Chapter 3
Health Promotion and Long-Term Care for the Elderly in Rural Areas of Hokkaido, Japan

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Abstract There is a pressing necessity to find an effective means of health promotion, especially, in rural areas of Hokkaido Prefecture, in which local residents themselves can be actively involved. Several epidemiological studies have thus been conducted to grasp a feasible way of promoting health in the area. We found, from the time-series study measured with an accelerometer in Hokkaido, that the average number of step counts, the averages of total energy consumption per day and energy consumption by physical activity per day, and the average duration of moderate and vigorous physical activity were all significantly less in the snowfall season than the non-snowfall season. Therefore, a light-burden and indoor physical exercise program called "Fumanet" exercise, or net-step exercise (NSE), has been developed. From the result of a longitudinal study conducted in Hokkaido, the elderly who participated in NSE classes once a month or more had a significantly lower risk of poor self-rated health 2 years after their participation, compared with nonparticipants. Furthermore, from a result of an 8-week intervention study in Hokkaido, we found that cognitive function assessed by the Touch-M test and gait performance assessed by the Timed Up and Go test were significantly improved by participation in NSE classes among healthy older adults. Our results indicate that NSE offers an option for the older population whose maintenance of cognitive health and gait function require easier methods. In other words, such NSE classes are a feasible method for older people's health promotion in lesser populated municipalities.

Keywords Health promotion · Elderly · Physical activity

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M. Washio, C. Kiyohara (eds.), *Health Issues and Care System for the Elderly*,
Current Topics in Environmental Health and Preventive Medicine,
https://doi.org/10.1007/978-981-13-1762-0_3

3.1 Recommendation of the Net-Step Exercise (NSE) for Health Promotion Among the Elderly in Rural Areas of Hokkaido

There are four seasons in Hokkaido Prefecture, which is located in the northern part of Japan. It snows in winter, and it is thought that as a result of this, physical activity decreases. Consequently, we conducted a time-series study to assess reduction in physical activity in winter (unpublished work), and the results of this study are shown in part in Sect. 3.2.

There are numerous rural areas with low population in Hokkaido. In such areas, health-care services and health science authorities are limited. Accordingly, there is an increased need for an effective means of health promotion in which local residents themselves can be actively involved. Although there is a reasonable number of evidence that higher physical activity promotes individual health, it is necessary to consider forms of physical activity that are easy to perform and less physically burdensome, especially, for the elderly.

Therefore, a light-burden and indoor physical exercise program called "Fumanet" exercise has been developed in Hokkaido [1, 2]. Fumanet is derived from "net" and *fumanai* which in Japanese means to avoid stepping on something. Fumanet is a 4 m × 1.5 m net that is comprised of 50 cm × 50 cm squares arranged in a 3 × 8 grid (Fig. 3.1). One or two persons at a time are required to walk carefully, yet rhythmically, from one end of the Fumanet to the other without stepping on the ropes or being caught in the net. NSE is conducted with groups of approximately ten people each. In this paper, Fumanet exercise is abbreviated to the net-step exercise (NSE). NSE requires the simultaneous use of cognitive function and gait performance.

Fig. 3.1 Photograph of Fumanet exercise or the net-step exercise (NSE)

Results of a longitudinal study and an intervention study on effectiveness of NSE are shown in part in Sects. 3.3 and 3.4, respectively [1, 2].

3.2 Time-Series Study on Reduction in Physical Activity in the Snowfall Season Among the Elderly in Chitose, Hokkaido

3.2.1 Introduction

It has been suggested that the climate and other environmental factors may influence physical activity, and there is large diversity in physical activity among different climates [3–7]. However, studies on the differences in physical activity among seasons are few, to our knowledge, even in the snowfall area. Therefore, we examined seasonal differences in physical activity in the daily life of the elderly, comparing physical activity in the snowfall season with that in the non-snowfall season in Chitose, Hokkaido.

