Effectiveness of a far-infrared low-temperature sauna program on geriatric syndrome and frailty in community-dwelling older people

Masamitsu Sugie,1,2,3 Kazumasa Harada,1,2 Tetsuya Takahashi,1,3,4 Marina Nara,1,3,5 Hajime Fujimoto,2 Shunei Kyo6 and Hideki Ito7

1Department of Geriatric Health Promotion, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan
2Department of Cardiology, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan
3Institute of Gerontology, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan
4School of Health Science, Juntendo University, Tokyo, Japan
5Japanese Association for Healthy Life Expectancy, Tokyo, Japan
6Department of Cardiac Surgery, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan
7Department of Diabetes, Metabolism, and Endocrinology, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan

Correspondence
Masamitsu Sugie, MD, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, 35-2 Sakae-cho, Itabashi-ku, Tokyo 173-0015, Japan.
Email: masamitsu_sugie@tmghig.jp

Aim: Although it is known that geriatric syndrome is associated with the development of frailty, it is not known whether an amelioration of geriatric syndrome also improves shared risk factors and frailty.

Methods: In total, 67 community-dwelling older people (79.6 ± 6.5 years, 49 women) participated in this study (41 were classified as pre-frail and 26 as frail). We analyzed indices of physical frailty and cognitive depression, exercise tolerance and health-related quality of life as frailty related indices, and the participants completed a questionnaire regarding common geriatric symptoms (cold extremities, leg edema, breathlessness, urinary incontinence, chronic headache, chronic pain, a sense of numbness, anorexia, constipation, insomnia and skin trouble) using numeric ratings. Frailty was evaluated using the Japanese version of the Cardiovascular Health Study (J-CHS) criteria. The participants then underwent a far-infrared low-temperature sauna (FILTS) program twice a week for 3 months and the above parameters were reassessed.

Results: After the FILTS program, there were significant differences in usual walking speed, peak oxygen uptake, Geriatric Depression Scale-15, health-related quality of life and the severity of several geriatric symptoms. Of the 67 participants, 18 showed improvements in their J-CHS frailty score, 47 showed no change and two showed reductions. Linear regression analysis showed that the change in the numeric rating of the coldness of extremities (B = −0.105, P = 0.013) and the cumulative numeric rating for geriatric syndromes (B = 0.044, P < 0.001) were independent determinants of the change in the J-CHS score.

Conclusions: A 3-month FILTS program ameliorates geriatric syndrome, the severity of frailty and frailty related indices in older Japanese people. Geriatr Gerontol Int 2020; 20: 892–898.

Keywords: accumulation deficit model, far-infrared low-temperature sauna, frailty, geriatric syndrome, low fitness.

Introduction

In our aging society, there is an urgent demand for measures to prevent frailty and disability in community-dwelling older people. Frailty is a common clinical syndrome in older adults that carries a higher risk of poor health outcomes, including falls, disability, hospitalization and mortality.1-3 Frailty is a biological syndrome that can manifest in a number of ways, but can be defined as the
presence of three or more of the following five components: un-  
intentional weight loss, self-reported exhaustion, weakness, slow  
walking speed and low physical activity.2,6 Inouye et al. proposed a  
unifying conceptual model in which shared risk factors may lead  
to the development of geriatric syndromes; in turn these may lead to  
frailty, with feedback mechanisms increasing the incidence of  
shared risk factors and geriatric symptoms, ultimately leading to  
disability, dependence and death.7 However, it is not known  
whether an amelioration of the geriatric syndrome would interrupt  
the feedback mechanisms, thereby improving shared risk factors  
and frailty.

Common geriatric conditions include delirium, falls, frailty,  
dizziness, syncope and urinary incontinence,7 but we also fre-  
quently encounter problems with cold extremities, anorexia, con-  
stipation, chronic pain, breathlessness, urinary incontinence,  
chronic headache, insomnia, leg edema and skin problems, which  
may or may not be clinically significant, in elderly Japanese  
outpatients.

