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ORIGINAL ARTICLE

Physical activity plays a crucial role in multidomain intervention for frailty prevention

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Abstract

Background and Aims Taiwan is one of the most rapidly aging countries worldwide. Both physical activity and frailty affect older adults, and multidomain interventions prevent frailty. This study investigated the associations between physical activity, frailty, and the effects of multidomain intervention.

Methods This study enrolled individuals aged 65 years or older. The physical activity level was assessed using the Physical Activity Scale for the Elderly (PASE). Enrollees participated in a multidomain intervention program that consisted of twelve 120-min sessions administered over a 12-week period that included health education, cognitive training, and exercise programs. The effects of the intervention were evaluated using the instrumental activities of daily living scale (IADL), Mini Nutritional Assessment short form (MNA–SF), five-item Geriatric Depression Scale (GDS–5), Mini-Mental State Examination (MMSE), timed up and go test (TUGT), and Fried's frailty phenotype.

Results In total, 106 older adults (aged 65–96 years) were enrolled in this study. The mean age was 77.47 ± 7.19 years, and 70.8% of participants were women. PASE scores were significantly lower among participants who were of older age, frail, and had a history of falls in the last 12 months. Frailty could be improved by multidomain interventions and was significantly positively correlated with depression, and negatively correlated with physical activity, mobility, cognition and daily living skills. Moreover, daily living skills were significantly positively correlated with cognition, mobility and physical activity, and negatively correlated with age, sex, and frailty. However, multidomain interventions did not affect daily living skills suggesting daily living skills may need to be maintained from a young age. Finally, results from multiple regressions suggest that physical activity, mobility and depression may be predictors of frailty.

Conclusions Physical activity has an important role in frailty, may be a predictor of frailty, and strongly contributes to reducing frailty through multidomain intervention. Policies that encourage healthy aging should focus on increasing physical activity, maintaining basic daily living skills and reducing frailty.

Keywords Physical activity · Frailty · Multidomain intervention · Older adults

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Introduction

Taiwan is one of the most rapidly aging countries and will become a superaged society in 2025. Aging societies place heavy burdens on health-care systems—especially in terms of financing, families, and society [1]. Frailty is a major concern for older adults and is a syndrome involving physical decline that has been shown to lead to adverse consequences such as disability, falls, hospitalization, institutionalization, and death [2, 3]. Fried's frailty phenotype is one of the most popular methods of assessing frailty; it considers weakness, sluggishness, weight loss, fatigue, and physical activity [4]. The prevalence of frailty, as defined by physical phenotype in older adults, ranges from 4 to 27%, increases with age, and is higher in women [5–7]. Many factors are associated with frailty, including multimorbidity, depressive symptoms, loneliness, pain, malnutrition, body mass index, marital status, education level, and financial status [8–13].

Early screening, intervention programs, and risk factor reduction are key strategies to prevent or delay frailty in older adults. Exercise is undoubtedly effective for preventing frailty. Studies have pointed out that resistance exercise improves muscle strength, balance, and function, prevents frailty, and reduces the risk of falls [14, 15]. Jadczak et al. demonstrated that multicomponent exercise improves physical performance in frail and prefrail older adults [16]. Malnutrition is associated with inappropriate body weight, lack of muscle mass, and chronic disease; these lead to reduced muscle strength and physical performance, fatigue, reduced physical activity, and frailty. Sufficient protein intake and an adequate supply of vitamins, especially vitamin D, can help maintain function and prevent frailty [9, 17–20]. Previous study has shown that multidomain interventions can reduce frailty, malnutrition and depression and improve cognitive performance in community-dwelling older people [21].

Furthermore, physical activity is defined as any physical movement using the skeletal muscles that requires energy expenditure, including movement for leisure, movement, or work. According to the World Health Organization, physical activity has a positive effect on the quality of life and healthy aging of older adults [22] and reduces chronic disease, obesity, falls, cognitive impairment, osteoporosis, and muscle weakness [23]. Frail older adults with sufficient physical activity may benefit from additional physical activity [24, 25]. Therefore, in this study, in addition to the multidomain intervention, we also used the PASE questionnaires independently to assess the physical activity of the elderly in the community, hoping to find out the correlation between the effects of frailty and physical activity. Our results demonstrated that physical activity as a possible predictor of frailty and a significant contribution to reducing frailty through multidomain interventions. In addition, we found that daily living skills may also play an important role in the process of aging, as it has important correlations with age, sex cognition, depression, frailty, mobility and physical activity level.

