Health management of elderly persons using a pedometer

Takashi Oyabu (Kokusai Business Gakuin College, oyabu24@gmail.com)
Yusuke Kajiwara (College of Information Science and Engineering, Ritsumeikan University, kajiwara@de.is.ritsumei.ac.jp)
Haruhiko Kimura (Graduate school of Natural Science and Technology, Kanazawa University, kimura@ec.t.kanazawa-u.ac.jp)

Abstract
It is necessary to provide health management and abnormality countermeasure systems for elderly persons with the advancement of an aging society. The application of health management for aging people using a pedometer was examined in this study. It is considered that the number of steps correlates strongly with the amount of physical exertion. Circadian fluctuation and the long term change of steps for the elderly subjects were analysed. As the result, the physical activity can be estimated by the number of steps and it is able to apply to health management. It could be also recognized whether the subject lives their life as usual using the steps characteristic or not. The steps of an elderly subject (woman, over 85 years old) is extremely low compared with one for a middle-age subject. The middle-age subject had a week's period in the steps characteristic. In the period, the subject had a nearly constant number of steps on Monday to Friday and a high steps number on Saturday and Sunday because of playing tennis. This study was carried out with restricted subjects. It is necessary to examine the characteristics of more subjects. However, it is thought that a trend is shown.

Key words
pedometer, health management, lifestyle, physical activity, aging society

1. Introduction

In Japan, the number of the aged reached over thirty million and sixteen percent of the aged are living alone. The rate of elderly-couple household accounts for 40%. Namely, the total rate of both contents exceeds the 50%. The elderly means more than 65 years old. The demands for health management and detection of anomaly for the elderly are growing because there are few people who can watch elderly persons. The degree of safety and security for the elderly could increase when they can spend time with their family because they can be watched over by their family members. It is obvious that people living alone and elderly-couple household are increasing rapidly due to the investigating results of Japanese cabinet office. Consequently, an effective ICT system is desired to transfer the disaster information and health impairment concerning elderly persons. It is imperative to utilize ICT devices at the time of unusual conditions and disaster (Promotion committee for G-space x ICT in Ministry of Internal Affairs and Communications of Japan, 2013). It is also better to use positional information (location information-based service) at that time. In Japan, the information is called "G-space information". G means "Geography". It is obvious that the information is necessary for local residents to have safety and a secure lifestyle, and health care. Namely, it is necessary to understand the following information with the advancement of an aging society.

"when", "who", "where" and "what"

It is legitimate to gather the information with considering personal privacy at this moment. The Ministry of Internal Affairs and Communications (MIAC) in Japan suggests the necessities of the infrastructure development (MIAC named it "G-space X (times) ICT") as an important infrastructure of the 21st century. There is a health management as a field of the application. Pedometer data is effective to manage personal health. A system can understand the present point (G-space information) and the amount when the device has a positional information.

It can grasp whether the elderly person lives a healthy life by walking or not. Not only the number of steps every unit time but also daily steps number can be grasped and everyday-life of the subject can also be understood. In this study, the number of steps indicates the amount of activity and it is an effective factor. The pattern for step number will shift at an abnormal condition and disaster. Other vital signs are also measured every day, namely weight, body fat, base metabolism, body age, muscle mass, score of mass, level of visceral fat, estimated bone quantity, the highest and lowest blood pressure. The highest and lowest temperatures are also recorded. The degree of health can be understood daily using the steps data. Physical decline is also known using the long term data.

2. Experimental

The subjects were as follows: subject A (female: 86 years old), B (male: 64), C (female: 56) and D (male: 22). The steps for subject A were recorded only one day because she was well advanced in life. The vital signs and steps for subject B were recorded over a year. Steps and vital signs for subject C were recorded for three months. The data for subject D were measured for half a year. In this study, the following vital signs were recorded in the evening. The measurement was carried out before or after dinner so the weight probably shifted within one kilogram. The feeling at awakening was also recorded and it was evaluated on a level of one to five. The highest and lowest temperature were also recorded every day.

