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Original Study

Mail-Based Intervention for Sarcopenia Prevention Increased Anabolic Hormone and Skeletal Muscle Mass in Community-Dwelling Japanese Older Adults: The INE (Intervention by Nutrition and Exercise) Study

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A B S T R A C T

Objective: The aim of the Intervention by Nutrition and Exercise (INE) study was to investigate the effects of a mail-based intervention for sarcopenia prevention on muscle mass and anabolic hormones in community-dwelling older adults.
Design: A cluster-randomized controlled trial.
Setting and Participants: This trial recruited community-dwelling adults aged 65 years and older in Japan. The 227 participants were cluster randomized into a walking and nutrition (W/N) group (n = 79), a walking (W) group (n = 71), and a control (C) group (n = 77). We analyzed the physical and biochemical measurements in this substudy.
Intervention: Six months of mail-based intervention (a pedometer-based walking program and nutritional supplementation).
Measurements: The skeletal muscle mass index (SMI) using the bioelectrical impedance data acquisition system, biochemical measurements, such as those of insulinlike growth factor (IGF-1), dehydroepiandrosterone sulfate (DHEA-S), and 25-hydroxy vitamin D (25[OH]D), as well as frailty, were assessed by the Cardiovascular Health Study criteria.
Results: Participants in the W/N and W groups had significantly greater improvements in SMI, IGF-1, and 25(OH)D ($P < .05$) than those in the C group. Participants in the W/N group had significantly greater improvements in DHEA-S ($P < .05$) than in the other groups. These effects were more pronounced in frail, older adults.
Conclusion: These results suggest that the mail-based walking intervention of the remote monitoring type for sarcopenia prevention can increase anabolic hormone levels and SMI in community-dwelling older adults, particularly in those who are frail.

Sarcopenia is the age-dependent loss of skeletal muscle mass.[1] In 2014, the Asian Working Group for Sarcopenia recommended using the presence of both low muscle function and low muscle mass to diagnose sarcopenia.[2] Several epidemiologic studies have shown that sarcopenia is highly prevalent and a serious problem in older adults.[3,4] In addition, frailty is strongly associated with sarcopenia. Frailty is also highly prevalent with advanced age and is considered to be characterized by an impaired state of health with mortality.[5]

The mechanism underlying sarcopenia and frailty remains unclear. However, it may be related to the age-related loss of skeletal muscle mass due to multifactorial processes, such as a sedentary life, malnutrition, and changes in hormone levels.[6] Additionally, the age-dependent decrease in anabolic hormones, such as sex hormones and growth hormones, can result in increased skeletal muscle

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breakdown.[7,8] By contrast, age-dependent increases in inflammatory cytokines, such as tumor necrosis factor alpha and interleukin-6 (IL-6), may lead to skeletal muscle mass loss.[9]

A previous study reported that physical exercise can effectively increase anabolic hormone levels, such as those of testosterone and insulinlike growth factor (IGF-1). Several studies have also shown that testosterone is increased by resistance training.[10,11] Moreover, the dehydroepiandrosterone (DHEA) and IGF-1 levels showed a good correlation.[12]

The American College of Sports Medicine (ACSM) Position Stands indicate that usual walking for older adults corresponds approximately to high-intensity exercise for younger people.[13] Additionally, older adults exhibited greater activation of leg muscles for usual walking than young adults.[14] Furthermore, the ACSM reports that exercise with 40% to 50% of 1 repetition maximum for inactive older adults can improve muscle strength.[15] Therefore, it is possible that continuous walking can improve the muscle function in older adults. Indeed, body composition may be improved by light-to-moderate-intensity exercise, such as walking, in older adults.[16] The pedometer-based walking program in older adults also showed a significant increase in physical activity and physical function.[17,18]

The combination of physical exercise and nutritional supplementation is more effective in improving body composition and physical function than physical exercise by itself. Resistance training and amino acid supplementation, protein, β-hydroxy β-methylbutyric acid, or vitamin D together can improve muscle mass.[19–23] In addition, a more recent study showed that resistance training with a protein-enriched diet can effectively increase lean tissue mass and reduce IL-6 in older women.[24]

