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学　位　論　文

A cross-sectional study on characteristics of physical activity in pre-frail older adults

（ プレ・フレイル高齢者における身体活動
の特徴に関する横断研究 ）

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論　文　内　容　要　旨（和文）

学位論文題名	A cross-sectional study on the characteristics of physical activity in pre-frail older adults （ プレ・フレイル高齢者における身体活動の特徴に関する横断研究 ）

【目 的】　これまでのフレイル研究において、フレイルの前段階にあるプレ・フレイルとその身体活動の関連に着眼した研究は少ない。本研究の目的は、普段、住民主体の自主グループ活動に参加している高齢者と参加していない高齢者に分け、それぞれの集団におけるノン・フレイルとプレ・フレイルの身体活動量を比較検討することである。それによって、プレ・フレイル高齢者の身体活動の特徴を明らかにする。

【方 法】　対象は、宮城県山元町に居住する 65 歳以上の高齢者で、住民主体の自主運動グループ活動（ダンベル体操教室）に参加している高齢者（自主活動参加群）と地区の老人会の催し物に集まった高齢者（自主活動非参加群）に分け調査を行った。2017 年 9～12 月の期間に実施した。調査・測定項目は、基本情報と社会的情報、基本チェックリストの回答に加え、身体機能評価として 5m 通常歩行、握力、開眼片足立ち時間を測定した。身体活動量の評価は 3 軸加速度計により 7 日間の計測を実施し、身体活動時間と 1 日平均歩数を収集した。身体活動は、活動強度により座位行動、低強度身体活動、中高強度身体活動に分類した。フレイルの判定には Freid らの基準を日本人用に改変した J-CHS（Cardiovascular Health Study）の指標を用いた。該当項目なしをノン・フレイル、1～2 項目該当をプレ・フレイルと判定し、フレイル（3～5 項目）該当者は今回除外した。統計解析は、自主活動参加群と非参加群に層化し、プレ・フレイルの有無を独立変数、座位行動および各身体活動、歩数を従属変数として、年齢、性別、教育歴、加速度計装着時間で調整した共分散分析を行った。さらに、フレイルとの関連のある身体的要因、心理精神的要因、社会的要因についてもそれぞれ調整し、分析を行った。

【結 果】　解析対象は 256 名で、活動参加群が 190 名（うちプレ・フレイル 42%）、非参加群は 66 名（うちプレ・フレイル 52%）であった。活動参加群のプレ・フレイルではノン・フレイルの身体活動量と比べ有意差はみられなかった。一方、非参加群のプレ・フレイルでは中高強度身体活動（P=0.003）、歩数（P=0.005）が有意に低下していた。これらの結果は、共変量で調整後もその傾向は変わらなかった。

【結 論】　プレ・フレイル高齢者の身体活動の特徴は、自主活動参加群と非参加群では異なる活動量を示すことがわかった。普段、自主運動グループ活動に参加しているプレ・フレイル高齢者では、プレ・フレイルの状態にあってもノン・フレイルと同程度の身体活動量が維持されていた。一方、非参加群のプレ・フレイルでは中強度以上の身体活動量が特に低下しており、これと関係の深い 1 日の平均歩数が減少していた。今後はさらに縦断研究や介入研究を行い、より詳細な結果の検証が望まれる。

A cross-sectional study on the characteristics of physical activity in pre-frail older adults

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Abstract

This cross-sectional study aimed to characterize the physical activity (PA) of older adults in the pre-frail status by examining sedentary behavior (SB) and PA using tri-axial accelerometer data, with non-frail older adults as the controls. In this study, we divided the study participants into older adults who regularly participate in self-initiated citizen's exercise group activities and those who do not participate. Moreover, we compared and examined the physical activities of pre-frail and non-frail older adults to clarify the characteristics of PA of pre-frail older adults. We analyzed the data from 256 community-dwelling older adults aged ≥65 years who participated in the survey from September to December 2017. Frailty was determined using the Japanese version of the Cardiovascular Health Study modifying the criteria proposed by Fried et al.

As a result of moderate-to-vigorous physical activity (MVPA) and the daily mean number of steps (steps) were significantly lower in the pre-frail older adults who did not participate in the activities, even when adjusted for physical, psychosocial, and social factors. In contrast, pre-frail older adults who participated in the activities, and there was no difference in the length of SB and PA time with that of non-frail older adults, indicating that the PA level was maintained. Therefore, the opportunity to participate in self-initiated citizen's exercise group activities and other physical activities in the community may be a useful initiative to maintain the PA of pre-frail older adults from declining. Further it is hoped that conducting a longitudinal or intervention study will provide more detailed verification of the results.

Keywords:

pre-frailty,

physical activity,

moderate-to-vigorous physical activity,

self-initiated citizen's exercise group activities

Abbreviations:

physical activity (PA)

sedentary behavior (SB)

light-intensity physical activity (LPA)

moderate-to-vigorous physical activity (MVPA)

metabolic equivalent units (METs)

analysis of covariance (ANCOVA)

1. Introduction

Recent studies on frailty in older adults have been conducted in a wide range of fields, examining not only the physical problems associated with frailty, such as sarcopenia [1, 2] and falls [3], but also mental and psychosocial problems, such as cognitive dysfunction and depression, and social problems, such as solitude and being homebound. Among these, physical frailty, in particular, is a condition resulting in lifestyle dysfunction caused by a decline in motor function due to aging, and this is related to subsequent prognosis, with a high proportion of older adults transitioning to needing support and nursing care [4-6], with increased mortality risk [7, 8].