- weight, body fat, base metabolism, body age, muscle mass, score of mass, level of visceral fat, estimating bone quantity, the highest and lowest blood pressure, feeling, steps number
- highest and lowest temperature, weather

The vital signs can be recorded automatically into a PC through a cloud typed communication tool but the feeling at awakening can be recorded only manually. The measurement devices and the tool are shown in Figure 1. The data of the subjects can be stored into the cloud (network) using communication equipment (Karada-ni-iikoto Laboratory, 2015). The vital signs were measured using a pedometer (TANITA: Tn-Link, FB-723) and body composition meter (TANITA: Tn-Link, BC-503). Blood pressure manometer (TANITA: Tn-Link, BP-301) is also manufactured by the same company (TANITA Co. in Japan) (The Yomiuri, 2013).

Figure 1: Apparatuses used in the experiment

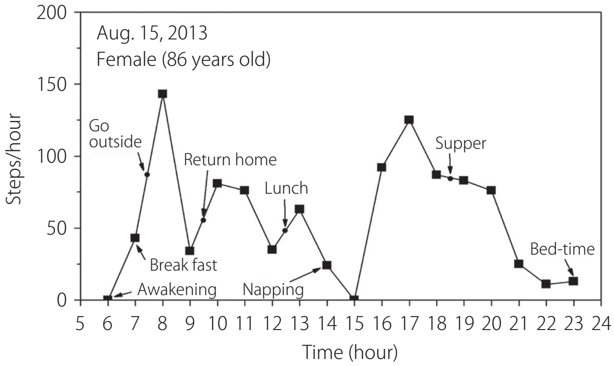

Figure 2: Hourly steps-characteristics of the aged person

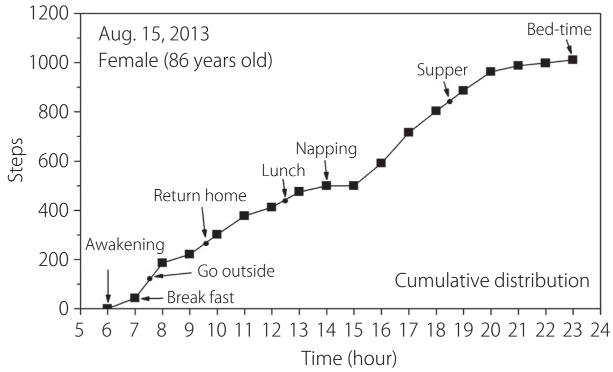

Figure 3: Cumulative distribution of steps/hour for the aged subject A

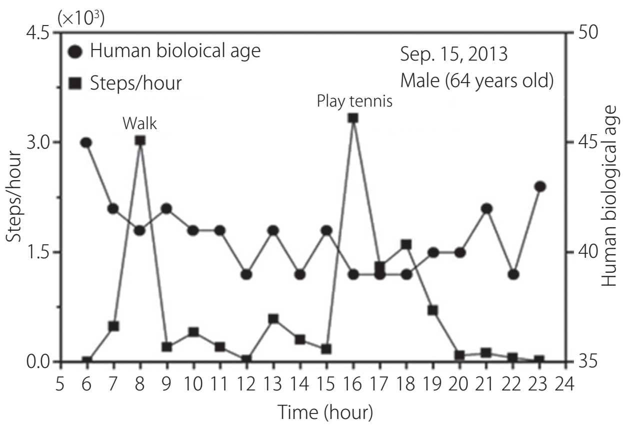

Figure 4: Hourly characteristics of steps and human biological age of the subject B

3. Experimental result

3.1 Daily variation of steps

The circadian fluctuation data (steps/hour) of pedometer for subject A (female, 86 years old) is shown in Figure 2. The data were measured once every hour from 6 to 23 o'clock (bedtime). The characteristic varies according on the time of day. She ordinarily wakes up at 7 and go to bed at 22 in winter. The peek value is 150 steps for 7 to 8 o'clock, not so many steps. She had an afternoon nap at about 14 o'clock and pulled up weeds in a garden from about 15 to 17 o'clock. The number of steps was about 125. The cumulative distribution is indicated in Figure 3. The total steps are about 1,000. The daily pattern (life-style) and approximate amount of activity can be understood by the distribution. Hourly characteristic for subject B (male, 64 years old) is indicated in Figure 4. The hourly number of steps reaches 3,000 twice a day in the figure and the characteristic is greatly different from subject A. The characteristic of human biological age is also shown in the figure. It becomes higher at bed-time and lower at the daytime when he was active. Cumulative step characteristic for subject B is represented in Figure 5. It shows a flat characteristic before and after lunchtime and is similar to the one for subject A. It can be understood that the steps number for