Methods

Participants and study design

Community-dwelling older adults were recruited from community-based care centers in Kaohsiung, Taiwan. Participants were included if they were aged ≥ 65 years, able to participate in training programs and classes, and presented with at least one of the following symptoms: self-reported memory complaints, loss of at least one instrumental activity of daily living (IADL), or gait speed < 1 m/s. Participants were excluded if they were totally or partially dependent when performing any ADL, had a life expectancy of < 6 months, were unable to complete a comprehensive geriatric assessment, or were institutionalized. This study was approved by the Ethics Review Board of Kaohsiung Veterans General Hospital (VGHKS18-CT6-10). All participants received baseline assessments before intervention. Outcomes were assessed after intervention. The estimated minimum sample size for the regression model was calculated to be 68, from five predictors, with an alpha value of 0.05, a power of 0.80, and a medium effect size, as determined using G* power version 3.1 software (Franz Faul, University Kiel, Germany).

Assessment and outcomes

Baseline demographic characteristics including age, sex, education level, marital status, smoking status, alcohol consumption behavior, history of falls in the last 12 months, and Charlson's Comorbidity Index (CCI) were obtained.

Physical activity levels were assessed using the Physical Activity Scale for the Elderly (PASE), which has good reliability and validity. We purchased the questionnaires from New England Research Institutes, Inc. The PASE is designed to assess the duration, frequency, exertion level, and amount of physical activity undertaken over a 7-day period by older adults aged ≥ 65 years and covers activities such as walking, leisure activities, housework, and occupational work. Higher scores represent greater physical activity [26].

Physical measurements included 6-m gait speed, handgrip strength, physical activity, and the timed up and go test (TUGT). In the gait speed test, the time taken to walk 6 m at a normal walking pace was recorded and transformed into gait speed (m/s). Participants were allowed to start with a cane or walker as required. Handgrip strength was measured using a digital dynamometer (TTM-YD, Tokyo, Japan), and the best measurement was recorded based on three trials using the dominant hand. In the TUGT, patients stand up from an armchair, walk a distance of 3 m, turn, walk back to the chair, and sit down. An assistant recorded the time taken to complete the test [27]. General cognitive performance was evaluated using the Mini-Mental State Examination (MMSE). Functional status was based on established indicators—the five-item Geriatric Depression Scale (GDS–5), the Mini Nutritional Assessment short form (MNA–SF), and the IADL scale.

Frailty was defined according to modified Cardiovascular Health Study (CHS) criteria, which include weakness, slowness, exhaustion, shrinking, and low levels of physical activity. Patients fulfilling three or more criteria were classified as frail, those who met one or two as prefrail, and those with no such deficits as robust. The criteria of frailty were as follows: (1) Weakness, assessed by the grip strength of the dominant hand with a dynamometer, was defined as < 28 kg of grip strength for men and < 18 kg grip strength for women. (2) Slowness, assessed by gait speed, was the time taken to walk 6 m. Gait speed was slow if it was ≤ 0.8 m/s. (3) The exhaustion criterion was met if the answer "More than 3 days per week," was given to the question, "How often in the last week did you feel this way?" regarding either of the following two statements: "I felt that everything I did was an effort" and "I could not get going." (4) Shrinking was defined as unintentional weight loss of > 5.0 kg or 10% of baseline body weight within the previous year. (5) Participants were considered to have low physical activity if physical activity was < 3.75 metabolic equivalent of task (MET)/h in men or < 2.5 MET/h in women (the lowest quintile of sex-specific baseline values) [4, 28].

Interventions

The multidomain intervention program consisted of twelve 120-min sessions administered over a 12-week period that included health education, cognitive training, and exercise programs [21]. All interventions were administered by appropriate professionals (e.g., a fitness coach, dietician, physiatrist, and geriatrician) or by trained staff. The intervention was carried out in groups by different community-based care centers.

Health education

Health education was provided in sessions totaling 7.5 h (10 sessions, each lasting from 30 min to 1 h). Lessons by trained instructors covered healthy diet, dementia, cardiovascular risk factors, osteoporosis, sarcopenia, and successful aging.