3.2.2 Methods

Chitose is located in the central-western part of Hokkaido and had a population of 96,428 in 2015. We recruited study subjects from adults aged 50 years or older who had participated in the health promotion program provided by Chitose office. We excluded persons who had difficulty in understanding the measurement contents, as well as those who had been diagnosed as having a psychiatric disorder, orthopedic disease, stroke, or disorder with severe pain. A total of 35 subjects (12 males, 23 females) participated in this study, after excluding three subjects due to fitting the exclusion criteria. Written informed consent under full explanation about the study was obtained from each study subject.

Their physical activity was measured with an accelerometer, i.e., the Kenz Lifecorder GS (Suzuken Co. Ltd., Nagoya). Items measured with this device were as follows: the number of step counts (STEP) per day, total energy consumption (TEA) per day (kcal), energy consumption by physical activity (ECPA) per day (kcal), and duration (min) of moderate and vigorous physical activity (MVPA). TEA per day is figured out as summation of ECPA per day and energy consumption by basic metabolism per day.

The Kenz Lifecorder GS is utilized via attachment to the waist of a person. It is advised to use from the time getting up to the time going to bed, excluding bathing time, and live as routine a life as possible. We adopted the previously proposed criteria for a sufficiently worn day as wearing it more than or equal to 10 h [8, 9].

Table 3.1 Comparison of background characteristics and physical activity in 35 study subjects and weather conditions of Chitose between the snowfall and the non-snowfall seasons (Ogawa et al. in subm.) (Mean ± standard deviation)

Variable	Snowfall season	Non-snowfall season	Difference in absolute value	*P* value
STEP	6420 ± 3098	8127 ± 3677	1707 ± 2439	<0.001
TEA (kcal)	1618 ± 148	1682 ± 195	64 ± 112	0.002
ECPA (kcal)	182 ± 82	236 ± 115	47 ± 65	<0.001
MVPA (min)	17 ± 15	22 ± 22	6 ± 11	0.007
Temperature (°C)	−4.1 ± 3.9	17.0 ± 2.4	21.2 ± 0.8	<0.001
Wind velocity (m)	3.6 ± 1.7	3.1 ± 1.0	0.5 ± 0.6	0.117
Precipitation (mm)	– (Not applicable)	6.0 ± 20.0		
Snowfall (cm)	2.6 ± 4.5	– (Not applicable)		

STEP average number of step counts per day, *TEA* average of total energy consumption per day, *ECPA* average of energy consumption by physical activity per day, *MVPA* average duration of moderate and vigorous physical activity per day (min)

The survey was conducted both in September 2015 for the non-snowfall season and in February 2016 for the snowfall season.

3.2.3 Results

The average age (standard deviation, SD) of the 35 study subjects was 69.3 (5.3) years, and means (SDs) of body height, body weight, and body mass index (BMI) were 155.8 (6.5) cm, 56.2 (7.3) kg, and 23.2 (2.7) kg/m^2, respectively. As shown in Table 3.1, the average number of step counts (STEP) was significantly less in the snowfall season (6420) than in the non-snowfall season (8127), and the difference was 1707 ($p < 0.001$). Similarly, the average of total energy consumption (TEA) per day was significantly less in the snowfall season (1618 kcal) than in the non-snowfall season (1682 kcal), and the difference was 64 kcal ($p = 0.002$). The average of energy consumption by physical activity (ECPA) per day was also significantly less in the snowfall season (182 kcal) than in the non-snowfall season (236 kcal), and the difference was 47 kcal ($p < 0.001$). In addition, the average duration of moderate and vigorous physical activity (MVPA) was significantly shorter in the snowfall season (17 min) than in the non-snowfall season (22 min), and the difference was 6 min ($p = 0.007$). The average temperature (standard deviation) of the snowfall and non-snowfall seasons in Chitose was −4.1 °C (3.9) and 17.0 °C (2.4), respectively ($p < 0.001$). There was no difference in average wind velocity between the snowfall (3.6 m) and the non-snowfall seasons (3.1 m) in Chitose.

