J Nutr Health Aging. 2019;23(5):425-430

EXERCISE AND/OR DIETARY VARIETIES AND INCIDENCE OF FRAILTY IN COMMUNITY-DWELLING OLDER WOMEN: A 2-YEAR COHORT STUDY

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Abstract: *Objective:* Exercise and dietary habits rich in variety may reduce the risk of frailty incident, but such association remains unexamined. This study aimed to examine the longitudinal associations between exercise and/or dietary varieties and incidence of frailty in older women. *Design:* A 2-year population-based prospective cohort study. *Setting and participants:* Six hundred and four community-dwelling older Japanese women aged ≥75 years with non-frailty at baseline survey. *Measurements:* Frailty was assessed using Fried's frailty criteria composed of shrinking, weakness, slowness, low activity, and exhaustion at both baseline and follow-up surveys. Frailty incident was defined as the presence of ≥3 components at the follow-up survey. At baseline, information about exercise and dietary habits were obtained from all participants through a face-to-face interview. Participants were grouped into two categories, high (≥2) and low (<2) exercise varieties, assessed by the number of participations in 17 exercise types. By dietary variety, assessed using Dietary Variety Score (range, 0 to 10), participants were grouped into two, high (≥4 points) and low (<4 points) dietary varieties. Binary logistic regression analyses were applied to obtain adjusted odds ratios (ORs) and 95% confident intervals (CIs) of the incidence of frailty in the 4 groups (low-exercise and low-dietary varieties [low EV + low DV] as reference; low-exercise and high-dietary varieties [low EV + high DV]; high-exercise and low-dietary varieties [high EV + low DV]; and high-exercise and high-dietary varieties [high EV + high DV]). *Results:* Frailty incidence rate was 9.3% over the 2-year follow-up period. Incidence rates of frailty in the 4 groups were as follows: 23.7%, 10.1%, 6.5%, and 7.7% in the low EV + low DV, low EV + high DV, high EV + low DV, and high EV + high DV groups, respectively. After adjustment for covariates, only the high EV + high DV group was associated with a significantly lower OR (0.38; 95% CI 0.15–0.92) of frailty incidence compared with the low EV + low DV group. *Conclusion:* Higher variety of exercise and diet was significantly associated with lower incidence of frailty. Thus, the combination of variety-rich exercise and dietary program may be useful in preventing the incidence of frailty in older women.

Key words: Variety, exercise, dietary, frailty.

Background

Frailty is one of the common problematic geriatric syndromes in older population. It is theoretically defined as a state of increasing vulnerability to respond adequately to stressors because of aging-associated impairment of multiple physiologic systems and loss of physiological reserve (1, 2). Frailty is associated with increased risk of serious adverse health events such as falls, worsening mobility and activities of daily disability, hospitalization, and mortality (1). Therefore, it is imperative to identify the factors associated with the incidence of frailty in older adults.

Several factors are associated with incidence of frailty (3) including sociodemographic factors such as age (4), education and income level (5); physical factors such as body mass index (BMI) (4), hearing and vision impairments (6, 7), and chronic pain (8); medical factors such as heart disease (9), diabetes (10); psychological factors such as depression (11) and cognitive impairment (12); and lifestyle factors such as smoking habit (13), pattern of alcohol consumption (14), and exercise and dietary qualities (15-18). Because habitual exercise and dietary pattern are individual's lifestyle factors that are a modifiable factor, it is important to consider frailty prevention interventions focusing on the qualities of such interventions. Greater understanding of exercise and dietary qualities associated with reduced risk of frailty incidents could allow for the development of lifestyle interventions that are more likely to be effective for frailty prevention.

Recently, two meta-analyses have reported that greater adherence to variety-rich diet, such as the Mediterranean diet, is significantly associated with lower risk of frailty incident (19, 20). Although the association between exercise variety and incidence of frailty is yet to be identified, some systematic reviews have identified that the most provided exercise program is the multi-component type. This type is composed of various types of exercises, and is the best strategy to improve physical capacity in frail older adults (21, 22). Additionally, the combination of exercise and nutritional supplement programs improves frailty condition more, compared with the exercise or nutritional supplement only programs, among

Received October 31, 2018
Accepted for publication December 4, 2018
Published online February 8, 2019, http://dx.doi.org/10.1007/s12603-019-1166-1

frailty older adults (23). Based on this theoretical background, it was hypothesized that both high varieties of exercise and dietary habit are more effective in reducing the risk of frailty incidence. However, this hypothesis was yet to be examined by previous investigators. To examine this is important especially in older women because frailty has been reported to occur more frequently in this population, resulting from their longer life expectancy, than in older men (24).