Cognitive training

Cognitive training was provided in sessions totaling 8.5 h (10 sessions, each lasting 30 min to 1.5 h). Lessons by trained instructors covered topics including memory and attention training, mnemonic strategies, problem solving, and logical reasoning practice.

Exercise

Exercise training consisted of eight sessions. Certified trainers conducted the training using standardized procedures. Each session lasted 1 h, including 10 min for warm-up and 50 min for the main activity, which included resistance training, balance training, and stretching exercises. Resistance training, 4 sessions, was performed statically with rubber bands for the muscles of the upper and lower limbs with 10–20 repetitions. Balance training, 3 sessions, included side walking and alternating gait with the agility ladder. Participants performed stretching exercises that covered the thorax, upper and lower limbs, and the whole body with the use of towels and exercise balls by sitting position in 1 session.

Statistical analysis

Statistical analyses used SPSS (version 23.0 for Microsoft Windows, IBM Corp., Armonk, NY, USA) and Sigmaplot (version 13 for Windows, Systat Software, Inc., San Jose, CA, USA). In this study, all continuous variables are presented as mean ± standard deviation (SD), and categorical data are presented as numbers (percentage). An independent sample *t* test was used to evaluate the associations of PASE scores between groups of age, frailty, and falls. Spearman rank correlation was used to assess the relationship between PASE and variables. The Wilcoxon signed-rank test was used to compare functional parameters before and after the intervention. The variables to predict frailty were evaluated using multiple linear regression models. For all tests, a two-tailed p value of < 0.05 was considered statistically significant.

Results

Study population

Participants were recruited from May 2018 to December 2018. Initially, 171 older adults (39 men and 132 women) from 15 community-based care centers were enrolled. The number of training sessions participants received may affect the efficacy of multidomain interventions, so we excluded

Table 1 Demographic characteristics of the study participants

Variable	Male (n = 31)	Female (n = 75)	Total (N = 106)
Age†(y)	77.81 ± 7.71	77.33 ± 7.01	77.47 ± 7.19
65–74‡	12 (38.7)	29 (38.7)	41 (38.7)
≥ 75‡	19 (61.3)	46 (61.3)	65 (61.3)
Educational level‡			
Elementary or below	14 (45.2)	44 (59.5)	58 (54.7)
Junior high school	3 (9.7)	11 (14.7)	14 (13.2)
Senior high school	8 (25.8)	16 (21.3)	24 (22.6)
College/university or above	6 (19.4)	3 (4.0)	9 (8.5)
Marital status‡			
Single/widowed/divorced/ separated	10 (32.3)	47 (62.7)	57 (53.8)
Married	21 (67.7)	26 (34.7)	47 (44.3)
Currently employed‡			
Yes	0 (0)	1 (1.3)	1 (0.9)
No	31 (100)	74 (98.7)	105 (99.1)
Financial status‡			
Rich	1 (3.2)	1(1.3)	2 (1.9)
Average	29 (93.5)	70 (93.3)	99 (93.4)
Poor	0 (0)	1 (1.3)	4 (3.8)
Other	1 (3.2)	0 (0)	1 (0.9)
Smoking‡			
Yes	3 (9.7)	0 (0)	3 (2.8)
No	28 (90.3)	73 (9.3)	101 (95.3)
Drinking‡			
Yes	3 (9.7)	1 (1.3)	4 (3.8)
No	27 (87.1)	73 (97.3)	100 (92.5)
Falls in the last 12 months‡			
Yes	3 (9.7))	22 (29.3)	25 (23.6)
No	28 (90.3)	53 (70.7)	81 (76.4)
CCI†	1.06 ± 1.21	0.71 ± 1.05	0.81 ± 1.11
Frailty status‡			
Robust	5 (16.1)	15 (20.0)	20 (18.9)
Pre-frail	22 (71.0)	40 (53.3)	62 (58.5)
Frail	4 (12.9)	20 (26.7)	24 (22.6)

Values presented as †mean ± standard deviation; ‡number (%)

CCI Charlson comorbidity index

subjects who did not fully attend the program. In total, 106 participants (31 men and 75 women) who completed the program by attending all intervention sessions were included for analysis. No participants had health problems such as cardiovascular or musculoskeletal complications during the intervention program or assessment.