Various risk factors have been associated with progression to frailty in older adults, such as prolonged sedentary lifestyle and decline in the amount of physical activity (PA) [9, 10]. Frailty is considered reversible and said to be a state in which functioning can be maintained or improved with appropriate intervention and support, and studies have shown the beneficial effects of various intervention programs. Recent studies on sedentary behavior (SB) and PA are divided into approaches for reducing the risk of frailty, whether the best approach is reducing sedentary time and replacing it with low-intensity physical activity (LPA) time [11, 12] or moderate-to-vigorous physical activity (MVPA) time [13, 14]. However, intervention has limited effect in older adults with severely advanced frailty [15, 16]. Many previous studies compared non-frail or pre-frail older adults and frail older adults and showed reduced PA in frail older adults [17, 18], with a clear focus on the frailty status. Very few studies have reported detailed characteristics of older adults in the preliminary pre-frail status [3, 19]. Therefore, the hypothesis of this study is that there may be a slight change in SB time, LPA and MVPA time, and number of steps in the transition stage from the non-frail to pre-frail status. This study aimed to verify this hypothesis.

In contrast, the practice and effects of various intervention programs have been previously reported as measures to prevent frailty. A systematic review by Apostlo et al. reported that group physical exercise programs improved frailty, but there was insufficient evidence on individual exercise [20]. In Japan, which is facing a super-aged society, proactive efforts are underway to prevent the need for long-term care, including measures against frailty. Among these types of intervention programs, providing a place for exercise and interaction through self-initiated citizen's exercise group activities, conducted mainly by local residents, has been shown to be effective for preventing frailty [21]. However, previous studies have not clarified the differences in PA between pre-frail and non-frail older adults depending on whether they participate in self-initiated citizen's exercise group activities. The second hypothesis of this study is that there may be a difference in PA time between pre-frail and non-frail older adults, regardless of whether they participate in self-initiated citizen's exercise group activities.

In this study, we divided the study participants into older adults who regularly participate in self-initiated citizen's exercise group activities and those who do not participate. Moreover, we compared and examined the physical activities of pre-frail and non-frail older adults, with non-frail older adults as the control, to clarify the characteristics of PA in pre-frail older adults.

2. Materials and Methods

2.1. Study design

This study was performed in a cross-sectional design implemented from September to December 2017.

2.2. Participants

The target area of this study was the town of Yamamoto in Miyagi Prefecture. As of 2017, the total population is 12,469, and there are 4,718 individuals aged ≥ 65 years (aging rate, 37.8%).

The study participants were older adults aged $\geq$ 65 years who participated in self-initiated citizen's exercise group activities run in 19 locations in the town, through invitation from the Yamamoto Community General Support Center, and participated in senior's club networking events held in three districts in the town.

The self-initiated group exercise is held about once a week, with the residents gathering for a 90-min program. The program is a multicomponent exercise incorporating balance exercises, step exercises, stretching exercises, and various games. Participants usually perform dumbbell exercises with moderate intensity using light dumbbells load of 300–700 g. It is also an opportunity for participants to interact with each other. Participants in the local senior's club networking events are local residents who are invited by the district officers and local welfare commissioners. The networking events are held approximately 2–3 times a year. In this study, the participants were divided into two groups: participants in the self-initiated exercise group activities formed the participation group, and those who gathered at the senior's club networking events formed the non-participation group. Older adults participating in both opportunities were included in the participation group. The inclusion criteria were the ability to walk on their own and independent performance of basic activities of daily living. The exclusion criteria were presence of severe underlying illness and difficulty in communicating.

All participants were provided verbal explanations on the research objectives, body measurements, questionnaire survey, and request for wearing the accelerometer, and written informed consent was obtained. The survey was approved by the ethical review committee of Tohoku Fukushi University on July 27, 2017 (No. RS170708) and Fukushima Medical University on September 12, 2017 (No. 29174).

2.3. Criteria of physical frailty

This study used the Japanese version of the Cardiovascular Health Study (J-CHS) [22], an improved version of the frailty phenotype (CHS criteria) [23] proposed by Fried et al. as an indicator of frailty, modified to better suit the Japanese population. Frailty was determined based on the following five items: 1) shrinking (unintentional weight loss of up to 3 kg in the past 6 months), 2) weakness (hand grips: male <26 kg, female <18 kg), 3) exhaustion (positive answer to the question "Did you feel exhausted without any reason in the last 2 weeks?"), 4) slowness (walking speed <1.0 m/s), and 5) low physical activity (negative answer to both questions, "How many days per week do you engage in light exercise or calisthenics?" and "How many days per week do you engage in regular exercise or sport?"). The participants were classified as non-frail when none of the items were applicable to their circumstances, pre-frail when one to two items were applicable, and frail when three or more items were applicable. However, the participants who were determined to be frail were excluded from the analysis in this study.