We hypothesized that far-infrared low-temperature saunas  
(FILTS) might be able to reduce the degree of frailty in the elderly  
population, thereby interrupting feedback mechanisms and ame-  
liorating shared risk factors and the geriatric syndrome.

A previous study has shown that FILTS ameliorates: dyspnea  
associated with chronic heart failure (i.e., Waon therapy) and  
chronic obstructive pulmonary disease; exercise intolerance asso-  
ciated with chronic heart failure; pain associated with fibromyal-  
gia, chronic fatigue syndrome; ulcers and other skin lesions  
associated with peripheral artery disease; constipation associated  
with ileus; mild depression; and anorexia associated with depres-  
sion.8 Although these symptoms are associated with specific dis-  
esases, many are consistent with those reported in geriatric people.

Therefore, in the present study, we aimed to determine  
whether FILTS ameliorates features of the geriatric syndrome,  
and whether such improvement is associated with the amelioration  
of frailty and frailty related indices.

Methods

Participants

Sixty-seven community-dwelling older people (18 men and  
49 women) living in the Tokyo metropolitan area participated in  
this study. Their mean age was 79.6 ± 6.5 years (range  
66–93 years). None of the participants were hospitalized at the  
time, but all were being treated on an outpatient basis at the  
Tokyo Metropolitan Geriatric Hospital and Institute of Geron-  
tology. The inclusion criteria were as follows: pre-frailty or frailty,  
determined using the Japanese version of the Cardiovascular  
Health Study (J-CHS) criteria9; lack of participation in an exercise  
determined using the Japanese version of the Cardiovascular  
time, but all were being treated on an outpatient basis at the  

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Criteria for the diagnosis of pre-frailty and frailty

Frailty and pre-frailty were diagnosed using the Japanese version  
of the Cardiovascular Health Study (J-CHS) criteria.9 These  
criteria include five domains: weight loss, slowness, weakness,  
exhaustion and low physical activity. The participants were classi-  
fied as robust, pre-frail or frail, as previously described.10

Geriatric syndrome questionnaire with numeric rating scale

We created a questionnaire that aimed to grade the symptoms  
of geriatric syndrome. The symptoms that were assessed using this  
questionnaire were coldness of extremities, leg edema, breathless-  
ness, urinary incontinence, chronic headache, chronic pain (e.g.,  
knee pain or back pain), a sense of numbness, anorexia, con-  
stipation, insomnia and skin trouble, all of which are features of  
geriatric syndrome in outpatients. The questionnaire was used to  
record the presence or absence of each symptom, and to grade the  
severity of each using a numeric rating scale from 0 to 10, where  
10 is very severe. The major symptoms of geriatric syndrome, falls  
and aspiration, were excluded from this questionnaire because  
these can be recorded as present or absent, but it is difficult to  
grade their severity using a numeric scale.

Far-infrared low-temperature sauna program

The FILTS program used a far-infrared dry sauna (Onkan-  
rebalance OR-1507; Digi-Tech Corporation, Takaoka City,  
Toyama Prefecture, Japan) that was maintained at 60°C. Particip-  
ants remained seated for 15 min, and then rested in a supine  
position, while covered with a warm blanket, for an additional  
30 min. All the participants were weighed before and after each  
FILTS session and instructed to drink more water than their  
weight loss from perspiration. The FILTS program consisted of  
two sessions per week for 3 months, for a total of 24 sessions.