Baseline characteristics

Participant demographic characteristics are summarized in Table 1. In total, 106 participants (mean age: 77.46 ± 7.19 years) were enrolled. Of these, 70.8% were women, 54.7% had a low education level, and 44.3% were married. Most of the participants were unemployed, did not smoke, did not consume alcohol, and were of average financial status. The mean CCI score was 0.81 ± 1.11. In total, 18.9% of participants were robust, 58.5% of participants were prefrail, and 22.6% of participants were frail.

Associations between physical activity and frailty

PASE scores for age, frailty, and history of falls were evaluated using independent sample *t* tests (Table 2). Age ≥ 75 ($t = 2.843$, $p = 0.005$), frailty ($t = -3.337$, $p = 0.001$), and history of falls ($t = -2.459$, $p = 0.016$) were associated with significantly lower PASE scores.

Table 2 Results of T- test to comparison of PASE between groups

	n	Levene's test		t	*p* value
		F	*p*		
Age (year)					
65–74[§]	41	0.037	0.847	2.843	0.005[b]
≥75	65				
Frailty					
Yes[§‡]	24	0.796	0.374	− 3.337	0.001[b]
No	82				
Fall					
Yes[§]	25	0.354	0.553	− 2.459	0.016[a]
No	81				

PASE Physical Activity Scale for the Elderly; *SD* standard deviation;
[§]dummy variable
[‡]frailty score ≥ 3
[a] <0.05; [b] <0.01

Spearman correlations of PASE with variables

Table 3 summarizes the associations between PASE scores and variables. PASE scores had significant positive correlations with cognition (ρ = 0.314, $p=0.001$), daily living skill (ρ = 0.244. $p=0.012$) and mobility (ρ = 0.380, $p<0.001$) and significant negative correlations with age (ρ = − 0.242, $p=0.012$), depression (ρ = − 0.371, $p<0.001$), frailty scores (ρ = − 0.423, $p<0.001$). Age had a significant positive correlation with mobility (ρ = 0.354, $p<0.001$) and significant negative correlations with cognition (ρ = 0.406, $p<0.001$), daily living skill (ρ = − 0.217, $p=0.026$), and PASE scores (ρ = − 0.242, $p=0.012$). Men had lower daily living skill (ρ = − 0.321, $p=0.001$) and higher nutrition scale scores (ρ = 0.217, $p=0.026$). Frailty scores had significant positive correlations with depression (ρ = 0.451, $p<0.001$) and negative correlations with cognition (ρ = − 0.376, $p<0.001$), daily living skill (ρ = − 0.198, $p=0.042$), mobility (ρ = − 0.531, $p<0.001$) and PASE scores (ρ = − 0.423, $p<0.001$). Mobility had significant positive correlations with cognition (ρ = 0.361, $p<0.001$), daily living skill (ρ = 0.405, $p<0.001$), and PASE scores (ρ = 0.380, $p<0.001$) and negative correlations with depression (ρ = − 0.286, $p=0.003$) and frailty scores (ρ = − 0.566, $p<0.001$). It was noteworthy that the daily living skills had significant positive correlations with cognition (ρ = 0.478, $p<0.001$), mobility (ρ = 0.405, $p<0.001$) and PASE scores (ρ = 0.244, $p=0.012$) and negative correlations with age (ρ = − 0.217, $p=0.026$) and sex (ρ = − 0.321, $p=0.001$).

Intervention effects on functional parameters and frailty scores

As shown in Table 4, MMSE scores significantly improved (25.00 ± 5.26 vs. 25.94 ± 4.82, $p<0.001$) and Fried's frailty