2.4. Questionnaire survey

Information on the participants' basic characteristics, including age, sex, educational history, whether they lived alone, current alcohol consumption, and smoking, was collected using a self-administered questionnaire. Information on past or present history of low back pain, knee pain, stroke, hypertension, heart disease, diabetes mellitus, osteoporosis, and arthropathy was also examined to check for pain and comorbidities. In this study, we also used the Kihon Checklist (KCL) [24]as a comprehensive evaluation of physical and mental function. The KCL consists of 25 questions, which the respondent answers with "yes" or "no" based on their own subjective viewpoint. The survey items include activities parallel to daily living (No.1 to 5), decline in motor function (No. 6 to 10), 3/5 items or more; malnutrition (No. 11 to 12), 2/2 items or more; decline in oral function (No. 13 to 15), 2/3 items or more; homebound (No. 16 to 17), 2/2 items or more; decline in cognitive function (No. 18 to 21), 1/3 items or more; and depression (No. 20 to 25): No. 25 overlaps with the criteria for determining frailty, so this item is excluded and depression is defined as 2/4 items or more.

2.5. Physical function and physical performance

All surveys were held at venues, such as meeting and public halls, in each district in the town, and the measurement sessions were performed by well-trained staff who assisted in filling the questionnaires, measured physical fitness, and explained the accelerometer survey. The participants' height and weight were measured, and body mass index was calculated. Walking speed was measured twice at the subject's normal walking speed over a distance of 5 m, and the walking speed (m/s) was the mean of the two measurements. Grip strength was measured using a digital grip strength dynamometer (TKK 5401 Grip-D; Takei Scientific Instruments, Tokyo, Japan). The measurement was performed in standing position, and the mean was calculated based on two measurements. The task of one-leg standing with eyes open was performed twice using the leg on which the participants found it easy to stand, and the maximum of the two measurements was used. The maximum time was 60 s, and if the subject reached 60 s in the first measurement, the second measurement was not obtained.

2.6. Sedentary behavior and physical activity assessment

SB and PA time were measured using a tri-axial accelerometer (Active style Pro HJA-750C; Omron Healthcare, Kyoto, Japan). The validity of the Active style Pro in estimating activity intensity has been confirmed [25, 26]. The participants were requested to wear an accelerometer on their waist for seven consecutive days from when they wake up in the morning until they went to bed at night and could remove it only when bathing or swimming. During the survey, the accelerometer was programmed such that only the clock was displayed on the device to minimize the situation of PA being promoted by wearing the accelerometer [27]. The accelerometer epoch length was set to 1 min [28]. The accelerometer data usage criterion was defined as non-wearing time when the accelerometer had no signal (estimated intensity of ≤0.9 metabolic equivalent units [METs]) for ≥60 min (with allowance for up to 2 min of some limited movement [≤1.0 METs]) [12, 29]. In addition, the participants who wore the device for ≥10 h a day (600 min) and recorded valid data for ≥4 days (including 1 day off) of 7 consecutive days were included in the analysis [30, 31]. Individual PA was based on the activity intensity evaluated from the number of steps recorded on the accelerometer, with activity of ≤1.5 METs defined as SB, 1.6–2.9 METs defined as light-intensity PA (LPA), and ≥3.0 METs defined as moderate-to-vigorous PA (MVPA) [32].

2.7. Statistical analyses

The mean value and standard deviation were calculated for accelerometer wearing time, SB time, LPA time, and MVPA time. The ratio (%) of SB and PA time to the wearing time was also calculated.

The t-test and Mann-Whitney U test for continuous scale were used to compare the basic attributes of pre-frail and non-frail older adults, and the χ^2 test or Fisher's exact test for nominal scale was used for intergroup comparison. The comparison of SB time, PA time, and number of steps between the pre-frail and non-frail older adults was performed using analysis of covariance (ANCOVA) adjusted for age, sex, educational history, and accelerometer wearing time (model.1) [12]. Simultaneously, low back pain, knee pain, and cardiovascular disease were adjusted with covariates as frailty-related diseases and physical factors (model.2), depression and cognitive function were adjusted as psychosocial factors (model.3), and homebound and consult with the other person, living alone were adjusted as social factors (model.4), and they are similarly analyzed using ANCOVA. Because the distributions of time spent in SB and MVPA and the number of steps per day were positively skewed, we used a log transformation before the analyses. In the descriptive tables, non-transformed data were presented for easy interpretation [33].

Furthermore, considering the possibility that the low physical activity items among the frailty criteria may affect the results, we redefined the criteria excluding this item and confirmed this action with sensitivity analysis. In addition, due to the difference in the number of men and women in the pre-frail and non-frail groups, trends were confirmed by a sensitivity analysis targeting women only. All statistical analyses were performed using SPSS Statistics for Windows version 23.0 (IBM Corp., Tokyo, Japan). Statistical significance was set at a P-value <0.05.