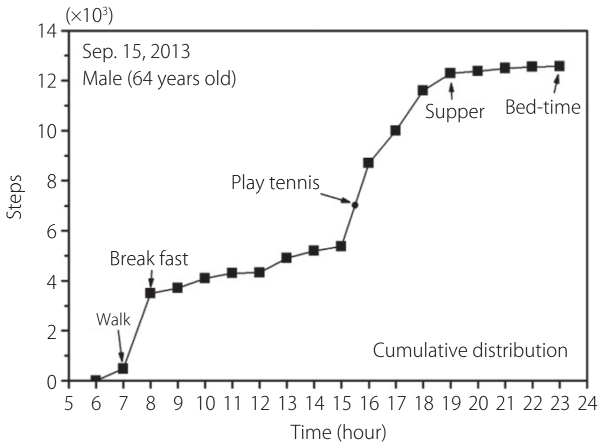

Figure 5: Cumulative step characteristic for the subject B

subject B becomes higher at the time of a morning walk and lower at lunchtime. And it becomes higher again before suppertime. The daily life-style can be estimated roughly using the figure. Of course there is a day dependence in the step characteristic. It can be understood whether a subject leads a normal life or not. There is a difference of more than ten times in the number of steps for subject A and B. The number of steps may be considered as a kind of physical activity.

3.2 Long-time transition of vital data

Much vital data can be reported every hour but it takes a high cost to arrange the data and retrieve the necessary information. Narrowing down the data is required to manage a centralize control when there are many surveying subjects. It is thought that the steps characteristic is effective to survey their life-style due to the results in the preceding paragraph. Some long-term vital signs and the number of steps are measured in this study.

3.2.1 Vital information of subject B

Subject B is some kind of office employee who tends to be short of exercise. There are some reports that the risk of diabetes is decreased by walking (Dwyer et al., 2013). Therefore, there are some papers in which measuring the number of steps make a contribution to health promotion and improvement in capacity for locomotion (Jinro et al., 2013; Nomoto et al., 2010). Subject B often plays tennis on his days off. The monthly average characteristics for weight, fat and metabolism of subject B are shown in Figure 6. Their plots are almost flat and there are not rapid changes in the figure. The horizontal axis means "month" for a year. In the same way, the ones for biological age, muscle mass, muscle score, visceral fat and bone quantity are indicated in Figure 7. The characteristics for all parameters are almost constant except muscle score which means the muscle mass for body height and it is rated using a nine-point scale, namely -4 to +4. Average is the values of -1, 0 and +1. Larger is +2, +3 and +4. Smaller is -4, -3 and -2. The subject runs from 1 through 2 and is rated as larger. The characteristic has a decreasing trend in summer (August and September) and winter (December and January).