Therefore, this study aimed to examine the associations between exercise and/or dietary varieties and incidence of frailty among older women. Identifying the exercise and dietary varieties that are associated with the reduced risk of frailty incidents could contribute to the suggestions of intervention programs for frailty prevention.

Methods

Design

This was a 2-year population-based prospective cohort study.

Setting

Baseline and follow-up surveys were conducted in 2008 and 2010, respectively, at the Tokyo Metropolitan Institute of Gerontology, Itabashi, Tokyo, Japan.

Participants

All participants were randomly selected from the basic resident register of the Itabashi ward, located in the northwest area of the 23 special wards in Tokyo. Detailed recruitment method of the baseline survey was described in a previous study (25). Briefly, we randomly selected 10,948 older women aged 75-84 years from the basic resident registers, of which 1,289 participated in the baseline survey. During the 2-year follow-up period, 552 people were lost to follow-up. After excluding 68 individuals with missing values and 65 with frailty at baseline survey, 604 participants were included in the analysis. This study complied with the guidelines of the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. All participants provided written informed consent.

Measurements

Frailty

Frailty was assessed using the Fried's frailty criteria, characterized by limitation in ≥3 of the following five conditions: slowness, weakness, exhaustion, low activity, and weight loss both at baseline and at follow-up (1). We operationally defined frailty by using the Japanese version of the Cardiovascular Health Study criteria (26). Each component of frailty was measured as bellow.

Slowness

Slowness was assessed using gait speed measurements, which were measured as the time taken to walk 5 m at usual speed, between the 3- and 8-m marks, on an 11 m walkway (27). The measurement was performed in a single trial and <1.0 m/sec was defined as slowness.

Weakness

Weakness was assessed using grip strength measurement, which was measured using the hand-held Smedley type dynamometer. The participants were instructed to stand naturally and to grip the device with their dominant hand as hard as possible (27). The measurement was performed in a single trial and <18 kg was defined as weakness.

Exhaustion

Exhaustion was assessed using one item on Kihon Checklist, a comprehensive health checklist developed by the Japanese Ministry of Health, Labor, and Welfare. The participants were asked "In the last 2 weeks, have you felt tired for no reason?" Those who answered "yes" were defined as having exhaustion.

Low activity

Low activity was assessed by asking the participants the following two questions regarding participation in exercise or physical activity: 1) "Do you engage in light intensity exercise or calisthenics?" and 2) "Do you engage in exercise or sports activities?" Participants who answered "no" to both questions were defined as having low activity.

Weight loss

Weight loss was also assessed using one question on Kihon Checklist: "Have you lost 2 kg or more in the past 6 months?" Participants who answered "yes" were defined as having weight loss.

Exercise variety

We investigated exercise habit through a face-to-face interview at baseline. Participants were asked to indicate "yes" or "no" to whether or not they participated in 17 exercise types including walking, calisthenics, Japanese croquet, jogging, golf, ball games, hiking, dancing, aqua exercise, martial art, yoga, bicycling, Tai Chi, bowling, quoits, strength exercise, and others (28). Exercise variety, assessed by the number of exercise types (out of 17 types), were categorized into participation in <2 (low-exercise variety) and ≥2 (high-exercise variety) exercise types. In this study, we arbitrarily defined high-exercise variety as participation in at least 2 exercise types, because the concept of exercise variety have yet to be examined by previous studies.

Dietary variety

Dietary variety was assessed through a face-to-face interview at the baseline using the Dietary Variety Score (DVS), which

consist of 10 food-based components including 1) meat, 2) fish/shellfish, 3) eggs, 4) milk, 5) soybean products, 6) green/yellow vegetables, 7) potatoes, 8) fruit, 9) seaweed, and 10) fats/oils (29). Participants provided the frequency of consumption of each of the 10 food-based components in the past 1 week based on 4 categories (1: eaten almost daily, 2: once/two days, 3: one or two times/week, and 4: hardly eaten). We scored "eaten almost daily" as 1 point and the others as 0, and summed each component. DVS ranges from 0 to 10 points, and higher scores indicate rich dietary variety, with <4 points as low-dietary variety and ≥4 points as high-dietary variety (29).