Evaluation of physical performance and other parameters

Body composition was assessed using skeletal muscle mass index  
and body mass index. Physical performance was assessed using  
handgrip strength, timed up-and-go test and usual walking speed  
(UWS). Cognitive function and depressive symptoms were assessed  
using the Japanese version of the Montreal Cognitive Assessment  
(MoCA-J)11 and the 15-item Geriatric Depression Scale (GDS-15).12  
HRQOL13 was assessed using a physical component scale (PCS) and  
a mental component scale on Short Form-8 (SF-8). Finally, exercise  
tolerance was assessed using cardiopulmonary exercise testing. All  
of these assessments were evaluated as previously described.10,14–17

Statistical analysis

A sample size of 54 participants was calculated for 80% power,  
α = 0.05, β = 0.2, and anticipated effect size = 0.35 (linear multiple  
regression: fixed model, R2 deviation from zero; a priori: compute  
the required sample size – given α, power and effect size) using sample  
size software (G*Power 3.1.9.2, Heinrich-Heine-Universität  
Düsseldorf, Germany).

The chi-squared test was used to compare the prevalence of  
age-related disease(s) between pre-frail and frail older people  
(Table 1). To compare the numeric ratings of geriatric syndrome  
and frailty related indices between baseline and the end of the  
3-month FILTS program, we performed Wilcoxon signed rank
Chi-squared tests (McNemar’s tests) were performed to compare the pre-frail and frail groups at baseline and after the 3-month FILTS program (Table 4). To determine whether frailty was affected by the presence of the geriatric syndrome, multiple linear regression analysis was used to predict the change in J-CHS score, after adjustment for the changes in the numeric rating of coldness of extremities, leg edema, breathlessness while walking, urinary incontinence, chronic pain, skin trouble, cumulative numeric rating of geriatric syndrome, age and sex (Table 5). To compare each index of frailty between baseline and the end of the 3-month FILTS program we performed chi-squared tests (McNemar’s test) (Table S1).

COPD, chronic obstructive pulmonary disease. Comparisons were made using the chi-squared test.

### Table 1  Participants’ characteristics and comparisons of the characteristics between pre-frail and frail participants

| Condition                      | All n = 67 (%) | Pre-frail n = 41 (%) | Frail n = 26 (%) | p    |
|--------------------------------|----------------|----------------------|-----------------|------|
| Hypertension                   |                |                      |                 |      |
| -                              | 32 (47.6)      | 21 (51.3)            | 11 (41.7)       | 0.458|
| +                              | 35 (52.4)      | 20 (48.7)            | 15 (58.3)       |      |
| Diabetes mellitus              |                |                      |                 |      |
| -                              | 50 (74.2)      | 30 (73.7)            | 20 (76.9)       | 0.908|
| +                              | 17 (25.8)      | 11 (26.3)            | 6 (23.1)        |      |
| Dyslipidemia                   |                |                      |                 |      |
| -                              | 42 (62.9)      | 26 (63.2)            | 16 (62.5)       | 0.958|
| +                              | 25 (37.1)      | 15 (36.8)            | 10 (37.5)       |      |
| Atrial fibrillation            |                |                      |                 |      |
| -                              | 62 (91.9)      | 37 (89.5)            | 25 (95.8)       | 0.64 |
| +                              | 5 (8.1)        | 4 (10.5)             | 1 (4.2)         |      |
| Coronary artery disease        |                |                      |                 |      |
| -                              | 53 (79.0)      | 32 (78.9)            | 21 (79.2)       | 0.984|
| +                              | 14 (21.0)      | 9 (21.1)             | 5 (20.8)        |      |
| Chronic heart failure          |                |                      |                 |      |
| -                              | 56 (83.9)      | 35 (84.2)            | 22 (83.3)       | 0.927|
| +                              | 11 (16.1)      | 6 (15.8)             | 4 (16.7)        |      |
| Previous cardiac surgery       |                |                      |                 |      |
| -                              | 61 (90.3)      | 37 (89.5)            | 24 (91.7)       | 0.776|
| +                              | 6 (9.7)        | 4 (10.5)             | 2 (8.3)         |      |
| Cerebral infarction            |                |                      |                 |      |
| -                              | 62 (91.9)      | 38 (92.1)            | 24 (91.7)       | 0.951|
| +                              | 5 (8.1)        | 3 (7.9)              | 2 (8.3)         |      |
| COPD                           |                |                      |                 |      |
| -                              | 66 (98.4)      | 41 (100.0)           | 25 (95.8)       | 0.205|
| +                              | 1 (1.6)        | 0 (0.0)              | 1 (4.2)         |      |
| Chronic kidney disease         |                |                      |                 |      |
| -                              | 63 (93.7)      | 38 (92.3)            | 25 (95.8)       | 0.577|
| +                              | 4 (6.3)        | 3 (7.7)              | 1 (4.2)         |      |
| Arteriosclerosis obliterans     |                |                      |                 |      |
| -                              | 67 (100.0)     | 41 (100.0)           | 26 (100.0)      |      |
| +                              | 0 (0.0)        | 0 (0.0)              | 0 (0.0)         |      |
| Knee osteoarthritis            |                |                      |                 |      |
| -                              | 58 (87.3)      | 34 (82.1)            | 25 (95.8)       | 0.111|
| +                              | 9 (12.7)       | 7 (17.9)             | 1 (4.2)         |      |
| Osteoporosis                   |                |                      |                 |      |
| -                              | 63 (93.5)      | 38 (92.1)            | 25 (95.8)       | 0.561|
| +                              | 4 (6.5)        | 3 (7.9)              | 1 (4.2)         |      |
| Cancer                         |                |                      |                 |      |
| -                              | 64 (95.2)      | 41 (100.0)           | 24 (91.7)       | 0.07 |
| +                              | 3 (4.8)        | 0 (0.0)              | 2 (8.3)         |      |
| Lumbar canal stenosis          |                |                      |                 |      |
| -                              | 58 (87.1)      | 35 (84.2)            | 24 (91.7)       | 0.394|
| +                              | 9 (12.9)       | 6 (15.8)             | 2 (8.3)         |      |

