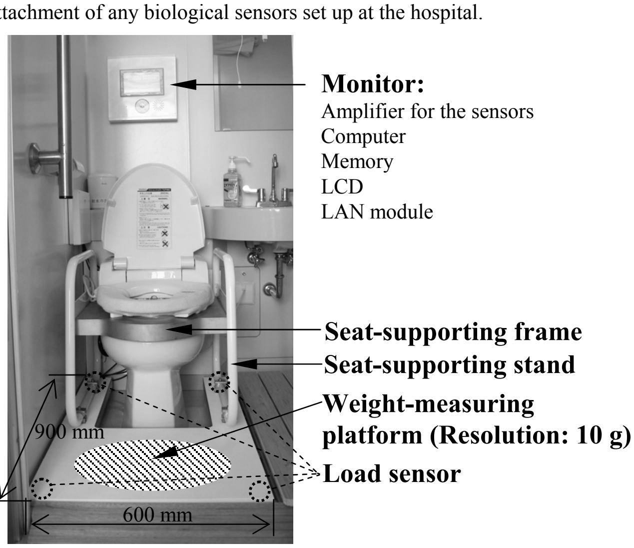

Fig. 2. Details of the sensor system installed at the toilet space which can measure the body and excretion weight.

Fig. 3 shows the details of the sensor system under the pillow at the bed. Four vinyl tubes of 2 mm inner diameters filled with silicon-oil are sandwiched by two acrylic plates, the width of which is aligned with a bed size. One end of each tube is connected to a pressure sensor and the other end is closed. This flat-type sensor is set under pillow or a bed mat.

The output signals from the sensors are led to an amplifier and fed to the computer via a 12-bit A/D converter (sampling frequency of 200 Hz). The inner pressure in each tube is changed in accordance with respiration, cardiac beating and snore, and thus such information can be detected by use of an appropriate digital filter (cardiac beat: 1~3 Hz, respiration:0.1~0.4 Hz). Also, the apnea and hypopnea can be detected from the lowering of the respiration signal more than 10 s based on the definition of SAS.

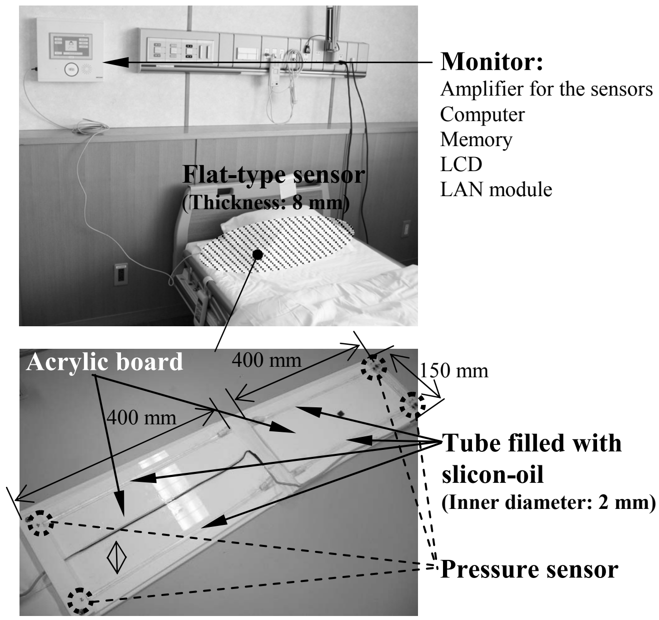

Fig. 3. Details of the sensor system installed under the pillow which can measure the cardiac beat, respiration and snore.

III. Subjects and Methods

Using the sensor system set up at the toilet, a patient with cardiac infarct (65 yrs) had measurements of body and excretion weight through treatment in Imizu City Hospital. We evaluated the recovery of circadian rhythm for the weight change by the treatment. Using the flat-type sensor under the pillow, 2 patients with SAS (45 and 56 yrs) had measurements of the respiration during sleeping and the apnea and hypopnea were detected from the lowering of the respiration signal. We also evaluated its detection accuracy by simultaneous recording of a polysomnography (PSG).

Before measurement, we acquired permission from the ethical review board at the hospital and the informed con-sent had been obtained in each patient.

IV. Results and Discussion

Fig. 4 shows an example of recordings of the weight change signal (DC~10Hz) with sitting the seat during urination, obtained in the male patient with cardiac infarct (65 yrs) in the toilet. After standing on the platform, considerable large artifact signal due to body movement such as taking off and put on subject's clothes, and setting down and standing up motion, are detected just before and after urination. These components are reduced due to less motion during urination, therefore the system can detect the total body weight in start and end of the urination, obtaining the excretion weight from the difference of the body weight.

