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Two-Year Repeated Study on Health Effect of Net-Step Exercise Program in Community-Dwelling Older Persons

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Abstract

Background: A light-burden and indoor physical exercise program called Net-Step Exercise (NSE) has been developed in Hokkaido, Japan. Conducting the two-year repeated survey with the Kihon Checklist (KCL) for the same older subjects living in a rural area of Hokkaido where a relatively large proportion of the older persons have participated in NSE activity, we assessed the effectiveness of NSE activity.

Methods: The whole of 3,155 community-dwelling persons aged from 75 years to 79 years in 8 towns were the candidates of the study subjects, and 2,183 subjects (69.2%) responded to the first survey (2018 Survey), answering the questions about both frequency of participation in NSE and each item in KCL. The same survey (2019 Survey) was conducted one year later, and completed by 1,956 subjects (93.3%), excluding 25 dead persons or 60 persons who had moved away from the community during the year. In the 2018 Survey as well as the 2019 Survey, Adjusted Odds Ratio (AOR) and its 95% confidence interval (95%CI) of each sub-category of KCL for NSE Participants compared with NSE Non-participants was calculated with unconditional logistic regression by sex, adjusting for age, smoking status, and other potentially confounding variables. Repeated-measures Analysis of Variance (ANOVA) was also applied by sex.

Results: Significantly reduced risk (AOR with 95% CI) was observed in NSE participants in difficulty in activities of daily living in the male subjects in the 2018 Survey (0.64, 0.42-0.98) and in the 2019 Survey (0.50, 0.32-0.79), as well as in the female subjects in the 2018 Survey (0.52, 0.38-0.70) and in the 2019 Survey (0.46, 0.33-0.65), houseboundness in the female subjects in the 2018 Survey (0.42, 0.29-0.60) and in the 2019 Survey (0.70, 0.51-0.96), impaired cognitive function in the male subjects in the 2018 Survey (0.58, 0.36-0.92), and depressive status in the female subjects in the 2018 Survey (0.66, 0.49-0.88). Significant findings were also shown in most of the above four sub-categories by analysis with repeated-measures ANOVA.

Conclusion: Either performance of NSE itself or participation in the program, or both, may promote healthy status in the older persons.

Keywords: Physical activity; Activity of daily livings; Houseboundness; Cognitive function; Depression

Abbreviations

NSE: Net-Step Exercise; KCL: Kihon Checklist; AOR: Adjusted Odds Ratio; 95% CI: 95% Confidence Interval; ANOVA: Analysis of Variance; ADL: Activities of Daily Living, PR: Pulse Rate

Background

There is an increased need for an effective means of health promotion in which the older persons themselves can be actively involved. Although there is a reasonable amount of evidence that 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 older persons.

A light burden and indoor physical exercise program called "Fumanet" exercise has been developed in Hokkaido Japan [1-4]. Fumanet is derived from "net" and "fumanai" which in Japanese means to avoid stepping on something. Fumanet is a 4m×1.5m net that is comprised of 50cm×50cm squares arranged in a 3×8 grid. 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. In this paper, Fumanet exercise is abbreviated to the Net-Step Exercise (NSE). At a typical program, NSE is conducted with groups of approximately 10 people each. NSE requires the simultaneous use of cognitive function and gait performance.

Since NSE was developed in 2004 in Kushiro City, Hokkaido, NSE has spread not only throughout Hokkaido, but also, to other areas of Japan, South Korea, Hawaii and California in the USA. The number of participants, so-called NSE supporters, has increased, especially, in rural area of Hokkaido, and number more than 7,000 to date.

The 25-question Kihon Checklist (KCL) is the self-administrated questionnaire tool for assessing the elderly for long-term care

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insurance, and has been utilized in some research projects [5-9]. KCL consists of seven sub-categories such as activities of daily living, physical strength, nutritional status, oral function, houseboundness, cognitive function, and depressive status. Each sub-category of KCL is composed of 5, 5, 2, 3, 2, 3, and 5 questions, respectively. Because the score of each answer is obtained binomially as better or worse status assigning to 0 and 1, respectively, total worse score in each sub-category is additively calculated per person.

Conducting the two-years repeated survey with KCL for the same subjects living in rural area of Hokkaido where a relatively large proportion of persons have participated in NSE activity; we assessed the effectiveness of NSE program.