However, sarcopenia is highly prevalent in community-dwelling older adults (approximately 10%–20%), and there are several limitations in group-intervention programs. Therefore, we have developed the mail-based walking intervention for sarcopenia prevention (pedometer-based walking program and nutritional supplementation). Many older adults can participate in the intervention program at the same time in this program because it is a remote monitoring type. The aim of the Intervention by Nutrition and Exercise (INE) study was to investigate the effects of a mail-based intervention for sarcopenia prevention on muscle mass and anabolic hormones in community-dwelling older adults. This intervention of a remote monitoring type is the combination of a stepwise approach to increase physical activity and nutritional supplementation. In addition, we examined the relationship between frailty and trainability for this intervention program.

Methods

Participants

Ine-cho is a small town located in the northern part of Kyoto prefecture. The population and aging rate in Ine-cho are 2185 and 42%, respectively. Participants were recruited by an advertisement in the local press and in a poster. The following criteria were used to screen the participants in an initial interview: aged 65 years and older, community-dwelling, and able to walk independently (or with a cane). The exclusion criteria were severe cardiac, pulmonary, diabetes, or kidney disease or musculoskeletal disorders; comorbidities associated with a greater risk of falls, such as Parkinson disease and stroke; severe cognitive impairment (Mini-Cog <3)[25]; and the use of psychotropic drugs or regular supplementation of amino acids and vitamin D in the last 12 months. Written informed consent was obtained from each participant in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 2000. The trial registration number is JMA-IIA00122.

Cluster Randomization

We used a 3-arm, cluster-randomized, controlled trial, and autonomous communities were randomly assigned to the walking and nutrition (W/N) group, walking (W) group, and control (C) group. Eleven autonomous communities were randomly allocated to each group and 79, 71, and 77 participants were enrolled in the W/N group, W group, and C group, respectively.

Intervention

Exercise program

Participants randomized to the W/N group and W group received pedometer-based walking programs for 6 months. A valid, accurate, and reliable pedometer, the Yamasa EX-300 (Yamasa Tokei Keiki, Ltd, Tokyo, Japan), was used to measure free-living step counts.[26]

We used a stepwise approach to increase physical activity in which the participants were instructed to increase the number of daily steps by 10% each month. In addition, the participants walked with an ankle weight (0.5 kg) at their own discretion. Written activity logs were averaged monthly to determine whether the participants were achieving their step goal. The intervention consisted of motivation for walking followed by goal setting, self-monitoring, and feedback. Participants were asked to record the step counts taken at the end of each day. A sheet for brief feedback and setting the number of daily steps was mailed to all of the participants to evaluate the recorded calendar monthly (Fig. 1).

Nutritional supplementation

Protein and a vitamin D supplement were provided every day for the participants in the W/N group for 6 months. Protein and the vitamin D supplement (200 kcal, 10.0 g of protein with branched chain amino acids 12.5 μg of vitamin D, and 300 mg of calcium [Resource PemPal Active; Nestle Japan Ltd, Tokyo, Japan]) were provided for the participants. Participants recorded the dietary supplementation and meal size per day on a calendar. The nutritional supplement was mailed to all participants monthly. Therefore, both the exercise and nutritional programs were remotely monitored by the researcher.

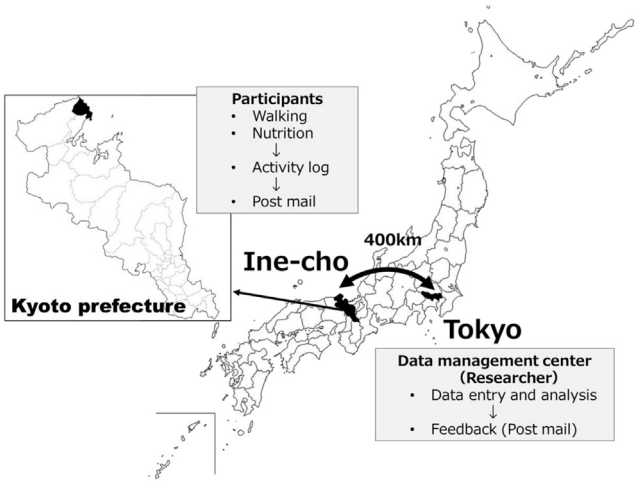

Fig. 1. Schematic representation of mail-based intervention of the remote monitoring type for sarcopenia prevention. Participants of the W/N and W groups were instructed to increase the number of daily steps by 10% each month. Protein and the vitamin D supplement were provided every day for the participants in the W/N group. Participants were asked to record the date on the calendar and steps taken at the end of each day. A sheet for brief feedback and setting the number of daily steps was mailed to all participants to evaluate the recorded calendar monthly.