Comparisons were made using Wilcoxon signed rank test.
statistical analyses were performed using the Statistical Package for the Social Sciences version 22 (IBM Japan, Tokyo, Japan), and the significance level was set at $P = 0.05$ for all the tests.

Ethical considerations

This study was approved by the ethics committee of the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology (authorization number: 240301) and conformed with the principles outlined in the Declaration of Helsinki. All participants gave their written informed consent before data collection.

Results

In total, 67 participants successfully completed the 3-month FILTS program and no adverse events related to the program were recorded; 41 (61.2%) participants were classified as pre-frail and 26 (38.8%) as frail. The pre-frail and frail participants were of similar ages (78.9 ± 6.3 vs. 80.5 ± 6.7 years). The clinical characteristics of each group are summarized in Table 1; there were no significant differences between the pre-frail and frail participants.

Table 2 shows the prevalence of each symptom and the change in the numeric rating of the geriatric syndrome during the FILTS program. There were significant improvements in the scores for coldness of extremities, leg edema, breathlessness while walking, urinary incontinence, chronic pain and skin problems, and the cumulative numeric rating of geriatric syndrome also improved. Furthermore, the ratings for none of the symptoms worsened during the FILTS program.

Table 3 shows the changes in frailty related indices during the 3-month FILTS program. Significant improvements occurred in UWS (m/s), peak VO$_2$/weight (mL/kg/min), peak power (W), GDS-15 score and PCS in SF-8; none of the indices worsened during the program. Among the components of SF-8, significant improvements occurred in physical function (42.0 vs. 45.0, $P = 0.007$), general health (46.3 vs. 48.4, $P = 0.025$) and emotional score (47.4 vs. 49.6, $P = 0.021$). There were no significant changes in physical score (43.5 vs. 45.7, $P = 0.101$), physical pain (43.9 vs. 44.2, $P = 0.816$), vitality (47.4 vs. 48.3, $P = 0.207$), social functioning (47.9 vs. 49.3, $P = 0.150$) or mental health (48.3 vs. 50.2, $P = 0.054$).