Subjects and Methods

Eight towns in rural area of Hokkaido, such as Hamanaka, Ikeda, Kamifurano, Pippu, Samani, Shihoro, Teshikaga, and Yuni, were selected as the target places of the study, because a relatively large proportion of the elderly have participated in NSE activity there. The whole of 3,155 community-dwelling persons aged from 75 years to 79 years in 8 towns were the candidates of the study subjects, and 2,183 subjects (69.2%) responded to the first survey in October 2018, referred to as the 2018 Survey, answering questions about both frequency of participation in NSE and each item in KCL. One year later in October 2019, the same survey, referred to as the 2019 Survey, was conducted and completed by 1,956 subjects, excluding 25 dead persons or 60 persons who had moved away from the community during the year. Accordingly, the response rate of 2019 Survey was 93.3% (1,956/2,098).

In the 2018 and 2019 Surveys, the following question was posed to the subjects: "In the last year, how many times did you participate in NSE on average?" They chose their answer from four options (never; several time in a year; once or twice monthly; more than or equal to three times monthly). In total, 1956 participants responded to the question both of 2018 and 2019 Surveys, and we conducted the following analysis based on the responses. Their distribution participation in the 2018 Survey was 1,447 (74.0%), 190 (9.7%), 216 (11.0%), and 103 (5.3%), respectively. Similarly, their distribution of participation in 2019 Surveys were 1,355 (69.3%), 289 (14.8%), 207 (10.6%), and 105 (5.4%), respectively.

We combined the last three categories of NSE participation as the group of NSE Participants (509 and 601 subjects at 2018 Survey and 2019 Survey, respectively), and compared with the group of Non-participants (1,447 and 1,355 subjects at 2018 Survey and 2019 Survey, respectively).

In the 2018 Survey as well as the 2019 Survey, Adjusted Odds Ratio (AOR) and its 95% confidence interval (95% CI) of each sub-category of KCL for NSE Participants compared with NSE Non-participants was calculated with unconditional logistic regression, adjusting for potential confounding factors. The outcome of each sub-category in KCL was classified binomially as having no worse scores or having at least one worse score. If AOR was significant in the male or female subjects at either 2018 or 2019 Survey, repeated-measures Analysis of Variance (ANOVA) was applied to total worse scores of each sub-category in KCL for NSE Participants compared with NSE Non-participants.

SAS statistical software was used for every analysis (SAS version 9.4, SAS Institute Japan, Tokyo). LOGISTIC procedure and MIXED procedure in SAS were utilized for logistic regression and repeated-measures ANOVA, respectively [10]. Significance level was set at a probability of 0.05.

Written informed consent was obtained from each subject. The Committee of Institutional Review Board of Hokkaido Chitose College of Rehabilitation (No.18006) approved the study.

Results

Table 1 shows the number of the subjects participating in NSE in the 2018 and/or 2019 Surveys. The number of female participation subjects was significantly greater in NSE in both surveys than the male subjects ($p<0.001$). Consequently, the following analyses were conducted by sex.

Table 2 shows the characteristics of the subjects according to NSE participation in the 2018 and/or 2019 Surveys by sex. Age was significantly lower in NSE Non-participants than NSE Participants in the male subjects ($p=0.001$). Current smokers were significantly fewer in NSE Participants than NSE Non-participants in the male subjects ($p=0.008$). Persons drinking alcohol at least once per week were not different either in the male or female subjects. The number of persons spending active time daily of more than 40min. were significantly greater in NSE Participants than NSE Non-participants among male subjects ($p=0.004$) as well as in the female subjects ($p=0.022$). The number of persons participating in any other program to prevent long-term care were significantly more in NSE Participants than NSE Non-participants in the male subjects ($p<0.001$) as well as in the female subjects ($p<0.001$). The number of persons with a history of diabetes mellitus, heart disease, apoplexy, or cancer was not different either in the male subjects, or in the female subjects.