Outcome Measures

Skeletal muscle mass index

A bioelectrical impedance data acquisition system (Inbody 430; Biospace Co, Ltd, Seoul, Korea) was used to determine bioelectrical impedance. This system uses electrical current at different frequencies (5, 50, and 250 kHz) to directly measure the amount of extracellular and intracellular water in the body. Participants stood on 2 metallic electrodes and held metallic grip electrodes. Using segmental body composition and muscle mass, a value for the appendicular skeletal muscle mass was determined and used for further analysis. Muscle mass was converted into the skeletal muscle mass index (SMI) by dividing by the muscle weight by height squared (kg/m^2).

Biochemical measurements

For all participants, the following 3 biomarkers were obtained: IGF-1, DHEA-S, and 25-hydroxy vitamin D (25[OH]D). Blood samples were drawn in the morning before physical exercise. The collected serum was stored at −80°C until the analysis. IGF-1 (ng/mL) was measured by immunoradiometric assay. Intra- and interassay coefficients of variance were 2.35% and 3.90%, respectively. DHEA-S (μg/dL) was measured by chemiluminescence enzyme immunoassay. Intra- and interassay coefficients of variance were 6.20% and 7.71%, respectively. Radioimmunoassay was used to measure 25(OH)D levels (ng/mL). Intra- and interassay coefficients of variance were 6.66% and 10.82%, respectively. All of the assays were performed in the same laboratory.

Definition of frailty

We defined frailty by the Cardiovascular Health Study criteria[27] with minor modifications by Shimada et al.[28]

We assessed weight loss by asking the single "yes or no" question, "Have you lost 5% or more of your body weight in the past 2 years?" Weakness was defined as a handgrip strength less than 26 kg in men and less than 18 kg in women. In the handgrip strength test, participants used a handheld dynamometer with the arm by the side of the body. The participant squeezed the dynamometer with the dominant hand using maximum isometric effort. No other body movement was allowed. The handgrip strength score was defined as the better performance of 2 trials. We assessed exhaustion by asking the single "yes or no" question, "Do you feel full of energy?" Slowness was defined as a usual walking speed less than 1.0 m/s identified in participants with a low physical performance. In the walking speed test, participants were asked to walk 11 m at a comfortable pace. A stopwatch was used to record the time required to reach the 5-m point (marked in the course). The time recorded in the 2 trials was averaged to obtain the data for the present analyses. We assessed low physical activity by the following 2 questions: "Do you engage in moderate levels of physical exercise or sports aimed at health?" and "Do you engage in low levels of physical exercise aimed at health?" Low physical activity was defined if the responses to these 2 questions were "no."

Required sample size

Several previous studies[19–23] showed that the effect size for physical exercise with nutritional supplementation on the skeletal muscle mass was approximately 0.65. Therefore, we designed the effect size of the current study to detect 0.65. With a significance level of 0.017 (0.05/3), a power of 80%, and an effect size of 0.65, 69 participants were needed in 3 groups. Accounting for a potential 10% attrition rate, a total of 228 participants were targeted for this study, a number that was sufficiently large to detect statistically significant differences.

Statistical Analysis

One-way analysis of variance (ANOVA) and post hoc test were used to test any differences in baseline measures between groups, and χ^2 test was performed on categorical variables. Bonferroni-adjusted t test was used to assess which group differed significantly from the others.

The effect of each intervention on outcome measurements was analyzed using a mixed 3 × 2 (group (W/N, W, and C group) × time (pretraining, posttraining) ANOVA. In addition, analysis of covariance (ANCOVA) with the baseline value as a covariate was used to determine the effect of the intervention on each outcome measure. ANOVA was used to test any differences in percentage changes of outcome measurements between the groups. Bonferroni-adjusted t test was used to assess which group differed significantly from the others.

