Original Article

Health care by walking in an aging society and encouragement for tourism

Takashi Oyabu (Nihonkai International Exchange Center, oyabu24@gmail.com)
Haruhiko Kimura (Komatsu College, hkimura@komatsu-c.ac.jp)
Aijun Liu (School of Foreign Languages, Dalian Polytechnic University, liuaijun_dl@126.com)

Abstract

Along with the economic development, aging of the population and declining birthrates are progressing in some Asian and Western countries. It is becoming difficult to manage the social security system (mainly pensions, medical and long-term care). The extension of healthy life expectancy and the improvement of labor force participation rate of the elderly can be proposed as a solution. The willingness to work and thirst for knowledge of the elderly will be increased by going on a journey and enjoying a sport game. It is said that walking has a high effectiveness for the extension of healthy life expectancy. Walking is a basic action in sport and trip. In this study, an early elderly person is adopted as a subject and the changes of biological information due to walking for 3 years are summarized. It was obvious that walking made a contribution to his health maintenance and the muscle mass was conserved. The number of steps was counted every day using a pedometer. He felt fatigue when the number exceeded 14,000 steps a day and the average number was about 9,000. Therefore, it is thought that the limit number of steps is 12,000 a day. It is necessary to maintain the limit while on a journey. Walking can develop one's muscle. The circadian period and weekly periodicity of the number of steps were also investigated. It could be examined using the characteristics whether the subject had the usual life or not. In this study, subjective person is only one. However, the purpose of this study is to establish a health care system for the elderly by walking using information technology (smart phone, Wi-Fi and wearable device etc.). The limit steps-number during travelling was evaluated to go on a pleasant journey. It is thought that the result of this investigation could become a kind of guideline for aging society.

Keywords

walking, number of steps, aging society, health care, tourism

1. Introduction

The rate of aging people (the rate of 65 years old or older) in Japan accounts for over 26% and it is the highest rate in the world. Italy and Germany follow Japan. The number of elderly people is estimated at 33 million and has a tendency to increase. The numbers of elderly people who live alone and the household for elderly couple are increasing [Cabinet Office of Japan, 2015]. It is difficult for the elderly to evacuate from various kinds of disasters because the family members who take care of them do not live together. It is an important issue to construct a social environment where the elderly live a life worth living happily. It is also a common issue shared by Japan, China, Korea and Taiwan in Asia. The rate of aging for Asian countries except Japan is less than 15 % now but the aging population is increasing at the high ratio. Japanese measure will be one of model. It is necessary to support the aging society as a business model constructed in Japan. The cost of social security is about 120 trillion yen in Japan and over one third is the medical expenses. The social-security system will fail in this situation. It is necessary to increase the rate of workwomen and aged workers.

The society in which the elderly could work in a safe and healthy manner should be established. Various kinds of health managing apparatuses are in the market. A very large number of apparatus uses information technology (IT). However, the elderly are not familiar with them. It is a future consideration to develop the cheap and elderly-friendly equipment. The elderly will have an interest in health management by using the apparatus and keeping their good health. They will be also willing to work. Walking is useful for keeping their good health. The most of life styles related to diseases could be prevented by the muscle enhancement through walking. In this investigation, long-range vital data for over three years are introduced as a walking effect and the characteristics are described.

2. Health management apparatus

It is required for the elderly to form the habitual walking to extend their healthy life expectancy. It is also necessary to solve the various issues on the aged society with advanced technology. In recent years, the elderly who are interested in the management of their health are increasing, and they can measure noninvasively the following items (biological information) using IT apparatuses, namely blood pressure, pulse, blood flow and offal fat. The basic vital signs (biological information) are blood pressure, pulse, body temperature, breath and consciousness. There are many measuring sensors for the first four items. It is difficult to develop a sensor which can detect the consciousness. Invasive sensor is also used unusually. Smart phones incorporated with various sensors have been spreading through the market in the world, and a system which can automatically measure the vital signs using the phone is already developed and the data is processed in a cloud system.

