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A Study on Effective Support of People's Daily and Working Life in Ageing Society

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1. Introduction:

The demographic change by population ageing has become an increasing concern, leads the world into uncharted ways. This change has a current and long-term effect across all aspects of society, such as economics, social development, and sustainability. As the augmented older adults increase, the required resources that society needs surge, and every community sector hold some of these burdens. Population ageing and low fertility rates result in a shrinking the youth workforce. Therefore, in an ageing society, like Japan, older adults need to be healthy to effectively contribute to the work market, prolong their working life, lower care expenses, lower their dependency, and enhance their living conditions. In addition, youth need to follow a healthy lifestyle for non-communicable diseases (NCDs) prevention and health investment for their coming future. Therefore, promoting physical activity throughout life may benefit the present and the future of an ageing society. In addition, changing work policies to increase the employability of older adults appears useful for future economic growth and positively impacts the lives of the elderly. Squander older workers' expertise, ability, and experience by not employing them may adverse society development, not only economics.

1.1 The objectives:

This dissertation focuses on ageing society issues in multiple aspects, i.e., employment, safety, and daily life. The dissertation theme is providing effective support to people in an ageing society within two practices. The first practice is related to support daily life through promoting physical activity. The other one is to support working life, i.e., employment policies and safe work procedures. Thus, there are overall three objectives in this dissertation. The first objective is to enhance the daily physical activity of the elderly by using personal wearable monitoring technology. Because of the current young persons will be the future ageing population. And the geriatric society conditions are expected to be more critical when the current youth generation will be elderly. Therefore, the second objective is to promote daily physical activity for present young persons by increasing their health awareness using wearable technology, contributing to their future health. The final objective, related to support working life, is to investigate the accident risk of older adults and define the influential factors on their safety. Four topics cover these objectives:

I. To promote daily physical activity by using continuous real-time feedback of the personal health and activity indicators. To this end, we conducted a 12-week trial on elderly persons who wore wearable activity trackers in their daily life. We investigated the impacts of activity self-monitoring on the elderly's awareness of physical activity and health-related issues. We also determined the effect of self-monitoring on their physical activity level.

II. To promote the habituation of physical activity with young persons in an ageing society by increasing their awareness of physical activity and health-related issues. We supposed that self-monitoring might positively impact their awareness of physical activity and health-related issues, and this increased awareness contributes to higher motivation for physical activity, then in turn to more physical activity. For this purpose, we conducted a 12-week trial on young people who wore wearable activity trackers during daily life. We investigated the changes in the youth's awareness of physical activity and health. We also explored their physical activity level trends.

III. Since there is still a variance in the acceptance of technology and the activity-health consciousness between young and elderly persons, we compared the impact of using self-monitoring technology between young and older people in the trials mentioned above (I and II). We aimed to determine differences in behaviour, motivation, and awareness between young and elderly persons when using wearable activity trackers.

IV. To support people working life, we investigated the age-related safety in one of the most demanding professions, i.e., truck driving, under the background of truck drivers' shortage in an ageing society. As a result, we extracted a guide for employment policies in the trucking industry. Furthermore, we defined the factors that may affect their driving safety, linking the accident involvement with individual driver attributes and task attributes from the drivers' age point of view.

2. Supporting daily life: Activity self-monitoring impacts among senior persons under covid-19 pandemic

This study aimed to explore the impact of self-monitoring by activity tracker on the elderly's awareness of physical activity and health-related issues when getting real-time feedback from activity trackers during the COVID-19 pandemic. This feedback may positively impact the

elderly awareness of physical activity and health as well as activity behaviour, e.g., the daily activity goal achievement.

2.1 Method

Thirty Japanese elderly persons with no mobility disorders participated in this trial. The mean age was 71.7 years ranging from 67 to 75 years old (SD: 2.0). They were requested to wear a wearable activity tracker any time during the day, including sleeping time for 12 weeks.