3.2.4 Discussion

Physical activities such as STEP, TEA, ECPA, and MVPA measured with an accelerometer were found to be significantly less in the snowfall season than the non-snowfall season. Togo et al. [4] reported that the step count increased with the mean ambient temperature over the range of −2–17 °C but decreased over the range of 17–29 °C. Yasunaga et al. [5] conducted a survey of Japanese elderly aged 65–83 years, using an accelerometer, and, similar to our study, they showed that step counts and amounts of physical activity were low in the winter, peaking in spring and autumn. Wagner et al. [7] examined the association between weather conditions and outdoor exercise with a survey using a structured questionnaire and found that the study subjects delayed outdoor exercise in winter, compared with other seasons.

The daily step counts are recommended to be more than 8000, and the daily duration of MVPA is recommended to be more than 20 min (150 min per week) by Aoyagi and Shephard [10]. Average physical activities of our study subjects were observed to be above the recommended levels in the non-snowfall season; however, they were below the recommended levels in the snowfall season.

There are several limitations in our study. Firstly, because of the small sample size in our study, examining a larger number of study subjects would be required in future studies. Secondly, because the study subjects may be relatively healthier, it is not possible to generalize our results to all adults living in the snowfall area. Thirdly, since we did not include a sufficient number of lifestyle or psychological factors in our study, it is necessary to consider those factors in the future study. Fourthly, although physical activity was measured with one axial accelerometer in our study, the devise mentions that the measurement accuracy is low when conducting less-intensive activity such as housework. A three-axial accelerometer would be recommended for future studies because of the higher accuracy in the less-intensive activity [11].

3.2.5 Conclusion

Through the time-series study measured with an accelerometer, it was discovered that the average number of step counts (STEP), the average of total energy consumption (TEA) per day, the average of energy consumption by physical activity (ECPA), and duration of moderate and vigorous physical activity (MVPA) were all significantly less in the snowfall season than the non-snowfall season.

3.3 Longitudinal Study on the Influence of Participation in Net-Step Exercise (NSE) Class for Elderly in Ikeda, Hokkaido

3.3.1 Introduction

We conducted a longitudinal study to assess the influence of participation in classes of Fumanet exercise or NSE among older residents in Ikeda, Hokkaido [2]. Ikeda is located in the central-eastern part of Hokkaido and is recognized as one of the lesser populated areas. The population of Ikeda was 7572 in 2012, and the proportion of the elderly aged 65 years or over was 35.4%. Residents have relatively frequently held NSE classes in Ikeda, and a proportion of participants in NSE have been among the highest in Hokkaido. Self-rated health (SHR) was used for the outcome variable because SHR has been shown to be significantly predicting for all-cause mortality [12, 13].

3.3.2 Methods

For a cohort consisting of 666 participants developed in 2012 in Ikeda, a follow-up survey was conducted in 2014. Written informed consent was obtained from each subject. In surveys regarding NSE participation at the time of baseline, the following question was posed to the participants: "In the last year, how many times did you participate in NSE per month on average?" The participants chose their response from four options (never; 1–2 times monthly; 3–4 times monthly; or at least 5 times monthly), and their answer was 75.5%, 14.5%, 3.8%, and 6.2%, respectively. A comparison was made between those who answered never (500 subjects) and those who answered more than or equal to once a month (166 subjects).

Self-rated health (SRH) was surveyed at the time of follow-up using the following question: "Overall, how was your health condition in the past month on average?" The participants chose their response from the following six options: extremely good, very good, good, not very good, not good, and not good at all. A comparison was made between good SRH (answered as extremely good, very good, or good) and poor SHR (answered as not very good, not good, or not good at all). Analysis with the multivariable logistic regression model was applied to calculate an odds ratio (OR) with 95% confidence interval (CI) for the association between participation in the NSE class and poor SRH.