It is necessary to develop an aged friendly system on health management in Japan. The percentage of the aged population of Japan is the highest in the world. Many managing devices are developed and commercialized. Some systems are conducted as a business model. The apparatuses are popular with

the years of adolescence (15-30 years old), late middle (31-44) and middle (40-64) ages rather than the elderly. These ages tend to use a smart phone than PC. However, they will become elderly person after several decades and utilization percentage of smart phone will improve moreover. A smart phone has the same functions with PC and can connect to the Internet. The user having the phone can receive various service related to GIS (Geographic Information System) information. The information is named "G (Geographic) space information" in Ministry of Internal Affairs and Communications of Japan [Council for the Promotion of G-space × ICT, 2013]. The utilization of G space information and ICT will become a trend in the branches of safety management and health.

Recently, IoT (Internet of Things) is also utilize widely, which can manages all things through the Internet using a smart phone. The technology means a goods and system with added value. Of course, it includes the health care field and makes the conditions of one's life more abundant. It is essential to acquire various information using artificial intelligence (AI) for maintaining healthy condition. AI is developed from obtaining knowledge to thinking hard, and creates business opportunities.

Various sensors are developed to measure the health management factors and the sensors are wearable basically. The data could be measured by means of an on-line system in many cases and stored in a cloud system. The system can counsel on individual life style. The consumed calories can be derived by putting in person's step size. The utilization of robot in which AI is incorporated, is required strongly. Robot will play an active part vigorously as a communal life person and give various suggestions to the elderly. The image of a living with robot is indicated in Figure.1. It can give appropriate directions when the elderly have a disaster or meet with an accident.

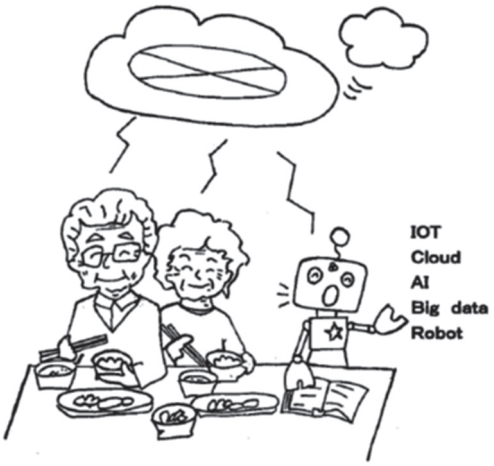

Figure 1: The life of the elderly monitored by a robot

3. Exercise for health maintenance

Body condition, habit and taste vary between individuals. There are various exercises for keeping good health, and walking is essential. Intake energy is consumed by exercises including walking. Person becomes overweight when intake energy is higher than the total energy consumption, and the probability to lead to lifestyle disease (high blood pressure, diabetes) becomes higher. Walking is effective to keep good health and health promotion. It uses every muscle of the body and is an aerobic exercise. Continuous walking is recommended for the elderly. Over-exercise is strictly prohibited. Muscle can increase with no connection to age and the basal metabolic rate also increases. Muscle development is good for the prevention of colds and contributes to reduction of medical expenses. The pattern of walking differs depending on age and physical condition (height, weight). Ministry of Health, Labour and Welfare of Japan guides the elderly to walk for over 20 min per day habitually. There is a negative correlation between the number of steps and the number of deaths by lifestyle-related illness [Ministry of Health, Labour and Welfare, 2014]. Therefore, it is necessary to prepare a social environment for the elderly to go out and encourage their walking. There is also an effect by continuing walking in a group. It helps the raise of motivation for walking. It is also necessary to understand the vital signs and the amount of exercise along with the geographic space information in the open air. An evacuation route could be indicated in disasters (volcanic eruption, earthquakes and tsunami). It is considering to incorporate the elements like a PC game, which is called "gamification". Quick action is necessary when we take into account Japanese social environment. The Social Security system could fall into a negative spiral when the action is not introduced.

4. Characteristics of the number of steps

A huge economic effect is expected when many elderly people walk continuously. However feeling of fatigue and emotional unstableness in addition to damage of bodily function are induced by over walking. The aged take time to recover from their strain and it is necessary to manage oneself regularly. It is important to understand the appropriate factors including steps-number and physiological conditions. A health care system matched to each person can be constructed using ICT. A healthy aged person was adopted as a subject in this investigation. The characteristics of steps-number and physiological data are collected using some devices on the market. The subject is just one person. The characteristic could not apply to many elderly people, but it is useful.