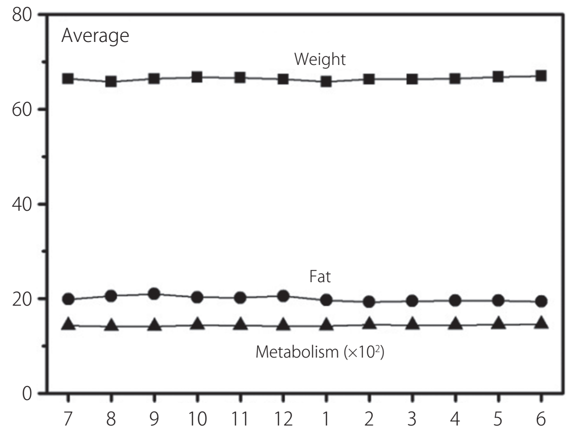

Figure 6: Monthly average characteristics of three vital signs on subject B

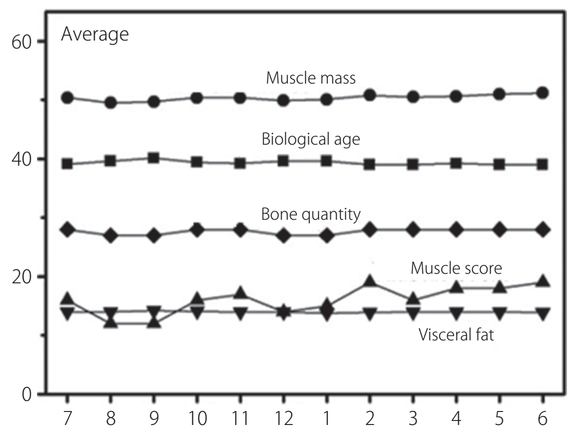

Figure 7: Monthly average characteristics of the five vital signs on subject B

Note: The vertical scale for bone quantity and muscle score is one-tenth.

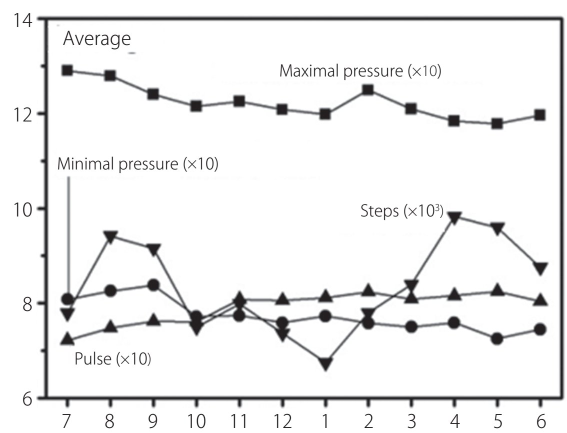

Figure 8: Monthly average characteristics of four vital signs on subject B

Namely, it is thought that there is a seasonality but the cause is unclear. Averages for maximal and minimal pressures, number of steps and number of pulse are plotted in Figure 8. The number of steps is larger in summer (August and September) and spring (April and May) and the averages are exceeding 9,000. It takes a minimum value in January. Apparently there is a seasonal variation in the step-characteristic. Minimal and maximal pressures had a decreasing trend because the subject watched out for his high blood pressure. Measurement has an effect on one's health management. The healthy range of maximal pressure is less than 130 and the one for minimal pressure is less than 85. The values for the subject shift to a healthy range. Various kinds of seasonal trends of vital signs can be seen from measured data for a year.

3.2.2 Long-term change of vital information on subject C

There is a survey result that the amount of physical exercise (for instance 6,000 steps per day) prevents overweight and metabolic syndrome of middle-aged and older females (investigation in Passo Fundo City of Brazil). The results are useful for the ones of subject C (female, 56 years old) in this study. The monthly average characteristics of weight, fat and metabolism for three months are plotted in Figure 9. The ones for biological age, muscle mass, muscle score, visceral fat and bone quantity are also summarized in Figure 10. Monthly average values of the highest and lowest blood pressure, number of steps and pulse are plotted in Figure 11 similarly. The number of steps is few and it is 5,000 to 6,000 steps per day. The characteristics for muscle score and bone quantity of subject C indicate same tendency to the ones for subject B. The tendency is similar to the characteristic for the number of steps. The highest and lowest blood pressures also decrease in August and return to the original state. In this study, it is difficult to indicate a relevance among these data. It is necessary to collect additional data in analyzing the relationship among the vital signs.