According to the results in Table 2, the following analysis was conducted by adjusting for age, smoking status, spending active time daily of more than 40 min. or not, and participating in any other program to prevent long-term care. Results of the 2018 Survey are shown in Table 3, and AOR for NSE Participants compared with NSE Non-participants was significantly low in difficulty in activities of daily living in the male subjects (AOR=0.64, 95% CI 0.42-0.98), and in the female subjects (AOR=0.52, 95% CI 0.38-0.70), houseboundness in the female subjects (AOR=0.42, 95% CI 0.29-0.60), impaired cognitive function in the male subjects (AOR=0.58, 95% CI 0.36-0.92), and depressive status in the female subjects (AOR=0.66, 95% CI 0.48-0.88). No AOR in the other sub-categories of KCL were significantly observed in the 2018 Survey.

Results of the 2019 Survey was shown in Table 4, AOR for NSE Participants compared with NSE Non-participants was significantly lower in difficulty in activities of daily living in the male subjects (AOR=0.50, 95% CI 0.32-0.79), and in the female subjects (AOR=0.46,

Table 1: Number of the subjects (percent) participating in NSE in 2018 and/or 2019 Surveys according to sex.

Sex	Both Surveys	Either	Neither	Total	P value
Males	114 (13.7)	68 (8.1)	653 (78.2)	835 (100.0)	<0.001
Females	331 (29.5)	152 (13.6)	638 (56.9)	1,121 (100.0)	
Total	445 (22.7)	220 (11.3)	1,291 (66.0)	1,956 (100.0)	

Table 2: Characteristics of the subjects according to NSE participation at Surveys in 2018 and/or 2019 by sex.

Items	NSE participation among the male subjects (n=835)				NSE participation among the female subjects (n=1,121)			
	Participants in both years (n=114)	Participants in either year (n=68)	Non-participants in both years (n=625)	P value	Participants in both years (n=331)	Participants in either year (n=152)	Non-participants in both years (n=638)	P value
Age, years, mean (SD)	77.9 (1.5)	77.9 (1.6)	77.4 (1.5)	0.001	77.3 (1.4)	77.5 (1.5)	77.3 (1.4)	0.467
Current smokers, n (%)	5 (4.4)	11 (16.2)	98 (15.0)	0.008	6 (1.8)	4 (2.6)	30 (4.7)	0.057
Alcohol drinking at least once per week (%)	52 (45.6)	29 (42.7)	275 (42.1)	0.784	25 (7.6)	11 (7.2)	46 (7.5)	0.981
Spending active time daily more than 40min.	112 (98.3)	62 (91.2)	576 (88.2)	0.004	321 (97.0)	144 (94.7)	591 (92.7)	0.022
Participating in any other program to prevent long-term care	42 (36.8)	16 (23.5)	39 (6.0)	0.001	166 (50.2)	48 (31.6)	46 (7.2)	<0.001
History of diabetes mellitus, heart disease, apoplexy, or cancer	58 (50.1)	37 (32.5)	356 (54.5)	0.777	108 (32.7)	61 (40.1)	208 (32.6)	0.097

Table 3: Adjusted odds ratios of Kihon Checklist at Survey in 2018 for NSE Participants compared with NSE Non-participants by sex.

Sub-categories of Kihon Checklist	Sex	NSE Participants			NSE Non-participants			Adjusted odds ratio# (95% confidence interval)
		Positive number (%)	Negative number (%)	Total	Positive number (%)	Negative number (%)	Total	
Difficulty in activities of daily living	Males	47 (37.0)	80 (63.0)	127	366 (52.1)	337 (47.9)	703	0.64 (0.42-0.98)
	Females	79 (20.8)	301 (79.2)	380	280 (38.3)	451 (61.9)	731	0.52 (0.38-0.70)
Reduction of physical strength	Males	65 (51.2)	62 (48.8)	127	417 (59.4)	285 (40.6)	702	0.68 (0.45-1.03)
	Females	267 (70.8)	110 (29.2)	377	572 (77.6)	165 (22.4)	737	0.80 (0.58-1.10)
Poor nutritional status	Males	25 (19.7)	102 (80.3)	127	145 (20.6)	560 (79.4)	705	1.05 (0.63-1.75)
	Females	67 (17.7)	312 (82.3)	377	179 (24.3)	558 (75.7)	737	0.78 (0.55-1.10)
Reduction of oral function	Males	62 (48.1)	67 (51.9)	129	355 (50.4)	349 (49.6)	704	0.99 (0.66-1.48)
	Females	190 (50.1)	189 (49.9)	379	394 (53.3)	345 (46.7)	739	0.95 (0.72-1.25)
Houseboundness	Males	20 (15.5)	109 (84.5)	129	163 (23.1)	542 (76.9)	705	0.81 (047-1.40)
	Females	51 (13.4)	329 (86.6)	380	230 (31.1)	510 (68.9)	740	0.42 (0.29-0.60)
Impaired cognitive function	Males	30 (23.3)	99 (76.7)	129	246 (34.9)	458 (65.1)	704	0.58 (0.36-0.92)
	Females	89 (23.4)	291 (76.6)	380	213 (28.9)	525 (71.1)	738	0.77 (0.56-1.06)
Depressive status	Males	41 (31.8)	88 (68.2)	129	277 (39.7)	421 (60.3)	698	0.91 (0.59-1.40)
	Females	120 (32.1)	254 (67.9)	374	328 (44.8)	404 (55.2)	732	0.66 (0.49-0.88)