Table 3 Spearman correlations of PASE with variables

		Age	Sex	Cognition	Depression	Frailty score	Living skill	Mobility	Nutrition	PASE score
Correlation Coefficient (rho) *p* value	PASE score	− 0.242[a] 0.012	0.055 0.574	0.314[b] 0.001	− 0.371[c] 0.000	− 0.423[c] 0.000	0.244[a] 0.012	0.380[c] 0.000	− 0.017 0.860	
	Age		0.025 0.801	− 0.406[c] 0.000	0.014 0.889	0.151 0.123	− 0.217[a] 0.026	− 0.354[c] 0.000	0.078 0.428	− 0.242[a] 0.012
	Sex	0.025 0.801		0.015 0.881	− 0.095 0.333	− 0.114 0.245	− 0.321[b] 0.001	0.009 0.923	0.217[a] 0.026	0.055 0.574
	Frailty score	0.151 0.123	− 0.114 0.245	− 0.376[c] 0.000	0.451[c] 0.000		− 0.198[a] 0.042	− 0.531[c] 0.000	− 0.073 0.460	− 0.423[c] 0.000
	Mobility	− 0.354[c] 0.000	0.009 0.923	0.361[c] 0.000	− 0.286[b] 0.003	− 0.566[c] 0.000	0.405[c] 0.000		− 0.179 0.066	0.380[c] 0.000
	Cognition	− 0.406[c] 0.000	0.015 0.881		− 0.269[b] 0.005	− 0.376[c] 0.000	0.478[c] 0.000	0.361[c] 0.000	− 0.080 0.413	0.314[b] 0.001
	Depression	0.014 0.889	− 0.095 0.333	− 0.269[b] 0.005		0.451[c] 0.000	− 0.131 0.181	− 0.286[b] 0.003	− 0.039 0.688	− 0.371[c] 0.000
	Living skill	− 0.217[a] 0.026	− 0.321[b] 0.001	0.478[c] 0.000	− 0.131 0.181	− 0.198[a] 0.042		0.405[c] 0.000	− 0.081 0.411	0.244[a] 0.012

PASE Physical Activity Scale for the Elderly; *IADL* Instrumental Activities of Daily Living; *GDS-5* Geriatric Depression Scale-5; *MNA-SF* Mini-Nutritional Assessment-Short Form; *MMSE* Mini-Mental State Examination; *TUGH* Timed Up and Go Test, the longer the time, the slower the mobility

[a] <0.05

[b] <0.01

[c] <0.001

Table 4 Wilcoxon Signed Rank Test to compare the effectiveness of health promotion interventions

Assessment		Pre-test (mean ± SD)	Post-test (mean ± SD)	Z	*p* value
Cognition	MMSE (score)	25.00 ± 5.26	25.94 ± 4.82	3.433	0.000[c]
Depression	GDS-5 (score)	0.35 ± 0.92	0.24 ± 0.76	− 1.544	0.143
Frailty	Fried (score)	1.22 ± 1.13	0.88 ± 0.98	3.633	0.000[c]
1. Weakness handgrip (kg)		23.06 ± 6.40	23.41 ± 6.50	1.696	0.09
2. Slowness gait speed (m/s)		0.92 ± 0.28	0.96 ± 0.27	2.826	0.005[b]
3. Weight loss (kg)		61.18 ± 10.68	61.33 ± 10.61	1.403	0.161
4. Exhaustion (score)		0.28 ± 0.45	0.12 ± 0.33	− 3.710	0.000[c]
5. Physical activity (kcal/week)		993.44 ± 1022.62	1153.26 ± 1112.47	2.332	0.02[a]
Living skill	IADL (score)	6.95 ± 1.50	6.93 ± 1.69	0.216	0.838
Mobility	TUGT (second)	10.66 ± 4.52	10.63 ± 5.99	− 1.639	0.102
Nutrition	MNA-SF (score)	13.27 ± 0.97	13.28 ± 0.95	0.119	0.916

GDS-5 Geriatric Depression Scale-5; *IADL* Instrumental Activities of Daily Living; *MNA-SF* Mini-Nutritional Assessment-Short Form; *MMSE* Mini-Mental State Examination; *TUGT* Timed Up and Go Test

[a] < 0.05

[b] < 0.01

[c] < 0.001

Table 5 Variables in multiple regression model to predict frailty in older adults

Model	Unstandardized coefficients		Standardized coefficients	t	Sig	95.0% confidence interval for B		Collinearity Statistics
	B	Std. Error	Beta			Lower bound	Upper bound	VIF
(Constant)	0.947	0.355		2.670	0.009	0.244	1.650	
PASE score	− 0.005	0.002	− 0.182	− 2.119	0.037[a]	− 0.010	0.000	1.220
Mobility	0.081	0.023	− 0.318	− 3.488	0.001[b]	0.035	0.127	1.375
Depression	0.363	0.112	0.290	3.235	0.002[b]	0.140	0.586	1.327

N = 106. Frailty scores = 0.947−(0.00513 * PASE score) + (0.0807 * mobility) + (0.363 * depression). Model summary: $R^2 = 0.384$; Adjusted $R^2 = 0.366$; Analysis of variance: F = 21.178, $p = 0.000$. Normality test (Shapiro–Wilk): Passed ($p = 0.495$). Power of performed test with alpha = 0.050: 1.000. All independent variables appear to contribute to predicting frailty ($p < 0.05$)