For stratified analysis according to the level of frailty, we divided the cohort into 2 groups: nonfrail and frail. We compared the trainability in frailty-stratified and unstratified analyses for each outcome measure.

The data were managed and analyzed using SPSS (Statistical Package for the Social Sciences, Windows version 21.0; SPSS, Inc, Chicago, IL). A P value less than .05 was considered to indicate statistical significance for all analyses.

Results

Overall, 248 people were screened, and 227 (91.5%) who met the inclusion criteria for the trial and agreed to participate were enrolled (Figure 2). Most of the participants who were excluded had diabetes mellitus or severe musculoskeletal disorders. Twenty-one older adults who were eligible for the study withdrew from their participation after screening. Of 227 individuals selected for the study, 222 (97.8%) completed the 6-month follow-up, 77 in the W/N group (97.5%), 70 in the W group (98.6%), and 75 in the C group (97.4%). The baseline characteristics in the W/N, W, and C groups were comparable and well matched (Table 1). The median relative adherence was 80% (25th–75th percentile, 67%–92%) with nutritional supplementation; however, all of the participants completed the step count record during this study. No fall incident or health problems, including cardiovascular or musculoskeletal complications, occurred during the study period. A minor problem observed in both intervention groups was muscle aches in the first intervention month. This was easily managed by adjusting the intervention, and the muscle aches decreased over the course during the intervention. In both the W/N and W groups, the average daily steps were increased by 35.7% (from 4471 ± 2370 to 6067 ± 2967) and 42.1% (from 3795 ± 1913 to 5394 ± 2197), respectively ($P < .01$).

Significant time effects were found for IGF-1, DHEA-S, and 25(OH)D ($P < .05$) (Table 2). The pre- and postintervention group statistics and Group × Time interactions are shown in Table 2. Significant differences were observed among the 3 groups for SMI, IGF-1, and 25(OH)D with significant Group × Time interactions using ANOVA. Similarly, significant differences were observed among the 3 groups for SMI and 25(OH)D with significant Group × Time interactions using ANCOVA. Participants in the W/N and W groups had significantly greater improvement in SMI, IGF-1, and 25(OH)D ($P < .05$), but not in the C group (Table 2). Participants in the W/N group had significantly greater improvements in DHEA-S ($P < .05$) but not in the other 2 groups (Table 2).

We next analyzed nonfrail older adults. In this group, we also found significant time effects for IGF-1, DHEA-S, and 25(OH)D ($P < .05$) (Table 2). Significant differences were observed among the 3 groups for IGF-1 and 25(OH)D with significant Group × Time interactions. Participants in the W/N and W groups had significantly greater improvements in IGF-1 and 25(OH)D ($P < .05$) but not in the C group (Table 2).

We also performed subgroup analysis in frail older adults. In this subgroup, we found significant time effects for IGF-1 and 25(OH)D