3. Results

Consent was obtained from 332 individuals in response to requests to 377 individuals for survey cooperation. A total of 54 individuals were excluded from the 332 individuals, including 1 who withdrew consent, 19 who refused to wear an accelerometer, 4 with difficulty communicating, 9 with poor physical condition, and 21 with bad accelerometer data or other missing data, so 278 individuals were included in the analysis. The prevalence of pre-frailty among 278 participants according to the J-CHS criteria was 41.0% (n=114), that of non-frailty was 51.1% (n=142), and that of frailty was 7.9% (n=22). An additional 22 individuals who had frailty were excluded, and the number of subjects in the analysis set was 256 (non-frail, n=142 (55.5%); pre-frail, n=114 (44.5%)). Of these subjects, 190 (74.2%) participated in self-initiated citizen's exercise group activities and 66 (25.8%) did not participate (Figure 1). Table 1 shows the characteristics of the subjects in the analysis.

3.1. Non-participation group and PA characteristics

There were 34 pre-frail subjects (51.5%) and 32 non-frail subjects (48.5%), and the percentage of women was 79.4% in the pre-frail group and 65.6% in the non-frail group. The mean ages were 80.1 ± 7.1 years in the pre-frail group and 77.3 ± 5.7 years in the non-frail group, but there was no significant difference. The percentage of subjects with heart disease (26.5%) was significantly higher in the pre-frail group ($P = 0.028$). In terms of physical function, grip strength ($P = 0.002$), walking speed ($P = 0.003$), and one-leg standing with eyes open ($P = 0.011$) were significantly lower in the pre-frail group. Among the relevant items in the KCL, consult with the other person ($P = 0.028$), homebound ($P = 0.004$), cognitive decline ($P = 0.025$), and depression ($P = 0.041$) were significant. Of the five items listed in the physical frailty criteria, the item with the highest prevalence was exhaustion at 44.1%, followed by slowness and weakness at 29.4%, with weight loss and low physical activity showing the lowest prevalence at 23.5%.

In terms of PA, there was no significant difference in the daily wearing time of the accelerometer (Table 2). We also found no significant difference in SB time and LPA time between the pre-frail and non-frail older adults. However, pre-frail older adults showed significantly lower MVPA and number of steps than non-frail older adults, even after adjusting for covariates of age, sex, education history, and accelerometer wearing time (model.1; MVPA, $P = 0.003$; steps, $P = 0.005$). The MVPA and steps were significantly reduced in the pre-frail group, even after adjusting the covariates by adding physical factors (model.2; low back pain, knee pain, heart disease), psychosocial factors (model.3; depression and cognitive function items), and social factors (model.4; consult with the other person, homebound items and living alone).

3.2. Participation group and PA characteristics

There were 80 pre-frail subjects (42.1%) and 110 non-frail subjects (57.9%), and the percentage of women was 91.3% in the pre-frail group and 90.9% in the non-frail group. The mean ages were 74.1 ± 5.7 years in the pre-frail group and 73.2 ± 4.7 years in the non-frail group, with no significant difference. Of the applicable items in the KCL, consult with the other person and depression were significant (consult with the other person, P = 0.016; depression, P = 0.006). Of the five items listed in the physical frailty criteria, the item with the highest prevalence was exhaustion at 45.0%, followed by weight loss at 36.3% and weakness at 26.3%, with slowness and low physical activity showing the lowest prevalence at 7.5% and 5.0%, respectively.

In terms of PA, the mean daily accelerometer wearing time was significantly shorter in pre-frail older adults (pre-frail, 870.2 ± 83.9 min/day vs. non-frail, 904.5 ± 89.6 min/day, P = 0.008) (Table 3). The trend remained the same when adjusted for age and sex covariates (model.1; P = 0.012). There was no significant difference in SB time and proportion of SB time during the daily wearing time, even when adjusted for covariates of age, sex, education history, and accelerometer wearing time: pre-frailty, 424.7 ± 97.8 min/day (48.9%) vs. non-frailty, 460.1 ± 103.8 min/day (50.9%) (P = 0.153). Similarly, there was no significant difference in the LPA, MVPA, and number of steps even when adjusted for covariates (LPA, P = 0.154; MVPA, P = 0.308; steps, P = 0.805). There was no significant difference in pre-frail SB, LPA, MVPA and steps, even when adjusted for covariates by adding physical factors (model.2; low back pain, knee pain, heart disease), psychosocial factors (model.3; depression items and cognitive function items), and social factors (model.4; consult with the other person, homebound items and living alone).

The results were almost the same in the sensitivity analysis except for the low physical activity item in the frailty criteria. Moreover, those trends did not change when a sensitivity analysis was conducted for women only with respect to the difference in the number of men and women in the pre-frail and non-frail groups (Data not shown).

4. Discussion

In this study, we theorized that there may be a slight change in SB time, LPA time, and MVPA time during the transition from non-frailty to pre-frailty. We also assumed that these differences in PA may present as a difference in PA time between pre-frail and non-frail older adults regardless of participation in self-initiated citizen's exercise group activities, and the study aimed to verify these theories.