4.1 Experimental

A subject (64 years old at the start of this experiment and now 67, male) was adopted and the various kinds of data were measured over three years. The following vital signs were measured at bed time except feeling and weather. The items were measured at the hour of rising. The feeling was evaluated on a scale of one to five; namely five means the most comfortable. The maximum and minimum temperatures of the day were also recorded at bed time. Measuring items are shown below.

- Weight, body fat, basal metabolism, body age, muscle mass, muscle score, visceral-fat level, estimated bone mass
- Maximum and minimum blood pressures, feeling at the time of rising, number of steps
- Maximum and minimum temperatures, weather at the time of rising

The vital signs can be recorded automatically in a cloud system [Research institute for body, 2016]. Measuring devices and communication equipment used in this experiment are shown together in Figure 2. The vital signs are recorded using two pedometers (TANITA: Tn-Link, FB-723 and omRon Calori Scan HJA-401F), body composition meter (TANITA: Tn-Link, BC-503) and blood pressure manometer (TANITA: Tn-Link, BP-301) [Oyabu, 2015; 2016].

Figure 2: Apparatuses used in the experiment

4.2 Results and discussion

4.2.1 Circadian characteristic of steps-number

A circadian characteristic of steps-number is shown in Figure 3. The subject walks about 115 steps per min at the time of walk. The number of steps for one hour reaches 3,000 at the morning walk. Human biological age is also shown in the figure. The age becomes higher at the times of rising and going to bed. It becomes lower in the daytime in which the subject is active. The cumulative distribution characteristic is shown in Figure 4. The number increases at the morning walk and does not increase at lunch time. It increases again in the evening. The characteristic differs depending on individual life style and the day of the week. It can judge from the characteristic whether the subject leads a normal life or not. Long-term characteristics of steps-number are shown in Figure 5. Each plot means monthly average. The characteristic of the third year is slightly higher than other two years and the ones bottom out in January. The number is from 8,000 to 10,000 steps and the standard deviation is 2,000 to 3,000 steps. The number has a maximum value in April and May after cold season and is about 10,000 as an average. It is necessary to increase the steps-number in winter. The recommendations of steps-number are 8,500 for male and 8,000 for female, which are introduced by Ministry of Health, Labour and Welfare of Japan.

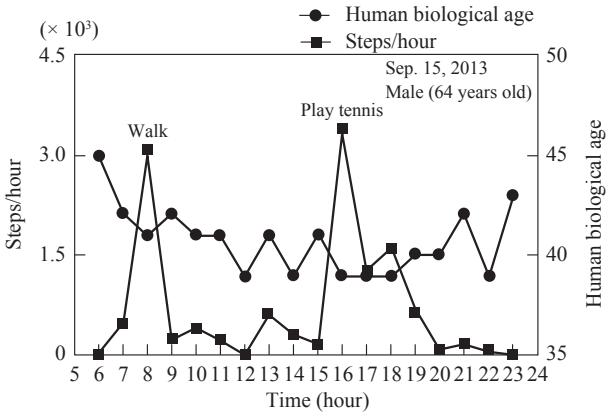

Figure 3: Characteristics of steps-number and human biological age measured every hour

