The net-step exercise may influence autonomic nerve activity in older people: result from a comparison of measurements before and after the exercise

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【Abstract】

［Background］A light-burden and net-step exercise (NSE) program called the "Fumanet" exercise has been developed in Hokkaido. NSE may influence autonomic nerve activity in older people.

［Methods］Voluntary participants aged over 60 years old were recruited for the NSE program in Chitose City, Hokkaido, Japan. Between March and May, 2018, 72 persons (18 males, 54 females) participated in this program. Their systolic and diastolic blood pressure, pulse rate, salivary α-amylase activity, and the Two-dimensional Mood Scale (TDMS) were measured just before and just after NSE program.

［Results］ The post-exercise pulse rate (median = 77.0 bpm) was significantly lower than that of pre-exercise (median = 78.0 bpm) ($p < 0.001$). SBP of post-exercise (median = 139.5 mmHg) was lower than that of pre-exercise (median = 141.0 mmHg), but it was not significant ($p = 0.087$). SAA of post-exercise (median = 5.0 kU/L) was lower than that of pre-exercise (median = 7.0 kU/L), but not significantly ($p = 0.150$). Self-perceived mood state of vitality and pleasure measured with TDMS were significantly increased just after the exercise, as compared with that just before the exercise ($p < 0.001$). The other variables were not significantly different between before and after the NSE program.

［Discussion］ It is thought that because a reduction in pulse rate is brought about with decreasing sympathetic nerve activity, and increasing in parasympathetic nerve activity, NSE may decrease sympathetic nerve activity, and/or, increase parasympathetic nerve activity.

Keywords：physical exercise, pulse rate, sympathetic nerve, parasympathetic nerve

1. Introduction

As the number of elderly people in Japan increases, a healthy lifestyle has become more important. In addition to good dietary habits and appropriate sleeping or resting, habitual physical activities have been shown to be associated with health benefits[1)], especially, in older adults[2,3)]. Although research on moderately-high or highly intensive physical activities have been conducted in considerable number, research on low intensive or light-burden physical activities has been performed in relatively small number, even in the elderly population.

A light-burden and called "Fumanet" has been developed in Hokkaido[4-6)]. 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. 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, and it is thought that

NSE requires the simultaneous use of cognitive function and gait performance[4-6].

The measurement of HR variability has become a widely used tool for assessing the autonomic input to the heart under various physiological conditions[7]. Physical activity induces changes in the autonomic nervous system, and salivary α-amylase activity (SAA) levels corresponding to plasma norepinephrine concentrations[8] are utilized as a measure of autonomic nerve reactivity to stressors[9,10].

The relation between physical exercise and psychological health has increasingly come under the spotlight over recent years[2,11]. Various studies have investigated the mood enhancing properties of exercise and have shown that exercise can indeed have a positive influence on mood states. The Two-dimensional Mood Scale (TDMS)[12] has been developed for assessing mood states showing reasonable validity and reliability. TDMS is measured using a questionnaire consisting of eight items via a six-point Likert-type scale, from zero (not at all) to five (extremely). Based on these scores, mood states such as vitality, stability, pleasure and arousal are calculated.

2. Subjects and Methods

Voluntary participants aged over 60 years old were recruited for the NSE program in Chitose City, Hokkaido, Japan, via mass media between February and May, 2018. The exclusion criteria were people who could not walk. Each subject participated once in the two hour NSE program including the following measurement, being offered five times on Saturday afternoons from 2 to 4 pm between March and May, 2018. In this NSE program, the instructor took a step toward the participants. After that, we carried out the warming up stage while checking the physical condition of the target person. The second was a trial step, where participants learned the design of new steps to be performed during the session. Participants had to remember the pattern of each step based on the instructor's demonstration. After the demonstration, participants practiced each step design twice. The third stage was a recreational step. Participants sing and walk with the same rhythm while

Table 1: Characteristics of 72 participants and their Net-step exercise (NSE) program