The results of the study found that the pre-frail older adults in the non-participation group had slightly older age than the non-frail older adults, and a larger proportion had physical factors, such as heart disease and knee pain; psychosocial factors, such as depression and cognitive decline; and social factors, such as consult with the other person, homebound and living alone. Simply having many of these negative related factors was expected to pose a high risk of future onset of frailty [6, 7, 34-39]. In addition, the results of pre-frail PA in this study revealed that MVPA and steps were still significantly lower in this group than those of non-frail older adults, even after adjusting for these three related factors. This is a greatly important point indicating the slight changes in PA occurring between non-frail and pre-frail statuses. There has been almost no discussion on this point in previous studies. Nagai et al. also reported that, compared to the non-frail and pre-frail group, SB time was significantly higher, and LPA time and MVPA time were significantly lower in the frailty group [14]. Based on these results, it is assumed that there will not only be further decline in MVPA and steps for pre-frail older adults in the non-participation group but also decrease in LPA and increase in SB time, and these pre-frail older adults will start to have frailty status. There are many studies [9, 10] related to the decrease in PA with the increase in SB time and occurrence of frailty, which means it is important to detect changes in MVPA and steps in the pre-frail status at an early stage.

In contrast, in the participation group there were significant differences in the psychosocial factors of depression and social factors of consult with the other person in pre-frail older adults compared to non-frail older adults. In terms of PA, the mean daily accelerometer wearing time was significantly shorter in pre-frail older adults. The accelerometer wearing time was calculated by subtracting the sleep and nap times from the other times when no activity was recorded. This was considered to be equivalent to the awake time of almost 1 day [31] and interpreted as shortened awake time in the pre-frail older adults. Next, there was no significant difference in SB, each PA, and steps, and there were no characteristic differences in MVPA and steps, like that observed in pre-frail older adults in the non-participation group. Previous studies have shown that PA in older adults considered to be in the pre-frail status is almost the same as PA in non-frail older adults [14, 40]. Although the results of this study are consistent with those findings, our result indicated that pre-frail PA is maintained at about the same level as non-frail PA. Based on non-frail SB and PA data from previous studies, it can be estimated that SB accounts for 48-56%, LPA for 41-47%, and MVPA for 3–5% of the daily awake time [14, 31, 40]. In this study, pre-frail older adults had low SB (48.9%), high LPA (44.7%), and an MVPA of 6.4%; therefore, we regarded that they were active. Even if a person is in a pre-frail status, participating in regular self-initiated citizen's exercise group activities may have led to opportunities to reduce the decline in pre-frail PA. The actual group activities gather once a week at each meeting place or community center in the area, and participants enjoy 90 min of exercise each time and interaction with other participants. The program is a multicomponent exercise incorporating balance exercises, step exercises, stretching exercise, and various games. Participants usually perform dumbbell exercises with moderate intensity using light dumbbells load of 300–700 g.

There are a number of reasons that may contribute to pre-frail older adults maintaining their PA in this self-initiated citizen's exercise group activities. The first is the perspective on activity intensity. Aoyagi et al. reported that there is a close relationship between the number of steps and length of time spent on activities at or above moderate intensity, and the length of time spent on activities at or above moderate intensity increases as a quadratic function as the number of steps increase [41, 42]. But it is not practical to apply more than moderate-to-vigorous intensity load to frail older adults, and opinions are divided into the view recommending exercise at the LPA level [11, 12] versus the view recommending exercise at the MVPA level [43]. Yamada et al. reported the results of a 4-year longitudinal study investigating self-management exercise group training and the incidence of new long-term care insurance (LTCI) certification among 1,620 older adults in the community. As a result, Yamada et al. noted that "only frail older adults but not robust or pre-frail older adults showed a significantly lower incidence of new LTCI service requirement certifications. This result may have been because the load intensity of training was too light to affect the robust or pre-frail older adults. Joining the community-based self-management group led to the most dramatic improvement in the PA levels of the frail older adults. Furthermore, we believe that a lifestyle change occurred in subjects who attend the self-management exercise group for at least 2 years" [21]. Considering these reports and the results of this study, it is important for older adults in the pre-frail status to set PA at or above moderate intensity and to have an opportunity to walk and engage in other activities. And it is believed that rather than short-term participation, what is necessary is long-term continuation to a certain extent. Many participants in these groups have been participating in these activities over a number of years. It is presumed that these factors have been firmly secured through the self-initiated exercise group activities in the pre-frail older adults.

As for the second perspective related to maintaining PA, participating in activities is believed to lead to opportunities to go out on a regular basis and establish a connection with society through mutual interaction among participants. Fujita et al. has shown that leaving the house less than once a week increased the risk of developing a gait disorder at an odds ratio of 4.02 in a 2-year follow-up study compared to leaving the house one or more times a day [44]. The effect on health indicators according to participation in the local community salon was also examined. Reports have shown significant differences in the 5-year incidence of functional disability [45] and the subjective self-rated health after 2 years [46] between participants and non-participants. These previous studies indicate that in addition to maintaining and improving physical function through exercise, the present study helped participants in self-initiated citizen's exercise group activities in establishing a connection with the community by providing them with an opportunity to go out once a week and preventing homebound by facilitating social interaction, which may also have been useful in maintaining PA. It is surmised that participation in self-initiated citizen's exercise group activities not only was linked to maintenance and improvement of physical function through exercise but also provided the opportunity of regular outings at least once a week.