Covariates

Age, BMI, years of education, medical history, depressive symptom, cognitive function, drinking habits, and smoking habits, were investigated as covariates. We categorized years of education into: ≥9 years (graduation from junior high school or higher) and <9 years. The BMI was calculated as the body weight divided by the body height squared. We asked participants whether they had medical histories including hypertension, stroke, heart disease, diabetes, and osteoporosis, in the past year. Depressive symptom was assessed using the Mini-international Neuropsychiatric Interview that comprised two questions (30). We defined participants who answered "yes" to either question as having depression (30). Cognitive function was measured using a 10-item Mental Status Questionnaire, which contains 10 questions regarding orientation and general memory (31). Cognitive impairment was defined as ≥3 errors over a 10-item Mental Status Questionnaire (32). Participants were asked about their smoking and drinking status: if they were "current" or "past or never." Participants who answered "current" were defined as drinkers and/or smokers.

Statistical analysis

First, the Shapiro-Wilk tests were applied to examine either normal or non-normal distributions of continuous variables. Second, chi-squared test or Fisher's exact test for categorical variables and Mann-Whitney U test for continuous variables were applied to compare differences in the baseline characteristics between the frailty and non-frailty groups. Next, to compare differences in frailty incidence between high-exercise/dietary and low-exercise/dietary varieties, chi-squared tests were applied. Then, we applied binary logistic regression analyses to examine the effects of exercise and dietary varieties on the frailty incidence. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for incidence of frailty were obtained for the following 4 groups; 1) low-exercise and low-dietary varieties (low EV + low DV) group as reference, as well as 2) low-exercise and high-dietary varieties (low EV + high DV), 3) high-exercise and low-dietary varieties (high EV + low DV), and 4) high-exercise and high-dietary varieties (high EV + high DV) groups. These associations were examined by four hierarchical models: unadjusted model; Model 1 included age and years of education as covariates; Model 2 had heart disease and diabetes added to Model 1; and Model 3 had depression and cognitive impairment added to Model 2.

All analyses were performed using IBM SPSS version 25.0 (IBM Corp., Armonk, New York, USA). P <0.05 was considered statistically significant.

Table 1
Comparison of the baseline characteristics between the non-frailty and frailty participants at follow-up survey

	n	Non-frailty	n	Frailty	P value
Age, years	548	78 [75-84]	56	80 [75-84]	<0.001[a]
Body mass index, kg/m2	548	22.4 [13-33]	56	22.9 [16-29]	0.431[a]
Years of education, ≥9 years	547	455 (83.2%)	56	42 (75.0%)	0.126[b]
Hypertension, yes	548	287 (52.4%)	56	37 (66.1%)	0.050[b]
Stroke, yes	548	26 (4.7%)	56	3 (5.4%)	0.744[a]
Heart disease, yes	548	93 (17.0%)	56	15 (26.8%)	0.068b
Diabetes, yes	548	44 (8.0%)	56	4 (7.1%)	1.000[a]
Osteoporosis, yes	548	167 (30.5%)	56	24(42.9%)	0.058[b]
Depression, yes	548	20 (3.6%)	56	5 (8.9%)	0.072[a]
Cognitive impairment, yes	548	6 (1.1%)	56	2 (3.6%)	0.165[a]
Drinker, yes	548	144 (26.3%)	56	15 (26.8%)	0.934[b]
Smoker, yes	548	19 (3.5%)	56	0 (0.0%)	0.243[c]
Exercise variety, types	548	2 [0-6]	56	2 [0-4]	0.013[a]
Dietary variety, score	547	6 [0-10]	56	6 [0-10]	0.189[a]

Notes. Values are indicated as median [minimum-max] or n (%). P values were calculated by the Mann-Whitney U test (a), chi-square test (b), and Fisher's exact test (c).

Results

Frailty incidence was observed in 56 (9.3%) participants during the 2-year follow-up period. Table 1 shows the comparison of the baseline characteristics between the non-frailty and frailty groups during the follow-up period. Although there was a significant difference in age and exercise variety between the two groups, no other characteristic showed a significant difference between the two groups.

Figure 1 shows the comparison of the frailty incidence between the low-exercise/high-exercise, and between the low-dietary/high-dietary variety groups. Although frailty incidence in the high-exercise variety group (7.6%) was significantly low compared to the low-exercise variety group (12.5%) (P = 0.047), in the frailty incidence between the high (8.5%) and low (14.3%) dietary variety groups, there was no significant difference (P = 0.089).