	Number	Mean	SD
Male/Female	18/54		
Age in year	72	73.5	5.5
Body mass index (BMI)	72	23.3	3.6
Duration of NSE in min.	72	33.7	6.3
Number of steps	72	652.0	449.5
Highest pulse rate in bpm	72	112.8	13.5

SD: Standard deviation　bpm: beats per minute

singing a children's song. The actual total walking time was about 30 minutes, and there were no breaks during that time. It was measured by the wearable wrist device only during this program to accurately measure PR and the like. The wearable list device used was Pulsense (Epson Co., USA) [13]. Just before and just after the NSE program, SBP, DBP, PR, SAA, and TDMS were measured in every participant. Indirect assessment of SBP and DBP was done by the use of sphygmomanometer and stethoscope.

The measurements before the exercise were made some time after arrival at the venue. An SAA biosensor called as the Salivary Amylase Monitor (Nipro Co., Tokyo, Japan) [10] was utilized to measure autonomic nervous system reactivity to stressors. TDMS was used for measuring mood states such as vitality, stability, pleasure and arousal[12]. Written informed consent was obtained from every participant. The ethical committee of Hokkaido Chitose College of Rehabilitation approved this study (Approval Number: CHIRIRIN17008).The Wilcoxon test for nonparametric comparison between the paired measurements before and after NSE program was used for the analysis because most variables were not normally distributed according to the Shapiro-Wilk statistic. Multiple linear regression analysis was performed to assess relationships among the measured variables, adjusting for each other. Significance level was set at 0.05.

3. Results

As shown in Table 1, 72 persons (18 males, 54 females) participated in this program. Mean age was 73.5 years (standard deviation, 5.5) with a range between 62 and 90 years, and mean BMI (SD) was 23.3 (3.6). From each record of Pulsense, mean duration (SD) of NSE program

Table 2: Comparison of blood pressure, pulse rate, salivary α-amlyase, and mood states between pre-and post-exercise in 72 participants.

Item	Number	Pre-exercise					Post-exercise					Difference (Post—Pre)					Wilcoxon test
		Mean	SD	Lower quarter	Median	Upper quarter	Mean	SD	Lower quarter	Median	Upper quarter	Mean	SD	Lower quarter	Median	Upper quarter	
Systolic blood pressure, mmHg	72	142.9	16.9	133.0	141.0	152.5	139.5	18.4	127.5	139.5	149.0	−3.3	13.4	−11.0	−1.0	5.0	0.087
Diastolic blood pressure, mmHg	72	88.5	10.9	82.0	87.0	95.5	87.2	11.7	80.0	87.0	93.5	−1.2	9.3	−7.0	−2.0	4.0	0.150
Pulse rate, bpm	72	78.2	11.2	70.0	78.0	86.0	75.6	11.0	67.5	77.0	83.5	−2.7	7.2	−6.0	−3.0	1.0	<0.001
Salivary α-amlyase, kU/L	71$	22.5	29.6	3.0	7.0	26.5	16.0	23.9	3.0	5.0	18.0	−7.0	29.2	−12.0	0.0	4.5	0.150
Vitality	72	1.7	2.7	0.0	2.0	3.0	3.1	1.8	2.0	3.0	5.0	1.4	3.0	−1.0	1.0	3.0	<0.001
Stability	72	5.8	3.3	3.0	6.0	8.0	6.0	3.3	4.0	7.0	10.0	0.8	3.5	−1.0	0.0	3.0	0.065
Pleasure	72	7.5	4.1	5.0	8.0	10.0	9.7	4.3	6.0	10.0	13.5	2.2	4.9	−0.5	2.0	5.0	<0.001
Arousal	72	−4.1	4.5	−7.0	−4.5	−1.0	−3.4	3.2	−5.0	−4.0	−2.0	0.6	4.4	−3.0	0.0	4.0	0.302

SD: Standard deviation bpm: beat per minute. $: Salivary α-amlyase could not be measured in a participant.