The results of this study showed different characteristics of PA in pre-frail older adults who did and did not participate in self-initiated citizen’s exercise group activities. Therefore, the opportunity to participate in self-initiated citizen’s exercise group activities and other physical activities in the community may be a useful initiative to maintain the PA of pre-frail older adults from declining.

The present study has several limitations. First, as for demographics, most of the subjects were women. Apart from this, the participation group had more subjects than the non-participation group. In addition, we assumed that the subjects in the participation group were highly motivated and had high physical function from the start. Therefore, although bias adjustment and stratified analysis were performed, in the interpretation of results, it must be stated that the allusion to representativeness and generalization potential to the community-dwelling older adults are extremely limited. Second, because this is a cross-sectional observational study, it is not possible to conclude the causal relationship between participation in self-initiated exercise group activities and maintenance of PA and that between pre-frailty and reduced PA. Third, this time, focus was placed on grasping the characteristics of physical frailty and activity. For this reason, consideration of the evaluation of social, mental, and psychological factors, which may have affected frailty and physical activity, was insufficient. Moving forward, a wide range of perspectives should be incorporated so that contributing factors can be understood and interpreted in detail. Fourth, although the accelerometer can objectively evaluate activities, it does not clearly distinguish between sitting and standing postures nor does it sufficiently reflect underwater activities, such as bathing and swimming, and activities involving stepping up and down, such as ascending or descending stairs. Therefore, it cannot be ruled out that the levels of SB and PA overall may be underestimated.

Despite these limitations, there are strengths in this study. We compared the PA of pre-frail and non-frail older adults by stratifying them into older adults who participate in self-initiated citizen's exercise group activities and older adults who do not participate in these activities. By doing so, we were able to clarify the PA characteristics of pre-frail older adults. Understanding these characteristics of pre-frailty PA, detecting minor changes in the transition from non-frailty to pre-frailty, and linking these observations to action would be beneficial in frailty prevention.

5. Conclusions

In this study, we divided the study participants into older adults who regularly participate in self-initiated citizen's exercise group activities and those who do not participate. Moreover, we compared and examined the physical activities of pre-frail and non-frail older adults to clarify the characteristics of PA of pre-frail older adults. MVPA and the number of steps were significantly lower in the pre-frail older adults who did not participate in activities, even when adjusted for physical, psychosocial, and social factors. In contrast, pre-frail older adults who participated in the activities, and there was no difference in the length of SB and PA time with that of non-frail older adults, indicating that the PA level was maintained. Therefore, the opportunity to participate in self-initiated citizen's exercise group activities and other physical activities in the community may be a useful initiative to maintain the PA of pre-frail older adults from declining. Further it is hoped that conducting a longitudinal or intervention study will provide more detailed verification of the results.

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Conflicts of Interest

The authors declare no conflict of interest.

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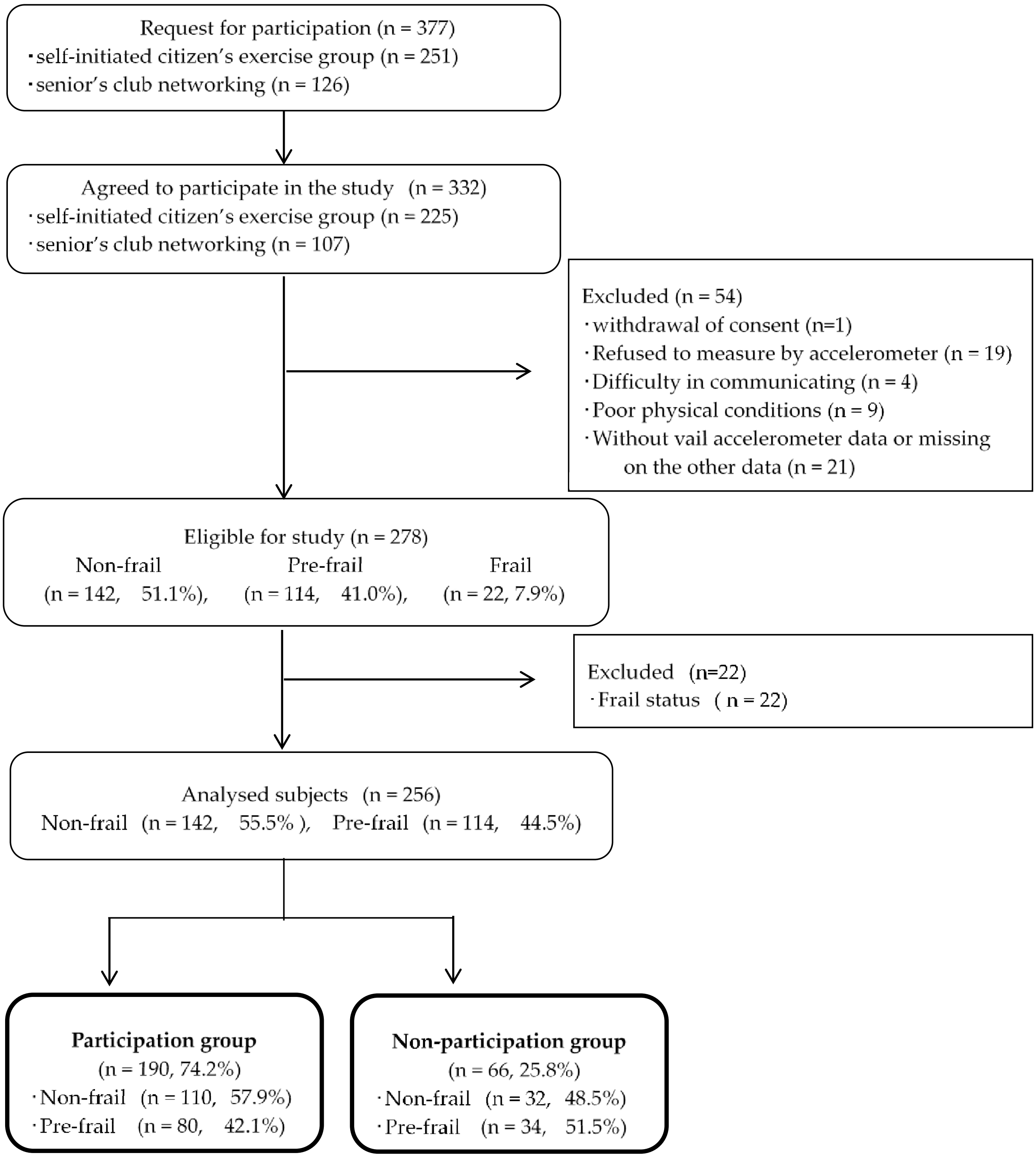