Table 4 shows the change in frailty status of the participants during the 3-month program. Of the 41 pre-frail participants, seven (17.1%) improved to become robust, 32 (78.0%) remained pre-frail and two (4.9%) deteriorated to become frail. Of the 26 participants in the frailty group, 11 (42.3%) improved to become pre-frail and 15 (57.7%) remained frail (McNemar’s test, $P < 0.05$).

We compared each index of frailty (weight loss, slowness, weakness, exhaustion and low physical activity) before and after

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**Table 3** Comparison of frailty related physical indices before and after the intervention

|                          | Pre-intervention | Post-intervention | $P$  |
|--------------------------|------------------|-------------------|------|
|                          | Mean ± SD        | Mean ± SD         |      |
| Body mass (kg)           | 51.3 ± 10.5      | 51.0 ± 10.2       | 0.20 |
| Body mass index (kg/cm$^2$) | 22.3 ± 3.5      | 22.2 ± 3.3        | 0.41 |
| Skeletal muscle mass index (kg/cm$^2$) | 6.0 ± 0.9       | 6.0 ± 0.9         | 0.37 |
| Men                      | 6.5 ± 1.1        | 6.5 ± 1.1         | 0.95 |
| Women                    | 5.8 ± 0.6        | 5.7 ± 0.7         | 0.67 |
| Hand grip strength (kg)  | 17.6 ± 6.2       | 17.4 ± 6.3        | 0.60 |
| Men                      | 24.3 ± 8.6       | 22.1 ± 9.4        | 0.14 |
| Women                    | 14.0 ± 3.5       | 14.9 ± 3.3        | 0.57 |
| Usual walking speed (m/s) | 0.7 ± 0.2        | 0.9 ± 0.2         | 0.05 |
| Timed up-and-go test (s) | 10.5 ± 5.2       | 10.0 ± 5.0        | 0.14 |
| Peak oxygen uptake/weight (mL/kg/min) | 14.3 ± 4.5       | 15.3 ± 4.5        | <0.001 |
| Peak metabolic equivalent | 4.1 ± 1.4       | 4.4 ± 1.4         | 0.08 |
| Peak power (W)           | 54.6 ± 24.5      | 59.8 ± 26.1       | <0.001 |
| MOCA-J                   | 22.6 ± 4.9       | 22.3 ± 5.4        | 0.37 |
| 15-item Geriatric Depression Scale | 4.7 ± 3.4       | 4.1 ± 3.4         | 0.04 |
| Physical component scale (SF-8) | 40.8 ± 8.1     | 42.7 ± 7.9        | 0.03 |
| Mental component scale (SF-8) | 50.0 ± 8.3     | 51.3 ± 7.5        | 0.13 |

MoCA-J, Japanese version of the Montreal Cognitive Assessment; SF-8, Short-Form Survey 8, Japanese version. Comparisons were made using Student’s $t$-test.
Table 5  Multiple regression analysis for the prediction of the change in the Japanese version of the Cardiovascular Health Study score

| Model 1 | B      | β      | P-value | LCI    | UCI    |
|---------|--------|--------|---------|--------|--------|
| Change in the cumulative numeric rating of geriatric syndrome | -0.334 | 0.011  | 0.0588 | -0.079 |
|         | 0.030  | 0.324  | 0.008   | 0.008  | 0.052  |

Model 2

| Change in the cumulative numeric rating of geriatric syndrome | -0.359 | 0.005  | 0.604  | -0.114 |
|         | 0.044  | 0.472  | <0.001  | 0.020  | 0.067  |
| Change in the numeric rating of coldness of extremities | -0.105 | -0.323 | 0.013   | -0.188 | -0.023 |

R² = 0.190.

B, regression coefficient; LCI, lower 95% confidence interval; UCI, upper 95% confidence interval.