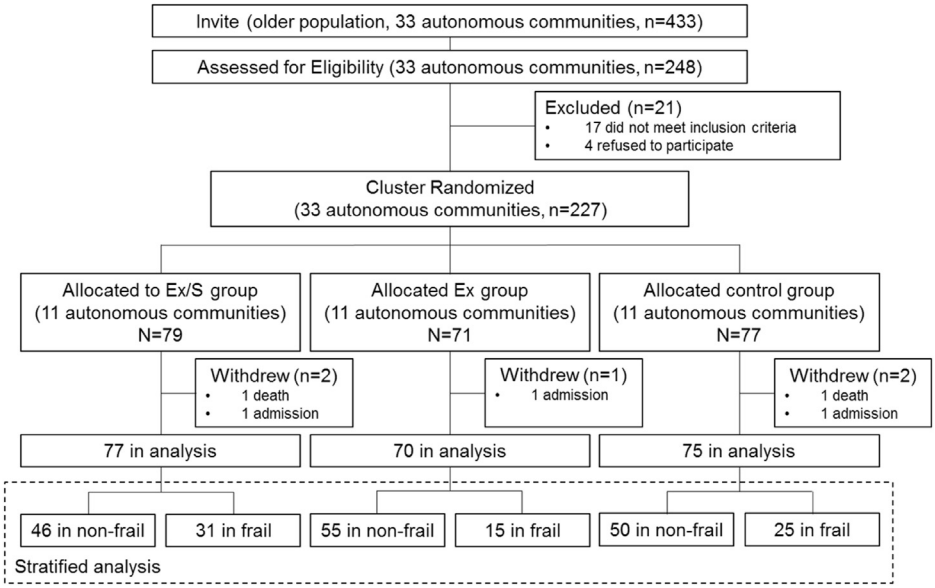

Fig. 2. A flowchart showing the distribution of participants throughout the trial.

($P < .05$) (Table 2). Significant differences were observed among the 3 groups for SMI, IGF-1, DHEA-S, and 25(OH)D with significant Group × Time interactions. Participants in the W/N and W groups had significantly greater improvements in SMI ($P < .05$) but not in the C group (Table 3). Participants in the W/N group had significantly greater improvements in IGF-1 and 25(OH)D ($P < .05$) but not in the others (Table 3).

Discussion

The 6-month mail-based walking intervention along with nutritional supplementation is an effective means to prevent sarcopenia in community-dwelling older adults. We have shown that participants in the W/N and W groups, but not in the C group, showed a significant increase in SMI, IGF-1, and 25(OH)D. The W/N group showed the largest increase in DHEA-S among the 3 groups. These results were more pronounced in frail older adults. These results suggested that the combination of walking exercise and nutritional supplementation may be beneficial for community-dwelling older adults to prevent and treat sarcopenia. In particular, this intervention program was useful for the muscle mass increase in frail older adults.

In this 6-month mail-based intervention for community-dwelling older adults, we have shown that the average daily steps were successfully increased by 35.7% and 42.1% in the W/N and W groups, respectively. We showed that the pedometer-based behavioral change program was very effective for the improvement of average daily steps. Goal setting and self-monitoring of behavior are crucial for behavioral change. In this study, pedometers and a record sheet

Table 1
Baseline Characteristics of the Study Participants in Each Group

	Walking + Nutrition		Walking		Control		F Value	*P* Value
	Mean	SD	Mean	SD	Mean	SD		
Overall	n = 77		n = 70		n = 75			
Age	76.3	5.9	75.8	5.2	75.7	6.5	0.38	.687
Height	153.5	8.4	152.8	8.3	155.1	9.3	2.67	.071
Weight	52.6	8.8	53.2	9.3	55.8	9.9	**4.49**	**.012****a*
BMI	22.3	3.2	22.7	3.2	23.1	2.8	2.08	.127
Women, n %	50	64.9%	48	68.6%	44	58.7%		.452
Nonfrail	n = 46		n = 55		n = 50			
Age	75.2	5.6	75.9	5.1	75.3	6.8	0.32	.724
Height	154.4	8.8	152.0	8.7	155.0	9.4	2.58	.078
Weight	53.6	8.9	52.9	9.5	55.3	9.3	1.52	.220
BMI	22.5	2.9	22.8	3.2	22.9	2.4	0.50	.609
Women, n %	31	67.4%	40	72.7%	29	58.0%		.452
Frail	n = 31		n = 15		n = 25			
Age	78.1	5.7	75.7	5.8	76.4	6.2	1.63	.199
Height	152.2	7.8	155.3	6.2	154.7	9.1	1.52	.222
Weight	51.3	8.6	54.5	8.7	55.7	10.1	2.94	.056
BMI	22.1	3.6	22.6	3.1	23.2	3.2	1.31	.272
Women, n %	19	61.3%	8	53.3%	15	60.0%		.452

BMI, body mass index.
**P* < .01.
a, W/N group versus C group.