PASE Physical Activity Scale for the Elderly; *VIF* variance inflation factor

[a] < 0.05

[b] < 0.01

phenotype scores were significantly lower (1.22 ± 1.13 vs. 0.88 ± 0.98, $p < 0.001$) after the multidomain intervention program. Three of the five components of Fried's frailty phenotype exhibited significant improvements: slowness (gait speed 0.92 ± 0.28 vs. 0.96 ± 0.27 m/s, $p = 0.005$), exhaustion (0.28 ± 0.45 vs. 0.12 ± 0.33, $p < 0.001$), and physical activity (993.44 ± 1022.62 vs. 1153.26 ± 1112.47 kcal/week, $p = 0.02$).

Variables for predicting frailty

Table 5 presents the variables input in the multiple regression model to predict frailty in older adults. PASE score, mobility, and depression were significantly correlated with frailty. Lower PASE scores (β = − 0.182, $t = -2.119$, $p = 0.037$), lower mobility (β = − 0.318, $t = -3.488$, $p = 0.001$), and more depressive symptoms (β = 0.290, $t = 3.235$, $p = 0.002$) were associated with frailty.

Discussion

Studies have demonstrated that frailty is more prevalent in older adults and in women. Frailty is associated with disability and mobility impairment [5–7]. The prevalence rates of frailty and prefrailty based on Fried's frailty phenotype in this study were higher than the rates found in other studies (4%–27% and 35%–50%, respectively) [6]. This may be because the participants in our study were older, were more likely to be women, and were required to have at least one of the following: a self-reported memory complaint, loss of at least one IADL, and gait speed < 1 m/s; all of these characteristics are risk factors for frailty. In the present study, only 23.6% of participants had a history of falls in the last 12 months, whereas in another study, more than one-third of community-dwelling people aged more than 65 years had a history of falling in the prior year [29]. Our study excluded older adults with total or partial ADL dependence, a life expectancy < 6 months, or who were institutionalized. These factors may have contributed to the lower rate of falls in our study.

In the present study, adults who were aged ≥ 75, were frail, or had a history of falls had significantly lower physical activity levels. Physical activity was significantly associated with age, disability, depressive symptoms, cognitive function, frailty, and mobility. Studies have demonstrated that age is correlated with frailty and physical activity [5–7, 30] and that older adults who are more physically active are less frail [24, 31]. Physical activity has many health benefits and reduces the incidence rates of chronic diseases, falls, and cognitive disorders and improves muscle strength [22, 23]. Physical activity helps preserve function and mobility and reduces the incidence of falls [32]. Physical activity, especially leisure activity, can reduce depressive symptoms through biological and psychosocial mechanisms [33–35]. In the present study, frailty was significantly associated with disability, depressive symptoms, cognitive function, and mobility. Previous studies have demonstrated that frailty leads to adverse outcomes such as disability, falls, hospitalization, institutionalization, and death in older adults [2, 3]. Physical activity is vital for healthy aging.

The multidomain intervention in the present study decreased frailty and improved cognitive function significantly. The decrease in frailty can mainly be attributed to improvements in slowness, exhaustion, and physical activity. Physical activity attenuates depressive symptoms such as exhaustion, prevents the development of slowness, and improves gait speed [33–36]. The decrease in frailty can mainly be attributed to the physical activity component of the intervention in this study. Frailty and gait speed were significantly improved after the intervention, which are similar to the findings of a previous study [21]. The exercise program in this study included resistance training, balance training, and stretching exercises. Both resistance training and multicomponent exercises (resistance training, aerobics, and balance and flexibility tasks) improve muscular strength, gait speed, balance, and physical performance [14–16]. Exhaustion significantly improved after the intervention in this study. Exercise may promote self-efficacy and prevent the development of depressive symptoms [33]. Physical activity significantly increased after the intervention. Overall, physical activity comprises more than just exercise. Participation in activities reduces sedentary time, and health education may encourage a healthier lifestyle. The multidomain intervention, which included health education, cognitive training, and exercise programs, increased physical activity and decreased frailty in the participants. A previous study found that physical activity combined with resistance training reduced frailty more than did resistance training alone [25]. Additional studies are warranted to investigate the effects of multidomain interventions on physical activity and frailty. Cognitive function improved significantly after the intervention in this study, which accords with the findings of previous studies. All cognitive, physical exercise, and combined training activities improved cognitive function. Diet and social activities have benefits in preventing cognitive decline [37–40].