Three questionnaires were developed in Japanese to survey the participants' views at several time points. (1) General questionnaire: To capture a participant's overall conditions before and after the trial as self-reported status, it comprised 13 questions on a five-point Likert-type scale. We asked the participants in this questionnaire about physical activity levels, health, willingness to monitor activity using the tracker and life satisfaction. (2) Weekly questionnaire: To measure the participants' awareness toward physical activity, health-related issues, and activity self-monitoring every week. This questionnaire included 20 questions on a 7-point Likert scale. (3) The effect of COVID-19 pandemic: We asked the participants whether the COVID-19 pandemic changed their daily routine and the approximate date of that change. In addition, it included 16 items about the psychological and psychological effects of the COVID-19 pandemic on a 5-point Likert scale.

We applied a principal component analysis (PCA) to all the participants' responses to the weekly questionnaires with the varimax rotation. Four principal components were elicited with 63% of the cumulative variance: Perception of physical activity benefits, satisfaction and enhancement of self-monitoring, willingness to check self-monitoring and sleeping feedback, and commitment to physical activity. In the same manner, a principal components analysis was applied to the participants' responses to the COVID-19 impact questionnaire. Three factors were elicited from the 16 items with 54% of the cumulative contribution: The necessity to maintain the activity level, the importance of self-monitoring, and reducing the negative impact of the pandemic on daily life. The participants were asked to wear the tracker any time possible, except taking a bath or charging time. We used the number of steps, the number of floors, and activity calories as physical activity indicators. The daily goal was set to be 6500 steps/day.

2.2 Results

There were no significant changes in the general questionnaire items between the pre- and post-trial except one item. There was a tendency to increase in the participants' health confidence ($p < 0.1$) at the end of the study (33%) comparing with the start of it (10%). For the physical activity indicators, very few participants had an increasing trend in the number of steps (7%), the number of floors climbed (10%), and activity calories (7%). In contrast, one-third of participants (33%) showed a decreasing trend in the number of steps. In contrast, many participants had increased trends in the awareness factors. An increasing trend was seen in the willingness to self-monitoring (53%). The participants increased their perception of the physical activity benefits on physical and health status (40%). For the satisfaction and enhancement of self-monitoring, the number of participants who increased (27%) was slightly higher than those who decreased (20%). More participants had an increasing trend (33%) than those who had a decreasing trend (17%) in the commitment to physical activity by self-monitoring. There was a high number of participants who completed their goals during the trial. Half of the participants achieved their goal for 11 weeks or more. Considering the recommended number of walking steps, i.e., 6500 steps/day, 73% ($N = 22$) of the participants walked 6500 steps or over in the last two weeks of the study. There was a slight decrease in the number of walking steps for 41% ($N = 9$) of the participants; the same number of participants had no effect of the pandemic on their number of walking steps. In addition, the majority of the participants (77%) concurred with the importance of monitoring activity during the pandemic. Half of the participants (50%) confirmed that it was necessary to maintain the activity level.

2.3 Discussion

Overall, there were more increasing trends than decreasing for all the awareness factors. Many participants increased their perception of the physical activity benefit on physical and health status. Also, they raised their willingness to self-monitoring by checking the activity tracker feedback. In addition, they increased their commitment to physical activity by self-monitoring. The usage of the wearable tracker may positively impact the elderly's understanding of the significance of daily exercise and activity monitoring. It also increases their awareness of adherence to physical activity in everyday life. The increased awareness of the commitment to physical activity may be reflected in the competence of the activity goal, as many participants

completed their goals during the trial. Since the wearable activity tracker provides the user with real-time feedback of his/her physical and biometric state, it may be helpful to maintain the recommended level of activity during staying at home. The participants' walking steps decreased by a small percentage (11%) after their daily routines were changed due to the pandemic effect. The feedback of the self-monitoring helps the elderly to maintain a certain level of physical activity to improve health, especially during non-normal conditions.

2.4 Conclusions

Providing wearable trackers for elderly persons in daily life can promote their healthy lifestyle and increase their awareness of physical activity and health-related issues. In addition, the activity goal feature, which is included in the tracker, can help the elderly maintain the recommended level of physical activity effectively during an unexpected situation such as the COVID-19 pandemic. Healthcare organizations should promote wearable trackers among senior citizens to improve their health and reduce the adverse effects of the COVID-19 pandemic. It is essential to deliver the wearable monitoring technology to the elderly and help them while using it by designing a system to monitor the elderly data and respond to their questions and inquiries related to tracker usage. Social and public health programs should be established to benefit from using advanced monitoring technology among the elderly in the ageing society.