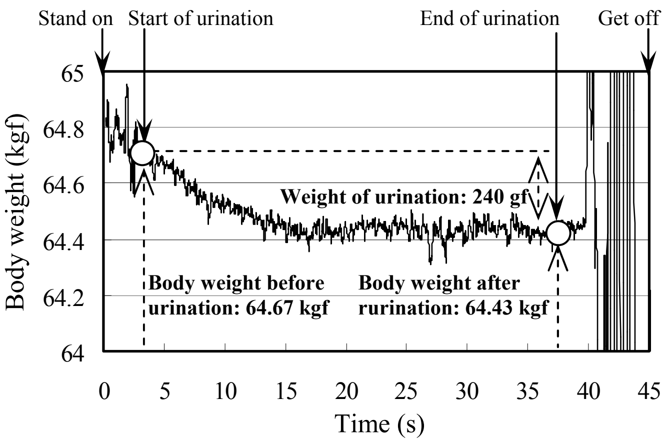

Fig. 4. Example of recording of weight change in the male patient with cardiac infarct during urination.

Fig. 5 shows analytical result of the one week trend-chart of the total body weight after excretion and excretion weight including the urination and defecation, obtained in the male patient with cardiac infarct (65 yrs) during treatment in the hospital. From this result, it was shown that the body weight came down and the circadian rhythm of the body and excretion weight was recovered by the treatment of cardiac infarct. It is demonstrated that the monitoring system for body weight in the toilet appears useful for the evaluation of health condition in the subject with cardiac infarct.

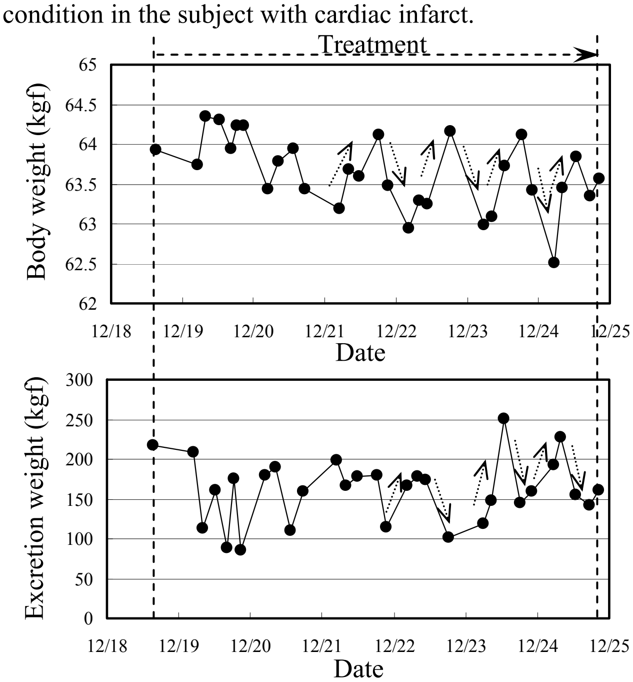

Fig. 5. Analytical results for the body and excretion weight of the male patients with cardiac infarct (65 yrs) during one week.

Fig. 6 shows an example of simultaneous recordings of the respiration signals and the apnea and hypopnea (AH) obtained by the flat-type sensor under pillow ($Resp_f$, AH_f) and the rhinal temperature method by the thermistor ($Resp_r$, AH_r) during sleeping, in the male patient with SAS (45 yrs). The AH in the flat-type sensor and thermistor were automatically obtained by detection of lowering of the respiration signal more than 10 s using the analytical program installed at PC. From these results, the AH obtained from the flat-type sensor under pillow coincided well with those obtained from the thermistor. In the dashed part, while artifacts were observed in the results using the rhinal thermistor, the flat type sensor could detect the apnea.

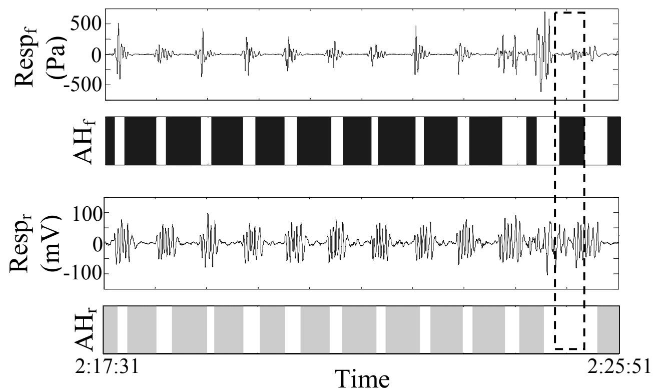

Fig. 6. Example of simultaneous recordings of the respiration signals and the apnea and hypopnea obtained by the flat-type sensor and the rhinal temperature method by the thermistor during sleeping. AC components of both signals are shown. Detected apnea periods are indicated as AH_f and AH_r.

Fig. 7 shows analytical results of the apnea and hypopnea index (AHI), i.e., the average number of times of those per hour obtained from the flat-type sensor and the thermistor in the male (45 yrs) and the female (56 yrs) patient with SAS. From these results, the AHI obtained from the flat-type sensor agreed well with those obtained from the thermistor. It is demonstrated that the system appears useful for screening of the SAS, evaluation for quality of sleep, and so on.