Table 2
SMI and Serum Biomarkers Before and After the Intervention in the Overall, Frail, and Nonfrail Groups

	Pre		Post		2-Way ANOVA				2-Way ANCOVA	
					Time Effect		Time × Group Interaction		Time × Group Interaction	
	Mean	SD	Mean	SD	F Value	*P* Value	F Value	*P* Value	F Value	*P* Value
Overall										
SMI										
Walking + Nutrition	6.5	0.9	6.4	0.9	0.21	.65	**7.75**	**<.001****	**5.98**	**.015***
Walking	6.5	0.9	6.4	0.9						
Control	6.6	0.9	6.7	1.0						
IGF-1										
Walking + Nutrition	77.1	24.3	95.4	32.7	**105.73**	**<.001****	**9.16**	**<.001****	3.13	.078
Walking	71.6	26.7	83.6	29.1						
Control	86.7	29.4	92.7	26.8						
DHEA-S										
Walking + Nutrition	72.8	47.4	80.8	45.3	**24.54**	**<.001****	1.80	.168	1.32	.271
Walking	62.2	47.3	71.7	50.5						
Control	89.9	55.2	93.1	60.3						
25(OH)D										
Walking + Nutrition	31.0	10.3	41.0	12.4	**58.35**	**<.001****	**17.89**	**<.001****	**18.33**	**<.001****
Walking	30.1	9.8	36.7	7.1						
Control	33.5	11.8	33.3	9.8						
Nonfrail										
SMI										
Walking + Nutrition	6.4	0.9	6.5	0.9	0.82	.367	2.60	.078	2.39	.095
Walking	6.3	0.8	6.4	0.8						
Control	6.7	0.9	6.7	0.9						
IGF-1										
Walking + Nutrition	80.6	23.2	96.3	27.8	**75.59**	**<.001****	**5.30**	**.006***	**3.60**	**.030***
Walking	70.2	27.0	82.8	29.4						
Control	94.0	30.5	99.4	26.8						
DHEA-S										
Walking + Nutrition	79.2	48.3	68.7	48.7	**24.10**	**<.001****	0.33	.720	0.26	.774
Walking	65.0	47.0	56.0	42.8						
Control	100.6	64.2	93.7	58.4						
25(OH)D										
Walking + Nutrition	30.9	11.1	41.2	12.9	**43.47**	**<.001****	**11.09**	**<.001****	**10.45**	**<.001****
Walking	30.2	9.8	36.8	7.0						
Control	34.6	13.5	34.8	10.1						
Frail										
SMI										
Walking + Nutrition	6.3	0.9	6.5	0.9	0.10	.755	**5.15**	**.008****	**4.39**	**.016***
Walking	6.8	1.0	6.9	1.2						
Control	6.7	1.1	6.4	0.9						
IGF-1										
Walking + Nutrition	71.5	25.4	94.1	40.0	**22.09**	**<.001****	**4.56**	**.015****	**4.48**	**.016***
Walking	75.3	27.0	84.3	29.7						
Control	75.7	26.1	81.1	25.1						
DHEA-S										
Walking + Nutrition	79.7	45.2	83.6	40.4	2.92	.093	**3.60**	**.034***	**3.76**	**.030***
Walking	86.2	57.3	97.8	57.1						
Control	84.6	51.9	80.6	53.9						
25(OH)D										
Walking + Nutrition	31.2	9.2	40.6	11.7	**11.38**	**<.001****	**6.39**	**<.001****	**6.83**	**.002****
Walking	29.2	10.5	36.1	8.0						
Control	32.6	7.9	30.8	8.7						

*$P < .05$; **$P < .01$.

were primarily used as motivational tools, and our behavioral support seemed to have mainly affected the behavioral change toward increasing physical activity.

The W/N group showed a significant increase in the serum DHEA-S and IGF-1 levels. The W group showed a significant increase in the serum IGF-1 levels only, and a tendency for higher serum DHEA-S levels after intervention. The age-dependent decrease in anabolic hormones, such as DHEA and IGF-1, may lead to a loss of skeletal muscle mass.[7,8] However, a recent study suggested that physical activity is associated with the serum IGF-1 level, and physical activity training can effectively increase the serum IGF-1 level in premenopausal women.[29] Several studies have shown that an exercise training program greatly increases the serum DHEA levels in older adults.[10,11] In addition, the serum IGF-1 and DHEA can be maintained at a high level by long-term training in older adults.[30] The current trial shows that physical activity was increased in the W/N and W groups. Therefore, the W/N and W groups, but not the C group, showed a great increase in the IGF-1 and DHEA-S levels.