3. Supporting daily life: The effects of self-monitoring physical activity on the awareness and behaviour of young people

This study aimed to uncover the self-monitoring impact with real-time feedback on university students' awareness of physical activity and overall health status perceptions and explore the physical activity trends. To achieve the objectives, we explored the individuals' awareness changes and physical activity trends through the long-term use of wearable activity trackers in the real-life setting. Further, we examined the individual human-related factors that affect the changes in awareness and activity level.

3.1 Method

Thirty-six participants with a mean age of 22.4 years, ranging from 20 to 25 years (SD: 1.30) were included in this study. Similar to the previous study, two measures were used to

assess participants' views at several time points during the trial. (1) General questionnaire captured the participants' overall conditions before and after the trial based on self-report. It was composed of eight questions about health status, physical activity levels, and willingness to monitor activity using the tracker on a 5-point Likert-type scale. (2) Weekly questionnaire captured the participants' awareness of physical activity. It included 20 questions on a 7-point Likert-type scale. We applied principal component analysis (PCA) with varimax rotation to the entire weekly questionnaire sample. Five dimensions were elicited with 63% of the cumulative variance: Perception of physical activity benefits, satisfaction and enhancement of self-monitoring, willingness to physical activity self-monitoring, willingness to sleeping self-monitoring, and commitment to physical activity by self-monitoring. Each participant was asked to wear a wristband-type activity tracker during the 12-week trial term, including sleeping time. They could remove the tracker only for charging it or while taking a bath. The tracker's default daily goal setting was 10,000 steps/day. We used the number of steps and the activity calories as physical activity indexes.

3.2 Results

There were significant differences in many general questionnaire items between the pre- and post-trial. Slightly more participants decreased their confidence of health condition (22%) compared to the start of the trial (28%). The agreement percentage of the necessity of physical exercise was higher at the end of the trial. They were conscious that they should have done more physical activity than what had done (86%), and they acknowledged the importance of finding more time to exercise (72%). There was no increasing trend in participants' physical activity and fourteen participants (39%) did not meet their number of steps goal in the trial period. Regarding the awareness factors, more participants had a decreasing trend in the following three factors: satisfaction and enhancement of self-monitoring, willingness to physical activity self-monitoring, and willingness to sleep monitoring.

3.3 Discussion

We assumed that the feedback of the wearable tracker would positively impact youth awareness and results in more physical activity levels. Contrary to the assumption, there were very few positive changes in the participants' understanding of physical activity and health-

related issues. University students are unaware of their own risky behaviour and regard themselves as healthier than they really are. Many participants showed no change in awareness of physical activity contribution, activity enhancement, or the condition inhibiting them from exercise. There was more negative change than positive one in participants' awareness of willingness to monitor physical activity and sleeping time. The tracker and its application may be cumbersome or stress the participants. Besides, in the participants' self-reported state, slightly more participants did not want to use an activity tracker after the trial.

3.4 Conclusions

The results suggest it may not be adequate to rely on advanced technology and real-time feedback to enhance youth awareness of physical activity. Neither to achieve physical activity habitation and then to prevent related chronic diseases in the future. Young university students need to be involved in education programs to raise their awareness of physical activity and the inactivity adverse impacts on health. Public organizations should establish effective programs to educate the youth about the future implications of the habituation of physical activity at a younger age. The awareness toward a current and future healthy lifestyle needs to be promoting among youth in the media and press. Youth current physical activity should take high priority on the health future planning in the ageing society.

4. Supporting daily life: The different effects of activity self-monitoring between young and older people

This study aimed to determine differences in activity behaviour, motivation, and awareness between youth (20s years old) and older (70s years old) people when they wear wearable activity trackers.

4.1 Method

We compared the activity tracks effects between young and elderly from the studies mentioned in chapter 2 and 3. Both age groups followed the same tracker wearing instructions. To measure the awareness of physical activity, self-monitoring, and health-related issues, the structure of the elderly study was used as a base to compare the awareness perceptions between the youth and elderly respondents.