3.3.3 Results

As shown in Table 3.2, the age- and sex-adjusted OR of participation in NSE classes more than or equal to once a month at baseline against poor SRH 2 years later at the follow-up was 0.53 (95% CI 0.34–0.78). After adjusting for age, sex, and other

Table 3.2 Odds ratio (OR) with 95% confidence interval (CI) of poor self-rated health in follow-up related to net-step exercise (NSE) participation in baseline (Showa et al. 2016)

Variable	Content	Number of subjects	Age- and sex-adjusted OR (95% CI)	Multivariable- adjusted OR (95% CI)[#]
NSE participation	None	500	1.00	1.00
	≧once per month	166	0.49 (0.30–0.78)	0.50 (0.29–0.85)

[#]Age, sex, education level, living arrangement, and regular exercise were adjusted

potential confounding variables, such as education level, living arrangement, and regular exercise, the adjusted OR was 0.50 (95% CI 0.29–0.85), which was significant as well.

3.3.4 Discussion

This study revealed that NSE class participation provided by the residents was inversely associated with poor SRH in older people 2 years after participation. This result is consistent with previous studies, which showed association of physical activity with decreased risk of poor SRH [14–17]. From the result of the follow-up study, Malmberg et al. [14] reported that no weekly vigorous global leisure time activity was associated with an increased risk of decline in SRH in men. From the result of the cross-sectional study, Han et al. [15] discerned that the prevalence of poor SRH was significantly lower as the level of physical activity increased. Wang et al. [16] found from a result of the cross-sectional study that a lack in physical activity had a strong positive association with poor SRH both in men and women.

In addition, our study might support previous studies of significant association between more social participation and better SRH [18–20]. Fujiwara et al. [18] reported that elderly volunteers who read books for children during the 18 months significantly improved their SRH compared with the control group. Nieminen et al. [20] showed from a result of the cross-sectional study that good SRH was associated with a high level of social participation.

There are several limitations in this study. Firstly, the cohort was limited to 56% of the population. Secondly, the one-time assessment of NSE class participation excluded the opportunity to account for the later changes in NSE class participation. Thirdly, data on some potential confounding factors, such as socioeconomic status and mental health, were unavailable in this study.

3.3.5 Conclusion

From the result of a longitudinal study, the older individuals who participated in NSE classes once a month or more had a significantly lower risk of poor SRH 2 years after their participation compared with class nonparticipants. Such NSE

classes are a feasible method for older people's health promotion in municipalities with a lower population.

3.4 Intervention Study on Effects of the Net-Step Exercise (NSE) for Elderly in Kushiro, Hokkaido

3.4.1 Introduction

Physical activity has been shown to have a beneficial effect on cognitive function and reduce the risks of dementia [21–24]. In addition, physical activity has a beneficial effect on gait performance and reduces the risk of falls [24]. There is an increased need to identify types and levels of physical activity that are suitable for the majority of older people to improve their cognitive function and gait performance [25]. Our study aimed to assess the effect of a light-burden NSE performed once a week for eight consecutive weeks on improvement in cognitive function and gait performance [1].

3.4.2 Methods

A randomized single-blind controlled trial was used to evaluate the effect of the NSE on cognitive and gait function in older adults in 2014. Participants included volunteers from the federation of senior citizen's club in Kushiro, located in the eastern area of Hokkaido. The participants had to possess a driver's license and drive more than once a week, in order to exclude individuals with dementia or other cognitive and physical impairments. In Japan, driver's license holders whom are older than 70 years must pass an official government screening test for dementia, eyesight, and motor skills every 3 years.

Thus, 60 participants between the ages of 71 and 89 years were enrolled in the study. Written informed consent was obtained from each subject. Participants were randomly assigned into the NSE group (30 persons) and the control group (30 persons) using a lottery. The 8-week NSE program was conducted at the same time and day of the week and in the same room at Hokkaido University of Education, Kushiro Campus, for all members of the intervention group. Throughout the 8-week NSE program, the difficulty of the step designs and the number of steps required in each session were gradually increased. Participants walked 216 steps per session during the first 4 weeks of the program and 240 steps per session for the fifth and eighth.