The W/N group showed the largest increase in 25(OH)D and SMI among the 3 groups. Several studies have suggested that a low 25(OH) D concentration is associated with lower muscle strength, reduced physical performance, and increased disability.[31–33] It has been shown that vitamin D supplementation may enhance muscle strength in frail older adults with vitamin D deficiency.[34] However, older adults have a high risk of inadequate protein intake,[35] and their

Table 3
Percentage Changes of Outcome Measurements in the Overall, Frail, and Nonfrail Groups

	Walking + Nutrition		Walking		Control		F Value	*P* Value
	Mean	SD	Mean	SD	Mean	SD		
Overall	n = 77		n = 70		n = 75			
Change of SMI	1.88	6.53	1.01	4.56	−1.85	6.90	**7.66**	**<.001**** *a*, *b*
Change of IGF-1	25.4	23.7	20.7	25.2	9.6	18.4	**8.03**	**<.001**** *a*, *b*
Change of DHEA-S	22.6	58.3	18.4	25.8	5.4	22.0	**3.26**	**.041*** *a*
Change of 25(OH)D	42.0	60.7	31.8	45.5	3.0	24.6	**12.50**	**<.001**** *a*, *b*
Nonfrail	n = 46		n = 55		n = 50			
Change of SMI	1.02	5.58	1.11	4.24	−0.86	5.72	2.32	.102
Change of IGF-1	21.4	20.3	22.5	25.5	8.6	17.1	**5.35**	**.006**** *a*, *b*
Change of DHEA-S	26.6	65.5	18.1	25.7	8.4	17.8	1.96	.145
Change of 25(OH)D	39.9	44.1	32.0	47.1	6.1	27.8	**7.35**	**<.001**** *a*, *b*
Frail	n = 31		n = 15		n = 25			
Change of SMI	3.16	7.66	0.64	5.76	−3.87	8.78	**5.63**	**.005**** *a*, *b*
Change of IGF-1	31.8	27.6	14.5	24.8	9.4	19.8	**4.70**	**.013**** *a*
Change of DHEA-S	15.9	44.2	19.7	27.3	−0.8	28.9	1.67	.197
Change of 25(OH)D	45.2	81.4	33.6	42.6	−5.6	16.5	**4.55**	**.015*** *a*

*$P < .05$; **$P < .01$.
a, W/N group versus C group; *b*, W group versus C group.

synthetic response to protein intake may be blunted.[36] Several studies have found a positive association between protein intake and muscle mass.[37,38] In fact, protein supplementation has been shown to augment the muscle strengthening effect of resistance exercise.[39,40] Therefore, the Society for Sarcopenia, Cahexia, and Wasting Disease (SSCWD) recently recommended the combination of exercise with protein and/or vitamin D supplementation for reducing the age-related skeletal muscle decline.[41] The results of the current study also supported the SSCWD recommendation, and the nutritional supplementation provided added benefits to those with walking exercise for increasing muscle mass.

The important point is that the effectiveness of this intervention was more pronounced in frail older adults. Recent frailty-related studies show that the frailty status is associated with muscle mass decline in older adults,[42] and regular physical activity may mitigate frailty in frail older adults.[43] Thus, it is possible that the intensity of our intervention was appropriate for frail older adults, but was low for nonfrail older adults. ACSM's recommendation is 40% to 50% of 1 repetition maximum for beginner or sedentary older adults, but the habitually exercising older adult requires 60% to 70% of 1 repetition maximum.[15]

Several limitations of the present study need to be mentioned. First, the intake of dietary food was not recorded. The nutritional supplement may have changed participants' dietary intake. Second, no follow-up after completion of the trial was conducted. Because there is a lack of evidence regarding the long-term effect of nutritional supplementation on sarcopenia treatment, this issue also needs to be addressed in future studies. Follow-up and cost-effective analyses are needed to confirm the present results and evaluate the most effective program for the prevention of sarcopenia and frailty.

In conclusion, the current study suggests that mail-based walking intervention of the remote monitoring type for sarcopenia prevention can increase anabolic hormone levels and SMI in community-dwelling older adults, particularly in frail older adults. This program is very simple and may be useful as a large population approach for the prevention of sarcopenia and frailty.

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