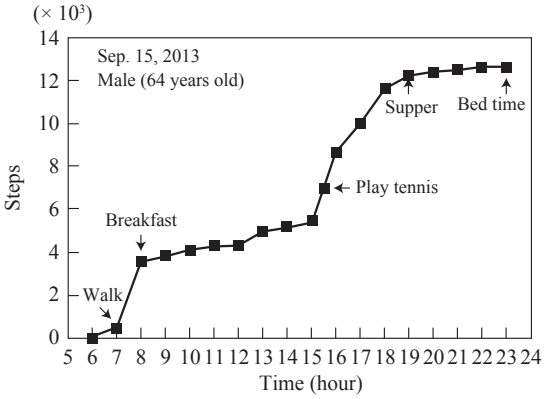

Figure 4: Cumulative distribution of step-number

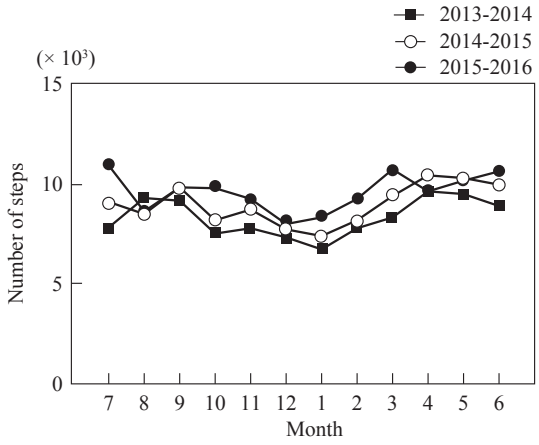

Figure 5: Long-term characteristics of monthly average of steps-number

4.2.2 Long-term transition of biological information

Many kinds of biological information can be measured every hour but it takes a cost to arrange and extract the features. It is necessary to narrow down the data by surveying many people, for example in the region. Figure 3 indicates that the character-

istic of steps-number is effective to understand their activities. Long-term biological information of the subject is indicated and advisability for health management is examined in this experiment. It is thought that a value-added suggestion could be derived by combining the steps-number with the other biological information. This is a future consideration and there is a possibility to create a new service.

The subject is a common office worker. Office workers have a tendency for lacking exercises. A risk of diabetes decreases by walking [Dwyer, 2010; Ratey 2008]. It is reported that walking has effects on health promotion and improvement of exercise function [Takato, 2003; Nomoto, 2010; Kajiwara, 2016]. The subject frequently plays tennis on holidays. The weight characteristic corresponding to Figure 5 is shown in Figure 6. The third year is lower than the other two years. It is about 66 kg. It is thought that the weight becomes lower due to walking. The standard deviation is about 0.4. The fluctuation is low. The subject did not become ill and was healthy according to the hearing investigation. The characteristic of body fat is shown in Figure 7. It is lower than the other two years. There is a tendency that it has a peak in September. The recent standard deviation is about 19 (%). The characteristics of blood pressure