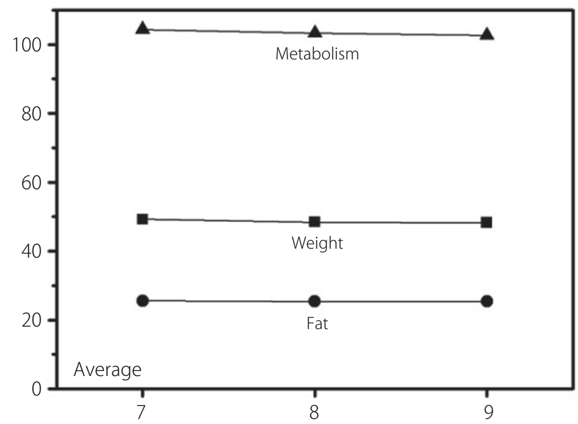

Figure 9: Monthly average characteristics of three vital signs on subject C

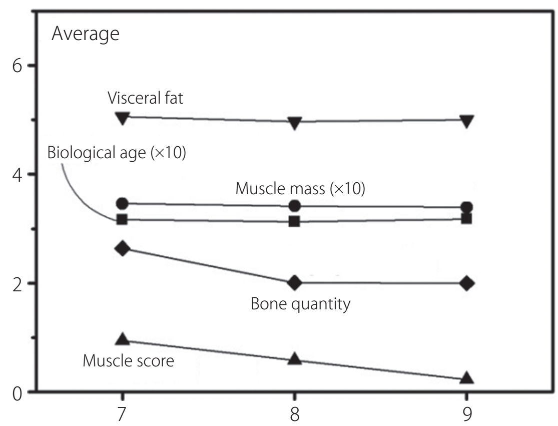

Figure 10: Monthly average characteristics of five vital signs on subject C

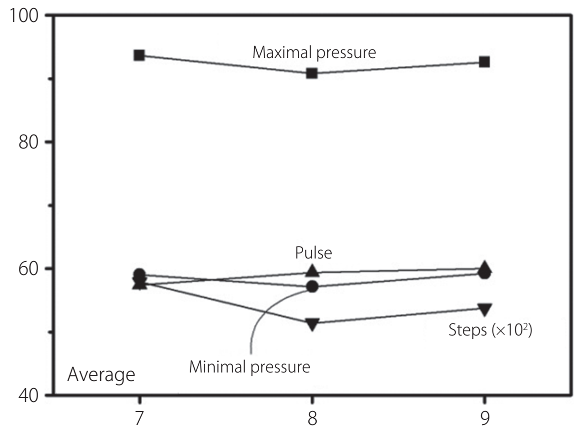

Figure 11: Monthly average characteristics of four vital signs on subject C

3.2.3 Changes of vital signs for young male subject

Arteriosclerosis of young people is increasing because they take in a lot high fat foods due to change of dietary environment. Therefore, a regular life and dietary intake of low-cholesterol food are required. Especially, it is necessary to abstain from eating food containing saturated fatty acid. Subject D (male, 22 years old) cooperated in this study. He is a single household. Subject B and C are not single. Monthly averages of weight, number of steps and fat for four months are indicated in Figure 12. The number of steps is relatively low and the value is 4,000's except for the one in September (6,000's). Therefore, it is considered that the value of fat increases in October. Monthly changes of the standard deviation (σ) of three vital signs on subject D are expressed in Figure 13. The number of steps becomes higher, but the standard deviation is not so large and the variation of steps is low in September. The one for fat is large, namely it is thought that the contents of his meals varies every day. Monthly coefficients of variation (cv) are plotted in Figure 14. Different kinds of parameters can be compared with the same standard. The cv for weight is small and the one for fat is larger in September and October. It is thought that his food appetite increases at that time. The weather cools in autumn and stimulates one's appetite. It is also thought that there is an irregularity in taking in food because he is single household. On the other hand, three cv characteristics (weight, fat and metabolism) on subject B are plotted in Figure 15. He is a married man. There is a small fluctuation in the characteristics. There is a difference in Figures 14 and 15. The cause does not become obvious in this study. It is thought that there are age differences and dietary habits as the cause.

4. Conclusion

It can be felt positively that the number of steps is effective to understand the amount of physical activity as a result of long-term measurement of many vital signs. It can be easily measured and is non-invasive. Subjects could measure the number with strong motivation and had a strong incentive to maintain their health. There are many wearable sensors which can detect various kinds of vital signs with the progress of ICT technique, but subjects do not use them if they could not understand the availability for health. Measuring steps-number is fruitful to maintain their health and understand the life-style. Family members also feel secure by measuring the number of steps. In the future, it is necessary to evaluate comprehensively the health degree using plural sensors if effective devices for sensing vital signs could be developed. The number of steps and other vital signs are measured in this study, but the relationship among the data could not be clarified explicitly. Walking is related to human lives and health management. If the steps-characteristics for the community residents could be understood, health monitoring for the community will be constructed. The system can survey comprehensively the health conditions for the residents. It is effective for the aged especially. The survey system for the aged without an invasion of privacy is important in an aged society. The number of steps is a specific index for health management. In the future, the study on high-level evaluating procedure for community residents (especially elderly persons) will be carried out using various kinds of vital signs.