Cognitive assessment was conducted using a device with a touch-panel computer screen called the Touch-M system [26]. The Touch-M system evaluates visuospatial function in the lateral prefrontal area to assess cognitive function and diagnose early stages of Alzheimer disease. The Touch-M system runs on the Microsoft Windows operating system and a touch-panel-type desktop PC.

The Timed Up and Go (TUG) test was used to measure gait performance. The TUG test requires the subject to stand up, walk 3 m, turn, walk back, and sit down, and the time (min) taken to complete the TUG is measured [27]. The repeated measures procedure was used in an analysis of covariance (ANCOVA). The two time points (baseline and 8 weeks) were treated as a within-participant factor. The difference between the NSE and control groups was treated as a between-participant factor. Covariates, such as age and sex, were included in the multivariate model.

3.4.3 Results

As shown in Table 3.3, the total score of the Touch-M test significantly improved by 5.4 points from the baseline in the NSE group ($p = 0.04$), and the mean difference from the baseline in the Touch-M test score was 4.9 times higher in the NSE group compared with the control group ($p = 0.04$). The time in the TUG test significantly improved by 0.98 s in the NSE group relative to the baseline assessment, and the results from the repeated measures ANCOVA showed a significant effect for the within-participant interaction in the TUG test ($p < 0.001$).

3.4.4 Discussion

Our study demonstrated that the NSE group had significant improvement of cognitive function after 8 weeks of NSE. This finding is consistent with previous research. Larson et al. [21] found from a result of the cohort study that persons who exercised three times or more per week had a reduced hazard ratio for developing dementia compared with those who exercised fewer than three times per week. Lautenschlarger et al. [22] reported from the result of a randomized controlled trial that participants in the physical activity group had better scores of cognitive function than those in the control group.

Table 3.3 Effect of the net-step exercise on gait and cognitive function in participants at the end of 8 weeks (Kitazawa et al. 2015)

	Mean difference from baseline with 95% confidence interval		*P* value for repeated measures ANCOVA	
Test	NSE group ($n = 30$)	Control group ($n = 30$)	Between participants	Within participants
Touch-M score in total	5.40 (2.29 to 8.51)	1.10 (−1.43 to 3.63)	0.04	0.04
Timed Up and Go test	−0.98 (−1.34 to −0.61)	0.40 (−0.01 to 0.81)	0.33	<0.001

ANCOVA, analysis of covariance

Our study also showed that gait performance was significantly improved in the NSE group compared with the control group. Similar to our result, Shubert et al. [24] reported from an intervention study that participants in exercise-based balance improvement program showed a significant improvement in gait performance. Moreover, cognitive function has been shown to be an indicator of gait and balance performance [28–30]. From this point of view, it is also assumed that NSE simultaneously improves cognitive function and gait performance.

This study has some limitations. Firstly, because a double-blinded study design was not possible, it was inevitable that participants discovered whether they belonged to the intervention or control groups. Secondly, the physical activity and social activity of the participants other than NSE were not controlled or monitored. Thirdly, potential confounding factors, such as socioeconomic status and lifestyle, were not included in this study.

3.4.5 Conclusion

From the result of the 8-week intervention study, we found that cognitive function, assessed by the Touch-M test, and gait performance, assessed by the Timed Up and Go (TUG) test, were significantly improved by participation in NSE classes among healthy older adults. Our results indicate that NSE offers an option for a large segment of the older population who require an easier way to maintain their cognitive health and gait function.

3.5 Future Study Planning

More than 6000 elderly individuals have been registered as NSE supporters by obtaining the qualified training of FSE in Hokkaido. There are some rural areas which are abundant in the NSE supporters, as well as in NSE participants. Accordingly, a longitudinal study of NSE supporters and NSE participants, as well as nonparticipants, is now undergoing planning to examine the effectiveness of NSE with a lager sample size in such areas.

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