was 33.7 min (6.3), and mean number of steps (SD) was 652.0 (449.5). The mean highest bpm (SD) of PR was 112.8 (13.5). As shown in Table 2, SBP of post-exercise (median = 139.5mmHg) was lower than that of pre-exercise (median = 141.0mmHg), but it was not significant ($p = 0.087$). DBP of post-exercise (median = 87.0mmHg) was similar to that DBP of pre-exercise (median = 87.0mmHg) ($p = 0.150$). PR of post-exercise (median = 77.0bpm) was significantly lower than that of pre-exercise (median = 78.0bpm) ($p < 0.001$).SAA of post-exercise (median = 5.0kU/L) was lower than that of pre-exercise (median = 7.0kU/L), but it was not significant ($p = 0.150$). As a result of questionnaire survey for TDMS, vitality score of post-exercise (median = 3.0) was significantly higher than that of pre-exercise (median = 2.0) ($p < 0.001$). Similarly, the pleasure score of post-exercise (median = 10.0) was significantly higher than that of pre-exercise (median = 8.0) ($p < 0.001$). Stability score of post-exercise (median = 0.0) was lower than that of pre-exercise (median = 6.0), but it was not significant ($p = 0.065$). Arousal score of post exercise (median = 0.0) was lower than that of pre-exercise (median = -4.0), but it was not significant ($p = 0.302$).

Discussion

Because PR of post-exercise was significantly lower than that of pre-exercise, it is thought that light-burden NSE program may decrease sympathetic nerve activity and/or increase parasympathetic nerve activity. Integrated yoga practice has been shown to decrease sympathetic nerve activity and increase parasympathetic nerve activity in pregnant women[14]. Streeter et al.[15] also hypothesized that yoga-based practice increases parasympathetic nerve activity. Tai et al.[16] reported that a ten-week practice of Tai Chi synergy T1 exercise enhanced parasympathetic nerve modulation and attenuated sympathetic nerve control. Young et al.[17] showed that a 12-week program of Tai Chi reduced systolic blood pressure in older people, indicating decreasing sympathetic nerve activity or increasing parasympathetic nerve activity. Our results indicate that it is likely that light-burden exercises such as Indian-style yoga and Chinese-style Tai Chi NSE programs may decrease sympathetic nerve activity and increase parasympathetic nerve activity.

Although it was not significant, SAA of post-exercise was lower than that of pre-exercise in our results. Eto[18] showed that both HR and SAA were significantly decreased after ‘Shiatsu’ (professional pressure massage by finger) to the anterior cervical region. It is speculated that ‘Shiatsu’ may decrease sympathetic nerve activity or increase parasympathetic nerve activity. Almela et al.[19] showed that HR increase was positively related to the SAA increase, and Nater et al.[20,21] reported that significant differences were found between the stress and the rest condition in SAA and HR. According to Okamoto et al.[22], there was a significantly positive correlation between SAA levels and cognitive demand stressor in drivers. These findings might show that this reduction in SAA may be mediated with decreasing sympathetic nerve activity and/or increasing parasympathetic nerve activity.

Vitality score and pleasure score in post-exercise TDMS were significantly higher than those of pre-exercise. Similarly, Kim and Sakairi[23] reported that pleasure score and vitality score in TDMS significantly increased after engaging in exercise. They inferred that individuals could regulate their mood states by appropriately taking advantage of the activation effect of exercise. From these findings, we might infer that their mood state just after NSE decreased sympathetic nerve activity and/or parasympathetic nerve activity, although the detailed mechanism is not yet clearly understood.

There are several limitations in our study. Firstly, we could not set up a control group who did not participate in NSE program. Secondly, sample size was not large. Thirdly, this interventional study was not longitudinal. Finally, participants did not receive a detailed assessment of their experience with NSE and their use of the drug. In addition, we did not set the exact rest condition of the evaluation measurement. Therefore, further research is needed to improve the study design. Accordingly, further study is necessary with improved study design.

In conclusion, because reduction in PR is brought about with decreasing sympathetic nerve activity, and an increase in parasympathetic nerve activity, it is thought that NSE may decrease sympathetic nerve activity, and/or, increase parasympathetic nerve activity.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work is supported by students at Hokkaido Chitose College of Rehabilitation. We are grateful to students at Hokkaido Chitose Rehabilitation University.

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