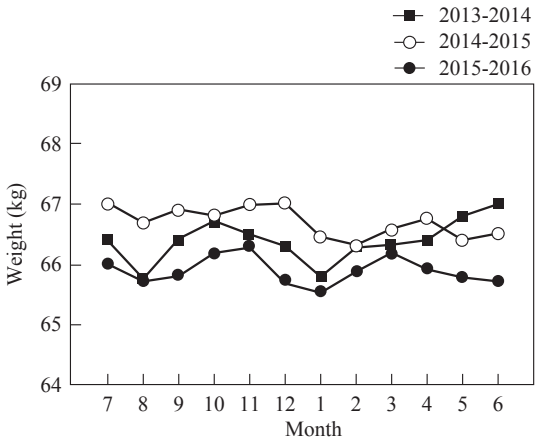

Figure 6: Long-term characteristics of monthly average of weight

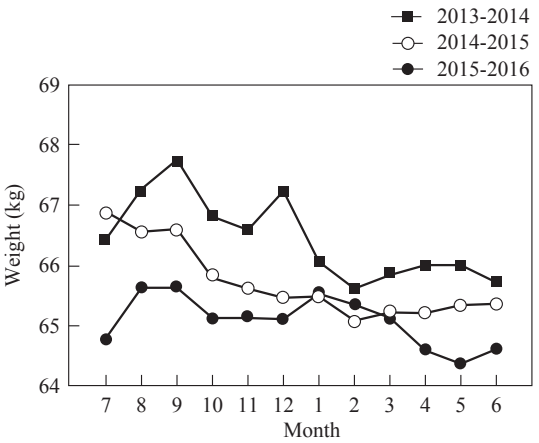

Figure 7: Long-term characteristics of monthly average of body fat

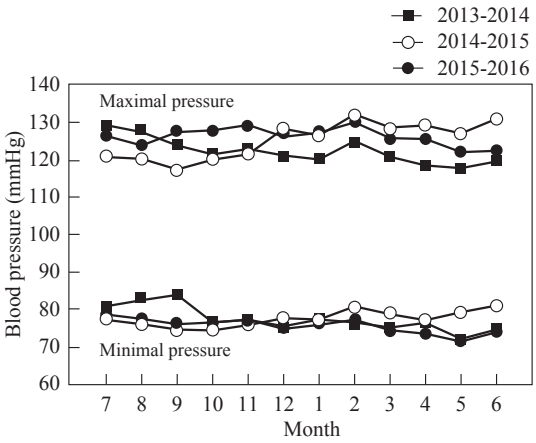

Figure 8: Long-term characteristics of monthly average for blood pressures

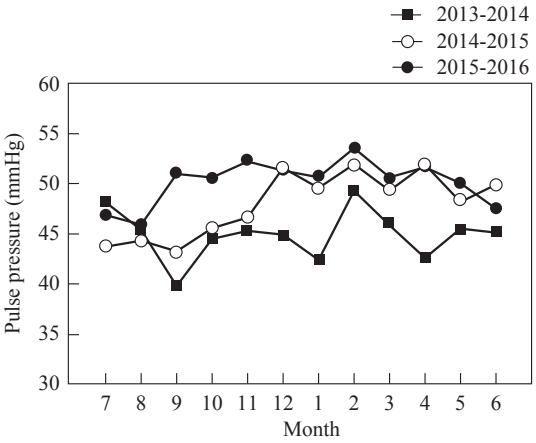

Figure 9: Long-term characteristics of monthly average for pulse pressures

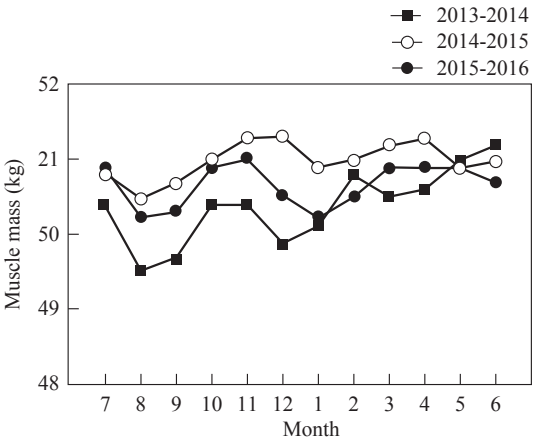

Figure 10: Long-term characteristics of monthly average for muscle mass

are expressed in Figure.8. Maximal pressure is about 125 and minimal pressure is about 75. Both pressures in the second year are higher than the others. There is a tendency that the maximal pressure increases in February which is the coldest month.

Healthy blood pressures are that the maximal pressure is under 130 and minimal pressure is under 85 mm Hg according to the guideline of Japanese Society of Hypertension. However the guiding values are 140 and 90 mm Hg respectively in the case of the elderly. The values of the subject are in the appropriate range and it may be said he is healthy. Characteristic of pulse pressure (maximal pressure–minimal pressure) is shown in Figure 9. It increases due to arteriosclerosis and is preferably between 30 and 50 mm Hg. It is necessary to take care when the one increases over 70 mm Hg. The subject has about 50 mm Hg. It becomes higher with age and in February. Muscle mass is measured and the characteristics are shown in Figure 10. Muscle mass includes a skeletal muscles, smooth muscle and body water in this paper. It is only a guiding index and not correct value. The characteristics show lower values in August and January.

Two pedometers (TANITA: Tn-Link, FB-723 and omRon Calori Scan HJA-401F) are used in this experiment. The former was used for over three years and the later was used for about two years. The latter pedometer can measure an aggregate consumed amount and physical activity in addition to the number of steps. The amount (kcal) increases in recent year. It