Figure 1 . Flow-chart of selection of subject to be analyzed.

Table 1. Characteristics of the participants.

	Participation group			Non-participation group		
	Non-frail	Pre-frail		Non-frail	Pre-frail	
	n = 110	n = 80	P-value	n = 32	n = 34	P-value
Age(years)	73.2 ± 4.7	74.1 ± 5.7	0.302	77.3 ± 5.7	80.1 ± 7.1	0.092
Sex, women	100 (90.9)	73 (91.3)	0.935	21 (65.6)	27 (79.4)	0.209
BMI(kg/m^2)	23.6 ± 3.2	23.6 ± 3.2	0.871	24.0 ± 3.5	24.5 ± 3.2	0.558
Education (Junior or Senior high school / Vocational college, University)	20 (18.2)	13 (16.3)	0.442	4 (12.5)	4 (11.8)	1.000
Living alone (yes)	13 (11.8)	16 (20.0)	0.729	2 (6.3)	8 (23.5)	0.084
Drinking(yes)	38 (34.5)	20 (25.0)	0.158	11 (34.4)	2 (5.9)	**0.004**
Smoking(yes)	2 (1.8)	4 (5.0)	0.241	1 (3.1)	0 (0.0)	0.485
Components of physical frailty criteria						
Hand grip strength (kg)	24.3 ± 4.8	22.5 ± 6.7	**0.006**	26.1 ± 5.7	22.1 ± 6.1	**0.002**
Usual walking speed (m/s)	1.34 ± 0.17	1.28 ± 0.20	**0.019**	1.27 ± 0.19	1.12 ± 0.21	**0.003**
One leg standing (s)	42.5 ± 20.2	38.7 ± 21.9	0.137	36.3 ± 21.6	22.6 ± 21.3	**0.011**
Pain & Primary disease						
Low back pain(yes)	40 (36.4)	39 (48.8)	0.087	16 (50.0)	18 (52.9)	0.811
Knee pain(yes)	30 (27.3)	29 (36.3)	0.187	9 (28.1)	17 (50.0)	0.069
Stroke (yes)	0 (0.0)	1 (1.3)	0.421	0 (0.0)	3 (8.8)	0.239
Hypertension (yes)	56 (50.9)	36 (45.0)	0.421	19 (59.4)	26 (76.5)	0.136
Heart disease (yes)	10 (9.1)	4 (5.0)	0.287	2 (6.3)	9 (26.5)	**0.028**
Diabetes mellitus (yes)	10 (9.1)	11 (13.8)	0.312	3 (9.4)	5 (14.7)	0.710
Osteoporosis (yes)	18 (16.4)	17 (21.3)	0.391	6 (18.8)	6 (17.6)	0.908
Arthropathy (yes)	27 (24.5)	23 (28.7)	0.516	5 (15.6)	11 (32.4)	0.113
Components of Kihon Checklist：KCL						
Activities Parallel to Daily Living(No.1-5)						
Outing by public transportation(no)	12 (10.9)	12 (15.0)	0.402	4 (12.5)	10 (29.4)	0.093
Shopping (no)	1 (0.9)	2 (2.5)	0.574	0 (0.0)	2 (5.9)	0.493
Maney management(no)	0 (0.0)	2 (2.5)	0.176	1 (3.1)	5 (14.7)	0.198
Visit family and friends(no)	7 (6.4)	7 (8.8)	0.534	2 (6.3)	6 (17.6)	0.260
Consult with the other person(no)	7 (6.4)	14 (17.5)	**0.016**	1 (3.1)	8 (23.5)	**0.028**
Physical strength(No.6-10)	7 (6.4)	10 (12.5)	0.143	2 (6.3)	8 (23.5)	0.084
Nutritional status(No.11-12)	0 (0.0)	1 (1.3)	0.421	0 (0.0)	0 (0.0)	-
Oral function(No.13-15)	15 (13.6)	18 (22.5)	0.111	3 (9.4)	8 (23.5)	0.123
Homebound(No.16-17)	14 (12.7)	15 (18.8)	0.254	2 (6.3)	12 (35.3)	**0.004**
Cognitive function(No.18-20)	39 (35.5)	39 (48.8)	0.066	10 (31.3)	20 (58.8)	**0.025**
Depressed mood(No.21-24)	10 (9.1)	19 (23.8)	**0.006**	3 (9.4)	10 (29.4)	**0.041**
Components of physical frailty criteria						
Exhaustion, n (%)	—	36 (45.0)		—	15 (44.1)	
Weight loss, n (%)	—	29 (36.3)		—	8 (23.5)	
Weakness, n (%)	—	21 (26.3)		—	10 (29.4)	
Slowness, n (%)	—	6 (7.5)		—	10 (29.4)	
Low physical activity, n (%)	—	4 (5.0)		—	8 (23.5)	