4.2 Results

As a mean of the six weeks, there was 39% of the young participants' sample (N = 14) did not complete their activity target compared to 23% elderly (N = 7) in the study periods. There was no significant difference in the walking steps between the youth and elderly participants (U = 17857.000, p = 0.163). There were significant differences in the age group's awareness for the perception of the benefits of physical activity (U = 13664.000, p = 0.000), satisfaction and enhancement of self-monitoring (U = 10614.500, p = 0.000), the willingness to self-monitoring (U = 15671.500, p = 0.001), and the commitment to physical activity (U = 12008.500, p = 0.000). Elderly participants were more aware of being committed to physical activity by self-monitoring (Median; Mdn = 4.7) compared to the young group (Mdn = 3.3). The elderly participants were slightly more satisfied with self-monitoring (Mdn = 5.4) than those younger (Mdn = 5.0). In addition, the elderly had higher scores related to willingness to self-monitoring (Mdn = 5.4) and in the perception of the physical activity benefits (Mdn = 6.2) than young participants.

4.3 Discussion

Elderly participants were slightly more tend to complete the activity goal compared with the younger group. In addition, elderly participants had higher scores in perceiving the benefits of physical activity. In addition, they were more satisfied with self-monitoring using wearable sensors compared to young participants. Compared to youth, the elderly persons were more willing to self-monitoring and had higher scores related to the commitment to physical activity. The elderly may realize the positive impacts of physical activity on their health, leading them to be more aware of physical activity, self-monitoring, and health-related issues. The elderly's usage of activity sensors may be purpose-driven by improving health and try new technology. Still, young people do not have those intentions as they think they are healthy and do not need physical activity for their health improvement. Self-health perspective may play an essential role in a person's behaviour and mental changes to adopt a healthier lifestyle.

4.4 Conclusions

Youth may not feel the need for physical activity in their daily lives as they are healthy and do not have chronic diseases. It seems that the activity self-monitoring by wearable tracker

influences elderly who release the need to improve daily life health. These chapter findings highlight the benefit of using wearable technology in health intervention among elderly persons. Public and social organizations need to put plans to encourage the elderly to use wearable monitoring technology, provide them with technical assistance to set up the trackers, and publish related information about the usage and the benefit of activity monitoring. It also recommended offering wearable trackers to senior persons on the government cost to promote the motivation to use activity self-monitoring. For youth, it seems the alarm bells need to ring about the future wellness of society. If the youth activity behaviour is not improved, the development challenge will be more severe in the super ageing society in the future.

5. Supporting working life: Occupational truck driver employment and driving safety in ageing society

In this study, we examined whether older adults have more accident involvements compared with younger age. In addition, key factors contributing to occupational drivers' safety outcomes are identified depending on drivers' age. The goal is to provide information about age-related safety that could guide employment policies in the trucking industry by linking the accident involvement records with the driver's individual attributes and work attributes.

5.1 Method

We collected empirical data from several Japanese trucking companies and then analysed it from the drivers' age point of view. The drivers' data sample included accidents records, individual attributes, and work-related factors for three years, 2015–2017. We explored the influencing factors that affect driver safety based on his/her age to enable the older drivers to work safely. Accident cases were recorded as the number of accidents for which the driver was responsible (injury and non-injury), accidents suffered, and the accident cost. We used only accident cases for which the subject drivers were responsible because the goal was to identify the factors that can affect the driver's involvement in an accident. The analysed driver sample included 306 drivers with a mean age of 48 years ($SD = 9$) ranging from 19 to 76 years old, with 5% female and 95% male. The drivers were dichotomised by age into drivers less than 50 years old ($N = 175, 57\%$) and drivers aged 50 years or older ($N = 131, 43\%$). The aggregated number of accidents for the three years was taken for each driver as a safety outcome measure. Based on

this measure, drivers were classified as accident-free ($N = 204$, 67%) or accident-involved ($N = 102$, 33%) drivers.