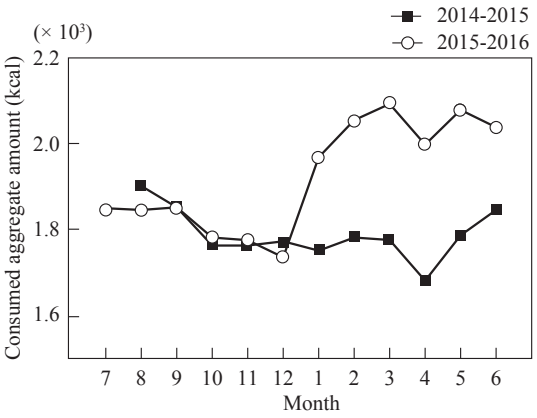

Figure 11: Long-term characteristics of monthly average for consumed aggregate amount

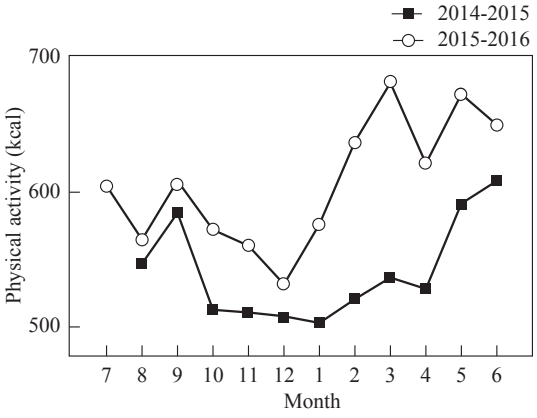

Figure 12: Long-term characteristics of monthly average for the physical activity

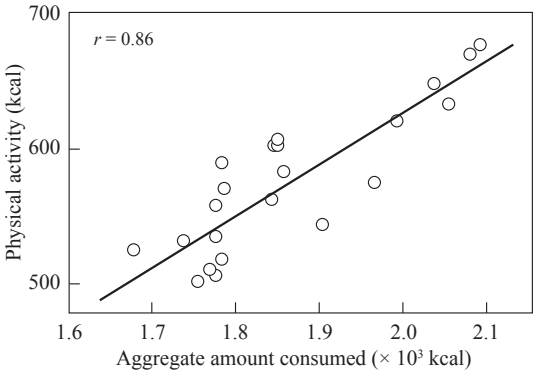

Figure 13: Correlation diagram between aggregate consumed amount and physical activity

is shown in Figure 11. Basal metabolism is about 1,400 kcal for 50 to 69 years old (when weight is 65 kg) and is 70 % of aggregate consumed amount; namely the metabolism by exercise and the life accounts for about 30 %. The physical activity is shown in Figure 12. The activity is also increased in recent years. It can be understand that the subject is excising considerably. It has a same tendency with the characteristic for the aggregate consumed amount. The correlation diagram between Figure 11 and Figure 12 is introduced and the characteristic is shown in Figure 13. The correlation coefficient r is 0.86. The value is very high and there is a high correlation relation. There is also a high correlation between the number of steps and physical activity, and the coefficient is over 0.85 [Oyabu, 2016].

4.2.3 Consideration for experiment

It is thought that the physical activity of the subject could be measured using number of steps according to the long term experiment over three years. Many biological information were measured concurrently in this experiment. The number can be understood noninvasively and easily. The motivation for walking was increased by understanding the daily steps-characteristic. It is possible to judge as a whole whether the subject is fine or not. In future, various kinds of sensor signals regarding biological information will be adopted in addition to number of steps. In this section, health care is investigated using steps-number and biological information. Walking strongly leads to health care and is essential for our survival. Ministry of Health, Labour and Welfare of Japan indicates the target steps for each generation. The subject felt that measuring the number was effective for health care and it improved the motivation. It is effective to construct a system which can survey the health care and living conditions of the elderly. The number of steps can be thought as an index to judge the health and physical activity, and the system will become as a model in the aged society.

5. Wellness tourism

The healthy elderly are full of intellectual curiosity and active. They sometimes go for not only domestic trip but also overseas travelling, and are strongly interested in world her-

itages and historic sites. When they go for a trip, they visit the sites in a group or couple rather than alone. Because they understand the risk for their health when they travel alone. There is a possibility to cause a disease and injury while on a journey. Therefore, it is necessary to pay close attention. Walking is essential even in a museum and maximum steps-number has to be understood. The walking over the number becomes the cause of fatigue and injury. The travel schedule should be matched to the most vulnerable person in a group tour. It took about 14,000 steps per day when the subject visited the Great Wall of China and it was a hard exercise for him.