The analysis was adjusted for the change in numeric rating of coldness of extremities, leg edema, breathlessness while walking, urinary incontinence, chronic pain, skin trouble, age, sex and the change in the cumulative numeric rating of geriatric syndrome.

our dataset, we found that the FILTS program, which was used in the present study, resulted in significant improvements in the Japanese version of the Cardiovascular Health Study score and the cumulative numeric rating of geriatric syndrome, as well as other geriatric syndromes. The analysis was adjusted for changes in numeric rating of coldness of extremities, leg edema, breathlessness while walking, urinary incontinence, chronic pain, skin trouble, age, sex and the cumulative numeric rating of geriatric syndrome.

Discussion

Our study used data from consecutively recruited pre-frail and frail older outpatients. Patients had no one specific underlying condition and were regularly attending the Tokyo Metropolitan Geriatric Hospital as outpatients for the management of chronic diseases. The prevalences of pre-fraility and frailty were 61.2% and 38.8%, respectively. A previous study reported the prevalences of the frailty in the Japanese population. Therefore, the prevalence of frailty in the participants in the present study was higher than that of the general population.

In total, 67 participants successfully completed the 3-month FILTS program and experienced no adverse events, which demonstrates the safety of FILTS for community-dwelling pre-frail and frail outpatients with chronic disease (Table 1). Table 2 shows the prevalence of common symptoms comprising geriatric syndrome in this study. According to the Comprehensive Survey of Living Conditions by the Ministry of Health, Labor and Welfare, Japan, the prevalences of these symptoms are cold extremities (0.7%), leg edema (1.8%), breathlessness (2.0%), urinary incontinence (1.6%), chronic headache (5.2%), chronic pain (back pain (16.6%) and joint pain (9.7%), a sense of numbness (4.2%), anorexia (0.4%), constipation (2.3%), insomnia (2.0%) and skin problems (1.6%) in community-dwelling older people. Therefore, the prevalences of these symptoms were high in the present sample of pre-frail and frail older people. Table 2 also shows that the FILTS program was effective at reducing the severity of some of these symptoms (coldness of extremities, leg edema, breathlessness while walking, urinary incontinence, chronic pain and skin trouble) and the cumulative numeric rating scale score for geriatric syndromes. However, it must be noted that the participants also continued taking their existing medication, rehabilitation folk remedies and/or supplements during the study.

Table 3 shows that the participants had relatively poor physical function, mild cognitive impairment, low physical HRQOL and, in particular, low physical fitness (peak VO₂/weight 14.3 ± 4.5 mL/kg/min and peak metabolic equivalent (METs) 4.1 ± 1.4 METs). Previously, we have reported that the peak VO₂/weight and peak METs in robust, pre-frail and frail individuals are 18.7 ± 4.0 mL/kg/min and 5.6 ± 1.0 METs, 16.7 ± 4.5 mL/kg/min and 5.2 ± 1.0 METs, and 14.7 ± 4.1 mL/kg/min and 4.4 ± 0.9 METs, respectively. In addition, it is well known that a peak VO₂/weight ≤14 mL/kg/min is a hallmark of low physical fitness, and it is accepted as an indication for cardiac transplantation in patients with heart failure with severe left ventricular dysfunction.

Table 3 also shows the effectiveness of the program with regard to UWS, peak VO₂/weight, peak power, GDS and SF-8 PCS. It ameliorated weight loss and low physical activity but not slowness (there was an improvement in UWS from 0.7 ± 0.2 m/s [P < 0.05], but the cut-off value of UWS for frailty is 1.0 m/s), weakness or exhaustion (Table S1).

In addition, we analyze gender-specific analyses among UWS, peak VO₂/weight, peak power, because these frailty related indices were expected gender differences. Significant differences were seen in UWS (0.74 ± 0.20 to 0.86 ± 0.20 m/s, P = 0.03), peak VO₂/weight (14.6 ± 4.6 m/s to 15.6 ± 4.7 mL/kg/min, P = 0.003), peak power (52.5 ± 23.8 W to 56.8 ± 23.1 W, P = 0.004) among female, but not in male (UWS: 0.82 ± 0.3 to 0.79 ± 0.26 m/s, P = 0.52, peak VO₂/weight: 13.7 ± 4.4 m/s to 14.7 ± 4.2 mL/kg/min, P = 0.11, peak power: 65.1 ± 27.2 to 73.0 ± 33.3 W, P = 0.07).