Figure 1
Comparisons of frailty incidence between the low and high exercise variety groups, and between the low and high dietary variety groups

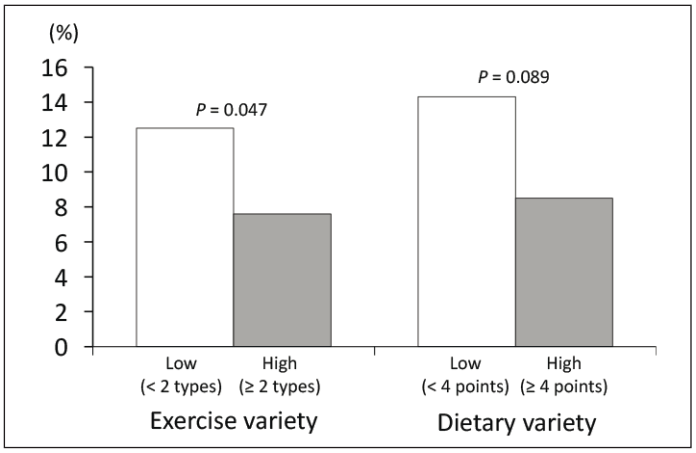
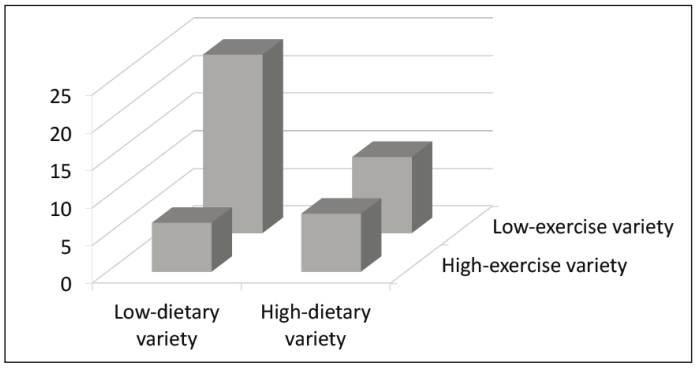


Figure 2 shows the incidence of frailty for the following 4 groups: low EV + low DV group (23.7%), low EV + high DV group (10.1%), high EV + low DV group (6.5%), and high EV + high DV group (7.7%).

Table 2 shows the ORs and 95% CIs for frailty incidence based on the 4 groups. In the unadjusted model, compared to the low EV + low DV group (reference), significantly lower ORs [95% CI] of frailty incidence were reported for low EV + high DV group (0.36 [0.15-0.89]); high EV + low DV group (0.23 [0.06-0.90]); and high EV + high DV group (0.27 [0.12-0.63]). After adjusting for all covariates (Model 3), only the high EV + high DV group indicated a lower OR (0.38, 95% CI [0.15–0.92]) of frailty incidence compared to the low EV + low DV group. There were no significant differences in ORs of frailty incidence between the other two groups (low EV + high DV and high EV + low DV) and the reference group (low EV + low DV).

Figure 2
Incidence of frailty according to 4 groups based low and/or high variety of exercise and dietary



Discussion

To the best of our knowledge, this study is the first to prospectively identify associations between exercise and/or dietary varieties and the risk of frailty incidence in older women. Although higher variety of exercise habit was significantly associated with lower incidence of frailty, there was no significant association between varieties of dietary habit and incidence of frailty. After adjustment for all covariates, only the high-varieties of exercise and dietary habit were significantly associated with reduced risk of frailty incidence. These results suggest that the combination of exercise and dietary habits, rich in varieties, may be important to reduce the risks of frailty incidents in older women.

In the physiological process of the progression of frailty, oxidative stress (33), inflammation (34), and imbalances in muscle protein synthesis (35) are directly associated with frailty status. Protein, contained plentifully in flesh, fish, soybean, and milk can decrease the risk of frailty incidents by stimulating muscle protein synthesis (36, 37). Vitamins and carotenoids, contained plentifully in vegetables and fruits, would also decrease the risk of frailty incidents by counteracting the oxidative status and inflammation (38). Therefore, focusing on individual foods could identify the inherent role of individual nutrients in reducing the risk of frailty incidents. On the contrary, with any food ingestion by humans, various nutrients interact with each other, and may cause synergistic effects. Thus, it may be a more reasonable approach to clarify complete dietary patterns compared to focusing on traditional single nutrient approach (39). Based on this theory, the beneficial effects of various dietary patterns including “Mediterranean” (40), “prudent” (41), “healthy” (42), and “traditional” dietary patterns (43), have been identified on the risk of frailty incident. These dietary patterns contain in common, various foods including olive oil, vegetable, fruits, legumes, and fish. Hence, it would be more important to focus on variety-rich dietary