The individual driver attributes included age, gender, work experience, penalty points, and driving aptitude test scores. The aptitude driving test was the Japanese National Agency for Automotive Safety and Victims' Aid test (NASVA) by the Japanese Ministry of Land, Infrastructure, Transport, and Tourism. The drivers' NASVA test scores were their most recent records collected from their companies' data samples. The aptitude test includes three main diagnostic tests, each containing several measuring factors with a different evaluation for each factor score rank. The task-related attributes refer to the factors related to performing delivery tasks. Examples of task-related attributes are the percentage of waiting time, vehicle type, gross vehicle weight, driving distance, and annual driving distance.

5.2 Results

No significant difference in the proportion of accident-involved/free drivers was detected by age group, regardless of age group classifications — for example, under 50 and 50 or older ($p = 0.87$) and under 45, 45 to 55, and over 55 ($p = 0.38$).

Exploring factors that influence safety outcomes by age groups, some factors were significant for one age sample and not for the other were identified. For instance, significant effects were observed for some work-related attributes in drivers under 50 years of age but not in the older age sample. For instance, under-50-driver accident involvement was less frequent (19%) in the case of a 10% or less waiting time, while the percentage of accident involvement significantly increased (46%) with higher waiting-time percentages. Gross vehicle weight significantly increased the younger-driver accident involvement from 30% to 45% when the gross weight exceeded 13 tons. Besides, accidents involving under-50 drivers became more frequent in the case of trailer driving (58%) compared with standard trucks (30%), trucks having freezers (33%), and other vehicle types (22%). Regarding the driving distance for delivery, younger-driver accidents occurred more often when the delivery distance was longer than 100 km (45%) compared with the town delivery distance (18%). The exact influence of the driving distance was also found in older drivers' sample but for longer delivery distances. Older driver accidents increased (47%) when the driving distance was longer than 400 km compared within the town (18%), short (26%), and medium (31%) distance for delivery.

5.3 Discussion

In this study, no evidence of more frequent involvement in traffic accidents of elderly truck drivers than that of the younger ones was found. Only two test factors showed a significant influence on accident likelihood for 50-year-or-older drivers: performance accuracy as a factor of cognitive and processing functions and degree of obesity. For instance, lower scores in the performance accuracy-test correlated with increased accident involvement for older drivers. The score in the performance accuracy-test seemed to be a predictive indicator of accident probability for old drivers. Regarding the driver age effect on truck driving safety, fewer factors significantly influenced older drivers than those for younger drivers. From the results, the older driver showed more stability in the work tasks. Among task-related attributes, waiting time, driving distance, vehicle type, and gross vehicle weight influenced younger-driver accidents. Only the driving distance for delivery played a significant role in older-driver accident involvement.

Regardless of age, the managers should consider determining the maximum limit of acceptable driving millage for all occupational truck drivers, e.g., 5500 km/year, and prevent the drivers from exceeding this limit. The number of 5500 km/year is not strict; managers can select the millage limits based on the company working data by calculating the average driving millage of its truck drivers and instructor the drivers not to exceed it. The viewpoint of defining the driving mileage limit is to prevent the overload and fatigue caused if the drivers want to work over his body and cognitive limitations and do not take enough rest. The second factor that can be manage is the waiting time for truck loading/unloading. The driver waits in the truck cab for vehicle loading/unloading. For more driving safety, the managers should optimise the work schedule to prevent prolonging the consumed time for loading/unloading the freight as much as possible. An additional factor that should be deemed is the resting time during the driving distance task daily; it is not favourable for drivers to drive a long distance. Managers need to consider fatigue due to less rest from driving for a long freight delivery distance for all drivers. For safe driving, the work schedule should contain frequent mandatory rest, e.g., 15-20 min to help the driver recover from fatigue. Driving trailer trucks or increase the vehicle's freight by over 13 tons tasks need to consider carefully for drivers of safety managers, especially for young drivers. A good driving experience may be necessary to handle the change in driving characteristics that are imposed by the increase in gross vehicle weight or the vehicle size. The

managers should avoid assigning those tasks to young drivers who do not have good driving experience.

5.4 Conclusions

The current findings can help understand the contribution of age to driving conditions and safety for future studies. Based on the results, the following employment policies are suggested, particularly to older drivers. It is believed that they can be applied to any trucking organisation, not only in Japan but in all highly aged countries. Elderly persons, at least up to 65 years of age, can be effectively employed as occupational drivers. They do not necessarily have a higher risk of driving accidents than younger drivers. Aged drivers seem to have some professional virtues, such as a higher tolerance for difficult working conditions, for example, waiting time and vehicle type. Also, it is recommended that elderly drivers be engaged in physical activity and be educated about the risk of obesity. Deliberate inspection of the penalty points of driving licenses should be required to start employment and be done regularly for elderly persons.