The subject participated in the Dalian Walk on May 22, 2016. Dalian belongs to Liaoning and is a center city in the area. The characteristic of the steps-number every hour is shown in Figure 14. Walking time was about one hour (12:00-13:00) and the participants walked gently. The event was suitable for an exchange of the aged. The total number was 11,700 steps and the number of steps during the event hour was about 4,000 (66 steps/min). The value is considerably low compared to the number of usual morning walk (115 steps/min). The following items were given as the points to keep in mind by a hearing investigation.

- Understand the number of steps clearly during trip
- Avoid long hour trip (don't leave a fatigue)
- Lie down for over eight hours
- Walk gently without strain (under 115 steps/min)

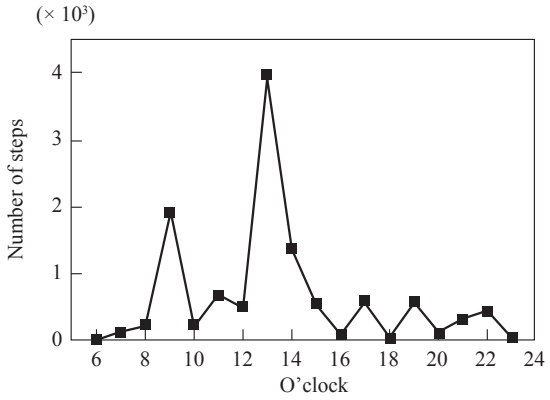

Figure 14: Characteristic of hourly steps-number in the day of Dalian Walk

6. Utilization of ICT

Social involvement and contributions by the elderly are desired. It is reported that the real consumption expenditure per senior citizen (60 or over) household accounts for 50% of personal consumption [General for Policy Planning of Cabinet Office Japan, 2015]. There is a difference of 70,000 yen (about $670) in living expenditures between the elderly working and non-working households. For the revitalization of regional economies, it is necessary to develop the social environment in which women and the elderly can be active. It is an urgent subject for this reason and the elderly should go out positively. Various kinds of risks (injury, accident and disaster etc.) may be caused when the times of going-out increases. Therefore, it is also necessary to understand the geographical information (G information) in addition to biological information of the elderly. It is obvious that multifunctional measuring instruments (sensors) linked with a smart phone will evolve. The following techniques will be also evolved such as cloud system, IoT, big data, AI and robot. New business will be constructed by merging these technologies. The system should be understood and used easily by the elderly. Moreover, it should give proper instructions to them. Utilization of ICT with G-information is a pivot to organize an age-friendly society [Ministry of Internal Affairs and Communications of Japan, 2016]. The role of sensor is important in the system and the development of the reliable ones is essential. For the elderly, a service with additional value is expected by fusing the information from chemical, physical and bio sensors. Social environment in which the aged can go to work willingly is required.

7. Conclusion

A fundamental factor for health maintenance is walking, but it is difficult to continue it alone every day. It is better to set a target steps and walk together as a group in the area or vicinity. A reward (card points, shopping ticket and facility usable ticket etc.) is effective at the attainment of the target. The cost is cheap compared with the one for national social security of the elderly. In total consideration of the published data including the one in this experiment, the elderly could maintain their own health by the combination of 6,000 steps every day and moderate-intensity activities for 15 min. The intensity means that the subject can walk somehow with a conversation. The value is not absolute and there are individual differences.

In the case of the subject adopted in this investigation, the reasonable number of steps is about 8,000 to 9,000 per day from the experience for three years. When the number exceeded 14,000 repeatedly on the weekend, he had a fatigue for three days (Monday to Wednesday). He did not feel fatigue when the number was below 12,000 (85 % of 14,000 steps) while on a journey. Walking tour with harmonious friends for about one hour is effective to achieve the target steps. There is a moderate steps-number in accordance with the individual's physical condition. Too much walking is not good for the aged. It is thought that the aged can maintain their own health and gain a muscular strength through moderate walking steps. A trigger for regional revitalization could be obtained by walking.

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