Table 2
Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of the incidence of frailty based on the high and/or low varieties of exercise and dietary groups (n=602)

	Low EV + low DV n=38	Low EV + High DV n=169	High EV + low DV n=46	High EV + high DV n=349
Unadjusted	Reference	0.36 [0.15–0.89]	0.23 [0.06–0.90]	0.27 [0.12–0.63]
Model 1	Reference	0.41 [0.16–1.02]	0.27 [0.07–1.12]	0.34 [0.14–0.80]
Model 2	Reference	0.41 [0.16–1.04]	0.29 [0.07–1.20]	0.35 [0.15–0.85]
Model 3	Reference	0.42 [0.17–1.08]	0.29 [0.07–1.23]	0.38 [0.15–0.92]

Note. EV: exercise variety, DV: dietary variety. All data are shown as odds ratio and 95% confidence intervals. Model 1: adjusted for age and years of education; Model 2: adjusted for Model 1 + heart disease and diabetes; and Model 3: adjusted for Model 2 + depression and cognitive impairment.

patterns for reducing the risk of frailty incident compared to focusing single food. However, there were no significant association between dietary variety and incidence of frailty; this might have resulted from the small sample size of this study, compared to that of previous studies (44, 17).

It is well known that the health benefit of exercise differs depending on exercise types. According to the American College of Sports Medicine, strength exercises are recommended to increase muscle mass and strength; aerobic exercises including walking, dance, and aqua exercise are recommended to improve cardiorespiratory endurance; flexibility exercise including calisthenics and yoga are recommended to improve the range of motion in joints; while balance exercises such as Tai chi are recommended to improve the balancing ability (45). Cadore et al. systemically reviewed the effects of different types of exercise on physical capacity in frail older adults and argued that the positive effects on physical capacity are more often observed when providing the multi-components of exercise including strength, aerobic, flexibility, and balance exercise, compared with providing only one type of exercise (22). Similarly, our study showed that higher-variety of exercise was significantly associated with lower-incidence of frailty (Figure 1). It is uncertain why the multi-component or variety-rich exercises are more effective in maintaining or improving physical capacity. However, similar to the theory of dietary variety, individual effects of different types of exercise may interact with each other and cause a synergistic effect.

While the best lifestyle intervention for preventing frailty remain unestablished, the strategy for preventing frailty via the prevention of sarcopenia may be theoretically accepted since sarcopenia is one of the components of the frailty cycle. For the prevention or improvement of sarcopenia, combination of exercise and dietary programs are most recommended (46), thus, such programs may be effective also in the prevention or improvement of frailty (23). Our study supported this argument and resulted in new findings concerning the importance of considering varieties of exercise and diet. In the future, intervention focusing on variety-rich exercise and dietary programs will be needed to clarify whether such habits reduce the incidence of frailty.

The major strength of this study is that it is the first to examine the association between exercise and/or dietary varieties and the risk of frailty incidence among older women. Furthermore, a population-based sampling helped to increase the generalization of the study results in this population. This study has several limitations. First, although this study was conducted using population-based sample, it should be noted that 88.6% of eligible women did not participate in the baseline survey and 42.8% of participants were lost to follow-up. This methodological limitation would indicate limited generalizability to the overall older population. Second, we could not collect information about the social-economic status and the total energy intake, nutrient intake, and consumption. This information may be another potential confounder. Therefore, it is unclear whether higher exercise and dietary varieties are associated with reduced risk of frailty incident, independent of these potential confounders. Third, although our prospective cohort design could quantitatively assess the degree of association between exposures and outcome, it may also contain the possibility of a reverse causal relationship.

Conclusion

Variety-rich exercise and dietary habit was significantly associated with reduced risk of incident frailty among older Japanese women. Thus, a combination of exercise and dietary program focusing on its variety would be a useful strategy to prevent the incidence of frailty in this population. To more clearly clarify the effects of such program on the risk of frailty incident, a randomized controlled trial should be conducted in the future.

Competing interests: The authors declare that they have no competing interests.

Authors' contributions: Study concept and design: YO, CW, TS, HK. Acquisition of data: NK, YY, MK, TS, HK. Analysis and interpretation of data: All authors. Drafting of the manuscript: YO. Critical revision of the manuscript for important intellectual content: All authors.

Acknowledgments: We are grateful to the participants and staff of the Tokyo Metropolitan Institute of Gerontology.

Ethical standards: All study participants provided informed consent, and the appropriate ethics review board approved the study design.

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