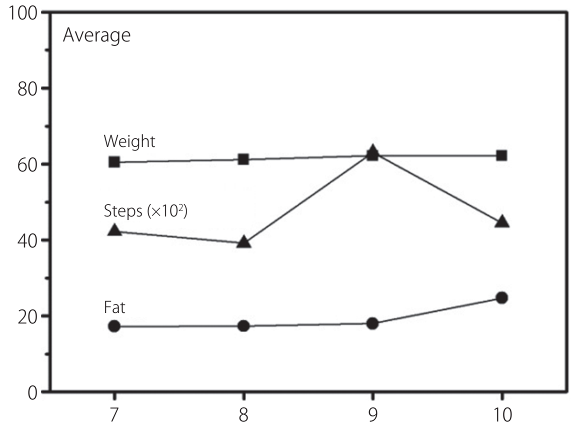

Figure 12: Monthly average characteristics of three vital signs on subject D

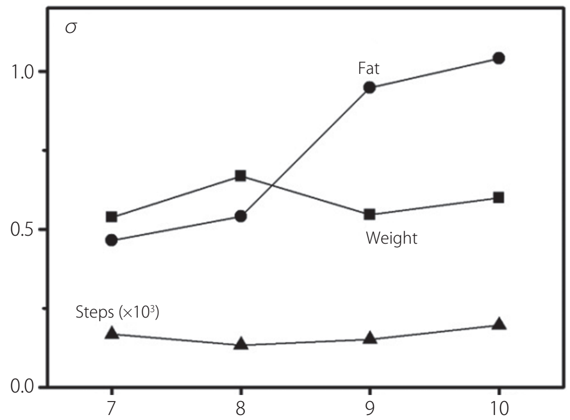

Figure 13: Monthly characteristics of standard deviations for three vital signs on subject D

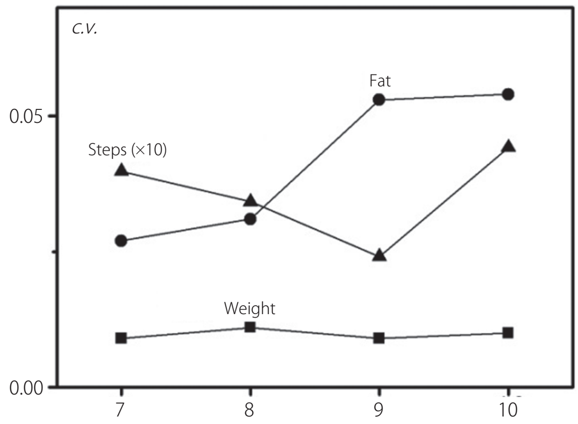

Figure 14: Monthly characteristics of variation coefficient for three vital signs on subject D

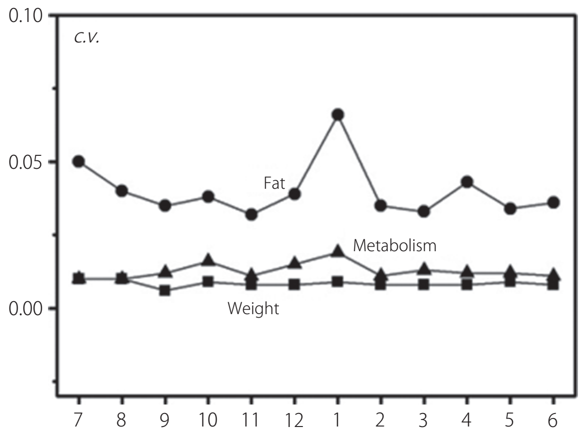

Figure 15: Monthly characteristics of variation coefficient for three vital signs on subject B

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