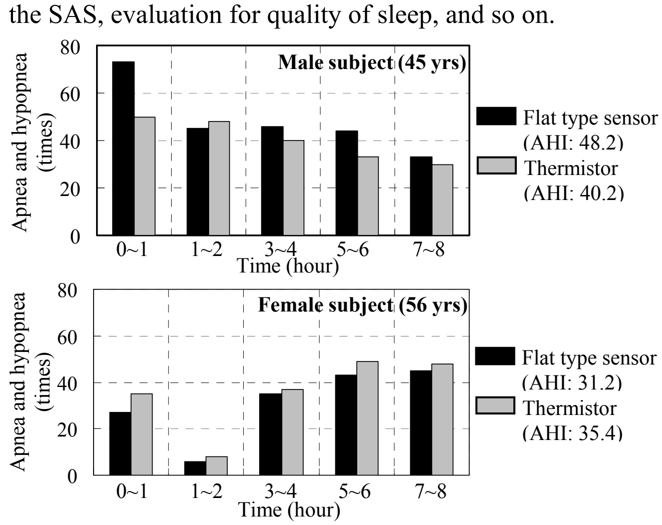

Fig. 7 Analytical results of the apnea and hypopnea index (AHI) obtained from the flat-type sensor and the thermistor.

V. CONCLUSION

We have developed the fully automated health-care monitoring system without attachment of any biological sensors set up at hospital room. This monitoring system obviates the need to perform special operations in order to measure, and the subject only need go to the toilet, bed and bath in a regularly way. Data acquisition, display and storage were also fully automated using the monitor and server equipment newly developed.

Firstly, we have attempted to measure the health condition related to body and excretion weight of the patient with cardiac infarct in the toilet and the respiration of the subjects with SAS during sleep. It is demonstrated that the monitor system appears useful for evaluating the health condition and the recovery by the treatment in the subjects with disease.

Further investigations will be needed such as evaluation for availability of measurements by the ECG and respiration monitor in the bathtub, the blood pressure monitor in the toilet seat and cardiac beat monitor in the bed through the use of a hospital, and measurements for longer period of time in many elderly during daily living at home using the system.

ACKNOWLEDGMENT

This work is partly supported by the Knowledge-based Cluster Creation Project (Ishikawa High-tech Sensing Cluster), Ministry of Education, Culture, Sports, Science and Technology.

REFERENCES

[1] M. Ishijima and T. Togawa, "Observation of electrocardiograms through tap water ," Clin. Phys. & Physiol. Meas. vol. 10, pp. 171-175, 1989

[2] M. Ishijima, "Cardiopulmonary monitoring by textile electrodes without subject-awareness of being monitored," Med. & Biol. Eng. & Comput., vol. 35(6), 685-690,1997

[3] Y. G. Lim, K. K. Kim and K. S. Park, "ECG recording on a bed during sleep without direct skin-contact," IEEE Trans. Biomed. Eng., vol. 54(4), pp. 718-725, 2007

[4] S. Ishida, N. Shiozawa, Y. Fujiwara, and M. Makiwawa, "Electrocardiogram measurement during sleep with wearing clothes using capacitive-coupled electrodes," Proceedings of the 29th Annual Conference of the IEEE Engineering in Medicine and Biology Society, pp. 2647-2650, CD-ROM, 2007

[5] P. Chow, G. Nagendra, J. Abisheganaden, and Y. T. Wang, "Respiratory monitoring using an air-mattress system," Physiol. Meas., vol. 21, pp. 345-354, 2000

[6] K. Watanabe, T. Watanabe, H. Watanabe, H. Ando, T. Ishikawa, and K. Kobayashi, "Noninvasive measurement of heartbeat, respiration, snoring and body movements of a subject in bed via a pneumatic method," IEEE Trans. Biomed. Eng., vol. 52(12), pp. 2100-2107, 2006

[7] T. Tamura, J. Zhou, H. Mizukami, and T. Togawa, "A system, for monitoring temperature distribution in bed and its application to the assessment of body movement," Physiol. Meas. vol. 14, pp. 33-41, 1993

[8] K. Yamakoshi, "Unconstrained physiological monitoring in daily living for health care," Frontiers Med. Biol. Eng., vol. 10(3), pp. 139-159, 2000

[9] K. Yamakoshi, ''Non-Invasive Cardiovascular Hemodynamic Measurements,'' Sensors in Medicine and Health Care, pp. 107-160, 2004

[10] S. Tanaka, M. Nogawa, and K. Yamakoshi, "Fully automatic system for monitoring blood pressure from a toilet-seat using the volume-oscillometric method," Proceedings of the 2005 IEEE Eng. Med. Biol. 27th Annual Conference Shanghai, CD-ROM, 2005

[11] X. Zhu, W. Chen, T. Nemoto, Y. Kanemitsu, K. Kitamura, K. Yamakoshi, and D. Wei, "Real-time monitoring of respiration rhythm and pulse rate during sleep," IEEE Trans. Biomed. Eng., vol. 53(12), pp. 2553-2563, 2006

[12] K. Motoi, S. Kubota, A. Ikarashi, M. Nogawa, S. Tanaka, T. Nemoto, and K. Yamakoshi "Development of a fully automated network system for long-term health-care monitoring at home," Proceedings of the 29th Annual Conference of the IEEE Engineering in Medicine and Biology Society, pp.1826-1829, CD-ROM, 2007