Table 4 shows that FILTS can ameliorate frailty. Of the 67 participants, 18 (26.9%) improved, 47 (70.1%) were unaffected and two (3.0%) worsened during the program. This might be the result of the FILTS program, but it might also have been the result of natural transitions. A previous study showed that individuals classified as pre-frail were subsequently classified as robust, pre-frail or frail, with prevalences of 23.1%, 58.2% and 18.2%, respectively, after 3.9 years, and those who were classified as frail were subsequently classified as robust, pre-frail and frail, with prevalences of 3.3%, 40.3% and 54.5% after the same period of time had elapsed. However, the natural transitions between categories have not been characterized in the short term, such as during a 3-month period.

We next used multiple linear regression analysis to determine whether the J-CHS score improved because of the changes in
numeric ratings for each of the symptoms, and found that the cumulative numeric rating for geriatric syndrome improved during the FILTS program. Table 5 shows that the changes in numeric rating for coldness of extremities and the cumulative numeric rating for geriatric syndrome are independent determinants of the change in J-CHS score. This finding might indicate that FILTS improves frailty by ameliorating the geriatric syndrome. Given that the change in the numeric rating of coldness of extremities is an independent determinant of the change in J-CHS score, FILTS may be a useful tool to ameliorate frailty; more generally, warming for older people with pre-frailty or frailty may be beneficial. In addition, because the change in cumulative numeric rating of geriatric syndrome is an independent determinant of the change in J-CHS score, FILTS might also improve frailty by ameliorating shared risk factors and the geriatric syndrome.

Mintz et al. first described the accumulation of deficits in older people in the Frailty Index, which incorporates the following in one index: symptoms; signs; diseases; disabilities; laboratory, radiographic and electrocardiographic abnormalities; and social characteristics. The results of the present study show that reducing the severity of symptoms of the geriatric syndrome is associated with an improvement in frailty score. However, the frailty score used in the present study depended on the phenotype of the frailty, and therefore might represent a subtype of accumulation deficit model. Nevertheless, the results of the present study suggest that measures aimed at reducing the severity of the geriatric syndrome are an important means of reducing frailty, and that FILTS might represent a suitable method of achieving this.

To date, changes in exercise and nutrition have been used to prevent or ameliorate frailty in older adults. However, in our aging society, many older people cannot exercise because of poor physical function and low fitness. Therefore, FILTS might represent an alternative method of treating unfit older people with poor physical function.

The present study had several limitations. First, although we recruited clinical outpatients consecutively and non-selectively, there may have been some bias. This could be because we excluded potential participants with acute or unstable diseases and those who regularly exercised. Second, our sample size was relatively small to describe the data of each gender, and third, there was no control group.

In conclusion, amelioration of the geriatric syndrome, with a 3-month FILTS program, is associated with an improvement in frailty score and frailty related indices in a group of elderly Japanese people.

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Disclosure statement

The authors declare no conflict of interest.

Author contributions

MS, TT, MN and KH made substantial contributions to the study design. MS, TT and MN contributed to the acquisition of data and performed the statistical analyses. KH, HF, SK and HI contributed to interpreting the data. MS, KH, TT and MN wrote the manuscript drafts. All the authors critically reviewed and contributed significantly to the intellectual content of the manuscript. All the authors agreed on the final content of the manuscript.

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**Supporting Information**

Additional supporting information may be found in the online version of this article at the publisher’s website:

**Table S1** Comparisons of the indices of frailty (weight loss, slowness, weakness, exhaustion, low physical activity) before and after the intervention using the chi-squared test.

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