NSE: Net-step exercise.

Available numbers were not the same, because several subjects did not respond to a part of the items.

#: Age; smoking status, spending active time daily more than 40 min, or not, and participation in any other program to prevent long-term care were adjusted.

95% CI 0.33-0.65), and, houseboundness in the female subjects (AOR=0.70, 95% CI 0.51-0.96). No AOR in the other sub-categories of KCL were significantly observed in the 2019 Survey.

Repeated-measures ANOVA was applied for four sub-categories found statistically significantly different in 2018 Survey and/or 2019 Survey with the logistic regression analysis. As results of repeated-measures ANOVA were shown by sex in Table 5, worse score of NSE Participants was significantly lower than that of NSE Non-participants in difficulty in activities of daily living in the male subjects ($F=10.40$, $p<0.001$), and in the female subjects ($F=27.30$ $p<0.001$), houseboundness in the female subjects ($F=26.44$, $p<0.001$), impaired cognitive function in the female subjects ($F=5.51$, $p=0.004$), and depressive status in the female subjects ($F=5.53$, $p=0.004$).

Discussion

We demonstrated that, in either or both of the male or the female subjects, NSE Participants had significantly better status than NSE Non-participants in four sub-categories of KCL such as difficulty in activities of daily living, houseboundness, impaired cognitive function, and depressive status. Especially, significantly reduced risk was associated with NSE participation in difficulty in activities of daily living in both sexes and houseboundness in females, consistently between 2018 and 2019 Surveys.

In KCL, [8] activities of daily living consist of five questions such as (i) Do you go out by bus or train by yourself? (ii) Do you go shopping to buy daily necessities by yourself? (iii) Do you manage your own deposits and savings at the bank? (iv) Do you sometimes visit your friends? (v) Do you turn to your family or friends for advice? Houseboundness consists of two questions such as (i) Do you go out at least once a week? (ii) Do you go out less frequently compared to last year?

Being consistent with our results, there are several reports that physical exercise has improved Activities of Daily Living (ADL). Oida et al. [11] showed that five-year intervention of exercise and health education significantly reduced the risk of ADL impairment in both

Table 4: Adjusted odds ratios of Kihon Checklist at Survey in 2019 for NSE Participants compared with NSE Non-participants by sex.