Data are shown as mean ± standard deviation or % (n). BMI, body mass Index ;

Student's t-test and Mann-Whitney U test for continuous scale and χ^2 test or Fisher's exact test for nominal scale

Table 2. Differences in the times spent in sedentary behavior and physical activity between Non-frail and Pre-frail older adults by self-initiated citizen's exercise group activities with Non-participant group

Non-participant group								
		Non-frail	Pre-frail	P-value				
Variables	Mean ± SD or %	(n = 32)	(n = 34)	Unadjusted	model.1	model.2	model.3	model.4
Acc wearing time (min / day)		875.4 ± 95.2	835.3 ± 84.4	0.075	0.115 [a]			
SB (min/day)		443.4 ± 89.6	458.6 ± 94.5	0.537	0.218 [b]	0.255	0.332	0.369
SB / Acc wearing time (%)		51.1	55.0					
LPA (min/day)		375.6 ± 98.7	349.3 ± 91.3	0.265	0.723 [b]	0.678	0.988	0.948
LPA / Acc wearing time (%)		42.5	41.7					
MVPA (min/day)		56.4 ± 37.5	27.4 ± 21.3	**＜0.001**	**0.003 [b]**	**0.015**	**0.041**	**0.017**
MVPA / Acc wearing time (%)		6.4	3.3					
Steps (steps/day)		5625.4 ± 3063.1	3202.8 ± 1842.7	**＜0.001**	**0.005 [b]**	**0.008**	**0.048**	**0.008**

Abbreviations; Acc: Accelerometer, SB: sedentary behavior, LPA: light-intensity physical activity, MVPA: moderate-to-vigorous physical activity, Steps: daily mean number of steps

Analyses were performed using analysia of covariance (ANCOVA).

[a] model.1: adjusted for age, sex, [b] model.1: adjusted for age, sex, education, accelerometer wearing time

model.2: adjusted for [b] model.1 + low back pain, knee pain, heart disease

model.3: adjusted for [b] model.1 + depressed mood, cognitive function

model.4: adjusted for [b] model.1 + homebound, consult with the other person, living alone

Table 3. Differences in the times spent in sedentary behavior and physical activity between Non-frail and Pre-frail older adults by self-initiated citizen's exercise group activities with Participant group

Participant group							
	Non-frail	Pre-frail	P-value				
Variables Mean ± SD or %	(n = 110)	(n = 80)	Unadjusted	model.1	model.2	model.3	model.4
Acc wearing time (min / day)	904.5 ± 89.6	870.2 ± 83.9	**0.008**	**0.012** [a]			
SB (min/day)	460.1 ± 103.8	424.7 ± 97.8	**0.026**	0.153 [b]	0.274	0.243	0.136
SB / Acc wearing time (%)	50.9	48.9					
LPA (min/day)	389.9 ± 90.4	389.8 ± 88.6	0.998	0.154 [b]	0.300	0.274	0.137
LPA / Acc wearing time (%)	43.1	44.7					
MVPA (min/day)	54.5 ± 36.2	55.7 ± 36.9	0.952	0.308 [b]	0.390	0.424	0.424
MVPA / Acc wearing time (%)	6.0	6.4					
Steps (steps/day)	5552.5 ± 3325.8	5090.0 ± 2266.9	0.654	0.805 [b]	0.845	0.691	0.790

Abbreviations; Acc: Accelerometer, SB: sedentary behavior, LPA: light-intensity physical activity, MVPA: moderate-to-vigorous physical activity, Steps: daily mean number of steps

Analyses were performed using analysia of covariance (ANCOVA).

[a] model.1: adjusted for age, sex, [b] model.1: adjusted for age, sex, education, accelerometer wearing time

model.2: adjusted for [b] model.1 + low back pain, knee pain, heart disease

model.3: adjusted for [b] model.1 + depressed mood, cognitive function

model.4: adjusted for [b] model.1 + homebound, consult with the other person, living alone