6. Thesis conclusion

6.1 Theoretical and practical contributions

As a relatively new research area, physical self-monitoring studies are growing in popularity. There are primarily two interests in the current wearable activity tracker research: The user experience and the change in physical activity level. In this dissertation's studies (chapters 3 and 4), we explore the effects of physical self-monitoring from the objective physical activity level and the subjective, physiological aspects, highlighting the importance of physical activity awareness on behaviour change. A model of assessment of the awareness toward physical activity and health-related issues was developed by using a weekly questionnaire. This model can be used for future studies.

One of the practical contributions of this research is the insights about supporting daily life with wearable activity technology. That implies for practical implementations, public healthcare and social programs should be placed on the expected benefit from using self-monitoring to improve elderly health. Public health programs by government organizations should be set up to promote the usage of wearable activity trackers among the elderly by

providing the tracker at low/no cost and providing adequate technical support. As such, the findings of the youth case study reveal the urgent need to take actions of healthcare organizations to promote the youth activity level as a long-term health risk prevention strategy. Public healthcare decision-makers should pay more attention to youth lifestyles. Public healthcare policies makers, media, and press should imply educational projects to increase the youth's awareness toward the current and future benefits of activity habituation at their age. Another practical contribution is that older drivers do not pose a higher accidents risk than younger ones. Policy-makers need to adopt new recruiting criteria with age neutralization to offset the young labors shortage to persuade other actors to join the new employment policies of promoting older adults' participation. In addition, promoting physical activity programs by companies for older adults employees will enhance their health and safety. We proposed several management policies for older adults in the truck driving career regarding driving safety. These suggestions not only encourage the managers to keep older adults longer in their work positions but also hire older adults to afford the young workers shortage. It is believed that they can be applied, not only in the trucking industry but in other industries sectors. Older adults seem to have a greater tolerance for challenging working environments, but it was recommended to help them to be physically fit. Older adults who had violence the safety rules need to get additional training to enhance their working safety. Decision-makers should establish working policies that change the traditional view of the elderly as a burden to play an influential role in economic development by their expertise and work attitude. In addition, we suggested that older adults should be promoted to participate in physical activity to improve their health and working safety. Wearable activity trackers can be a promising tool to achieve that. Companies' managers can provide their older employees with wearable physical activity trackers to improve their health and safety performance.

We hope these work suggestions provide effective support for people's daily and working life in an ageing society by helping to promote physical activity, improve older adults' employment, and enhance safety. This work results and conclusions may contribute somehow to shedding light on some practical support of the ageing society. This dissertation represents a useful source of information and suggestion for effective support for people in daily and working life not only for Japan society, but it can be implied in any ageing society.

6.2 Future studies

Future studies are proposed in response to the results and limitations. For the track drivers' study, large sample data is needed with no missing data to study the contribution of all individual and task-related attributes on the safety outcomes. The results suggested another future study; to confirm if fatigue plays a significant role for the Japanese older adults' occupational drivers. Recently, due to the COVID-19 pandemic, there is an enormous growth of e-commerce shopping. The trucking industry faces a challenging situation to fulfil its work obligations. Occupational drivers, especially older adults, in turn, may be confronted with demanding work conditions. Therefore, we suggest a future study about the safety outcomes of older adults' occupational drivers during the COVID-19 pandemic. This proposed study would be helpful to collect the accident records and the weekly work condition report from the trucking company. For the elderly self-monitoring study, we would suggest a future study with a long interval to investigate the effect of wearable trackers on physical activity and health. We would also recommend future research with a wearable activity tracker to monitor the heart rate and biological activity of older truck drives and explore the impacts on their safety performance.

In addition, for improving youth health, a future study with unhealthy participants, e.g., have obesity or diabetes. This future research could benefit the ageing society in enhancing the lifestyle for those youth and decreasing the long-term healthcare costs.