Sub-categories of Kihon Checklist	Sex	NSE Participants			NSE Non-participants			Adjusted odds ratio# (95% confidence interval)
		Positive number (%)	Negative number (%)	Total	Positive number (%)	Negative number (%)	Total	
Difficulty in activities of daily living	Males	34 (21.1)	127 (78.9)	161	230 (35.7)	414 (64.3)	644	0.50 (0.32-0.79)
	Females	65 (15.5)	354 (84.5)	419	208 (31.8)	447 (68.2)	655	0.46 (0.33-0.65)
Reduction of physical strength	Males	91 (60.7)	59 (39.3)	150	382 (63.6)	219 (36.4)	601	0.82 (0.55-1.23)
	Females	306 (77.5)	89 (22.5)	396	473 (78.0)	128 (21.3)	601	1.07 (0.71-1.42)
Poor nutritional status	Males	41 (24.1)	124 (75.2)	165	144 (22.3)	502 (77.7)	646	1.08 (0.70-1.63)
	Females	96 (22.6)	329 (77.4)	426	156 (23.9)	498 (76.5)	654	1.06 (0.77-1.47)
Reduction of oral function	Males	83 (50.6)	81 (49.4)	164	325 (49.2)	336 (50.8)	661	1.00 (0.69-1.46)
	Females	229 (54.1)	194 (45.9)	423	339 (50.6)	331 (49.4)	670	1.23 (0.94-1.62)
Houseboundness	Males	40 (24.4)	124 (75.6)	164	123 (18.7)	534 (81.3)	657	1.31 (0.82-2.09)
	Females	86 (20.1)	341 (79.9)	427	205 (30.4)	470 (69.6)	675	0.70 (0.51-0.96)
Impaired cognitive function	Males	45 (27.6)	118 (72.4)	163	212 (32.1)	449 (67.9)	661	0.75 (0.49-1.14)
	Females	104 (24.5)	321 (75.5)	425	191 (28.4)	481 (71.6)	672	1.02 (0.75-1.38)
Depressive status	Males	64 (40.3)	95 (59.7)	159	244 (38.5)	390 (61.5)	634	1.08 (0.73-1.61)
	Females	168 (41.1)	241 (58.9)	409	293 (45.6)	350 (54.4)	643	0.92 (0.70-1.22)

NSE: Net-step exercise.
Available numbers were not the same, because several subjects did not respond to a part of the items.
#: Age; smoking status, spending active time daily more than 40 min, or not, and participation in any other program to prevent long-term care were adjusted.

Table 5: Results of repeated-measures ANOVA for four sub-categories of Kihon Checklist found to be significantly different in 2018 and/or 2019 Surveys for NSE Participants compared with NSE Non-participants by sex.

Sub-categories of Kihon Checklist	Sex	Source	F value	P value
Difficulty in activities of daily living	Males	NSE	10.40	<0.001
		Survey (Year)	35.83	<0.001
		NSE × Survey	0.59	0.554
	Females	NSE	27.30	<0.001
		Survey (Year)	10.17	0.002
		NSE × Survey	0.39	0.676
Houseboundness	Males	NSE	1.09	0.335
		Survey (Year)	0.01	0.924
		NSE × Survey	2.31	0.100
	Females	NSE	26.44	<0.001
		Survey (Year)	3.13	0.077
		NSE × Survey	1.00	0.369
Impaired cognitive function	Males	NSE	2.93	0.054
		Survey (Year)	0.19	0.660
		NSE × Survey	2.80	0.062
	Females	NSE	5.51	0.004
		Survey (Year)	0.03	0.861
		NSE × Survey	0.33	0.720
Depressive status	Males	NSE	0.93	0.396
		Survey (Year)	1.28	0.257
		NSE × Survey	2.08	0.126
	Females	NSE	5.53	0.004
		Survey (Year)	4.55	0.033
		NSE × Survey	0.02	0.981

NSE: Net-step exercise.

men and women. They measured ADL impairment with categories that required help, for example, eating, dressing, using the toilet, and other activities at home. According to a six-year cohort study by Nagamatsu et al., [12] functional fitness significantly reduced the risk of ADL such as hand working and self-care working in males, but not in females.

Women were consistently reported to be prone to houseboundness, compared with men [13-16]. However, proportions of houseboundness were larger in the male subjects than the female subjects in our results of both the 2018 and 2019 Surveys. Some reports suggested that exercise programs prevented houseboundness [17,18]. Ohtake et al. [17] elucidated from a randomized controlled trial that an eight-week exercise program resulted in an intervention group with a lower degree of houseboundness. They defined degree of houseboundness with 20 questions including social activities. Uemura et al. [18] revealed that sarcopenia measured with the specific instrument were associated with significantly increased risk of becoming housebound, and sarcopenia is reflected by low physical performance or low muscle strength. Because these studies did not show the results by sex [17,18], it is difficult to explain that our significant finding only in the female subjects is generally observed or not with regard to preventive effect of physical activity program for houseboundness.

Results of NSE participants were significantly better in terms of cognitive function. This was found in our study of the male subjects at 2018 Survey as well as of the female subjects with the repeated-measure ANOVA. Kitazawa et al. [1] reported that NSE participants showed significant improvement in cognitive function from the result of experimental pretest/posttest study for 60 healthy older adults. Larson et al. [19] also showed in a prospective cohort study that regular exercise was associated with reduced risk of dementia. Lautenschlager et al. [20] denoted with randomized controlled trial

that a six-month program of physical activity provided significant improvement in cognition among adults with subjective memory impairment.

We found that NSE participants showed significant reduced risk of depressive status in the female subjects. Likewise, Showa et al. [2] revealed from a cross-sectional study of community-dwelling elderly that NSE had marginally significant inverse association with risk of depressive symptoms after adjusting for sex, although they did not show the results by sex. Similar to our results, Heesch et al. [21] reported, from a cohort study of community-dwelling women aged 70-78, the inverse dose-response association between leisure-time and score of depression and anxiety. Some other studies [22-24] revealed that greater physical activity was protective against depression in community-dwelling older adults, although the results were not shown by sex.

Intensity of NSE is as low as slow walking. Ogawa et al. [4] reported that, with measuring circulation of 72 older adults before and after a 30min NSE program, the post-exercise Systolic Blood Pressure (SBP) and the post-exercise Pulse Rate (PR) was rather lower than the pre-exercise SBP and pre-exercise PR. They inferred from the results that NSE was so low-intensity and comfortable to stimulate parasympathetic nerve activity, but not sympathetic nerve activity. There are several reports showing that even low-intensity physical exercise was effective in health promotion in older adults [25,26]. Kolbe-Alexander et al. [25] showed from a result of 20-week intervention study that a community-based, low-intensity exercise program improved dynamic balance and lower body strength. Brown et al. [26] also exhibited from a result of a randomized controlled study that significant improvement was made by the three-month low-intensity exercise group on a physical performance test.

Our study concentrated on the age class between 75 years and 80 years. Studies for effectiveness of physical exercise restricted to very old people, namely, aged over 75 years, are relatively few in Japan. Outside Japan, Lihavainen et al. [27] reported from the three-year intervention study on people aged 75-98 years that the intervention group improved in balance and walking speed, as compared with the control group. Bonnefoy et al. [28] suggested that those participants over 78 years old who lived at home independently participated in a self-administrated exercise program with good compliance. Because Japanese life expectancy is getting longer, more epidemiological studies are needed with regard to association of daily activity with health in very old persons.

Tomata et al. [5] indicated from a cohort study that all of the criteria in KCL were useful for predicting the risk of incident long-term care insurance certification. Satake et al. [8] as well as Yamada et al. [9] suggested from a cross-sectional study that KCL is a useful tool for frailty screening, although Fukutomi et al. [6,7] denoted from a cohort study that only physical strength in KCL was a predictor of the incident long-term insurance certification. We think that KCL is useful for surveys of older persons, because it is easy for them to understand and is composed of seven necessary sub-categories for assessing their daily living.

There are several limitations in this study. Firstly, the response rate was 69.2% and 93.3% to 2018 Survey and 2019 Survey, respectively. However, it is thought that majority of the study candidates participated in the survey. Secondly, data on some potential confounding factors, such as socio-economic status, were not included in this study, although age, daily activity, and participation in any other program for prevention of long-term care were adjusted in the analysis. Thirdly, although the study design was the repeated-measuring type, in addition to the cross-sectional study at two points, causal relationship between participation in NSE program and better status in health could be not indicated.

Conclusion

In conclusion, participation in the NSE program had brought better status in difficulty in activities of daily living, houseboundness, impaired cognitive function, and depressive status in the male and/or female subjects among persons aged from 75 years to 80 years. Either performance of NSE itself or participation in the program, or both, may promote healthy status in older persons.

Declarations

Ethics approval and consent to participation

Written informed consent was obtained from each subject. The Committee of Institutional Review Board of Hokkaido Chitose College of Rehabilitation (No.18006) approved the study.

Availability of data

Data sharing is not applicable to this article as no data are publicity available due to personal privacy but are available from the corresponding author on reasonable request.

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Authors' contribution

MM contributed to the research mainly for planning of the study, analyzing the data, and preparing the manuscript. KK, SS, and MT contributed to the research mainly for conducting the surveys. TS and ST contributed to the research mainly for preparing the surveys and making the data sets. All authors read and approved the final manuscript.

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