Since malnutrition is one of the risk factors for frailty, a session of health education in the intervention focused on healthy diets. Sufficient protein and vitamin D intake can help maintain function and prevent frailty [9, 17–20]. A previous study found that eating fruit and vegetables reduces frailty [41]. Although the MNA–SF scores did not increase significantly in our study, nutrition education may have some effect on reducing frailty. Furthermore, multidomain interventions including physical and cognitive training and nutrition and disease education improved physical, functional, and cognitive performance and reduced frailty, malnutrition, and depression among community-dwelling older adults. The beneficial effects of the intervention persisted 9–12 months after the intervention [21]. The results of the present study are consistent with those of previous studies.

The present study demonstrated that physical activity, mobility and depression can predict frailty. Previous studies have found that physical activity, disability, and depressive symptoms are associated with frailty [5–8, 10, 11, 30]. Another study showed that walking less and being less physically active increased the risk of becoming frail due to becoming slow [36]. In this study, the PASE scores of the participants ranged from 2.14 to 206.18. The mean PASE score was 77.33 ± 40.73 (data not shown). Moreover, the PASE scores of the middle-old and oldest-old adults were significantly lower than those of the youngest-old (aged 65–74 years). Our results show that frailty was correlated with physical activity and mobility but not age. Interventions do not improve living skills and mobility but do increase physical activity and improve cognition and frailty. Therefore, we encourage people to develop regular physical activity habits before the age of 65. It was important to note that although the intervention has no effect on daily living skills. However, it was related to age, sex, cognition, depression, frailty, mobility and physical activity level. Many factors are thought to contribute to the higher prevalence of frailty in women than in men, including biological and genetic factors, social roles, dietary choices, attitudes toward health, and physical activity habits [42, 43]. A previous study revealed vitamin D deficiency was significantly associated with sarcopenia only in men, low physical activity was significantly associated with higher odds of sarcopenia in women only, and low physical activity was significantly associated with obesity, sarcopenia, and sarcopenic obesity only in participants with vitamin D deficiency [44]. Another study demonstrated that pre-exercise nutrition may be more effective for women to see improvements in strength and lean body mass, than post-exercise nutrition [45]. Lee et al. (2022) revealed that physical frailty increased disability for women more than men [46]. Preventative programs for frailty may have some differences between men and women. Women, who have a greater frailty burden, should focus more on increasing physical activity, adequate diet, preventing obesity, and function maintenance. We believe that maintaining a good level of physical activity will help to improve mobility, which in turn will increase the ability to perform the skills of daily living. The impact of physical activity level on daily living skills can be explored in the future.

The COVID-19 pandemic since 2019 forced many countries had executed strict policies to prevent the outbreak. People avoid social contact and going out for fear of transmission. Furthermore, quite a few individuals suffered from post-COVID-19 syndrome such as fatigue, dyspnea, pain, and cognitive impairment after contracting this illness. The reduction of social activity, physical activity, and exercise in older adults during the COVID-19 pandemic and post-COVID-19 syndrome increased the risk of frailty [47, 48]. The physical activity recommendations for older adults are as follows: moderate-intensity aerobic activity 150 min per week, muscle-strengthening activity at least twice per week (8–10 exercises with 10–15 repetitions for each exercise), flexibility activities performed with aerobic or muscle-strengthening activity (at least 10 min with 10–30 s for a static stretch and 3–4 repetitions for each stretch), and balance exercise three times each week for preventing falls. The exercise intensity and the weight and frequency of stretching exercises should be adjusted by individual physical condition [49]. Multicomponent training interventions that lasted three months and were performed three times per week for one hour per session or lasted longer duration (≥ 5 months) and were performed three times per week for 30–45 min per session had a positive impact on frail older adults [50]. Previous studies revealed the home-based frailty prevention program is feasible and help prevent frailty [51–53]. The exercise training in the present study, including resistance training, balance training, and stretching exercises, which is safe, easy to learn, without taking up space, and suitable for doing at home. Developing distance learning, such as online and video teaching or leaflets, can help older adults exercise at home. Moreover, exercises that can be integrated into daily activities such as brisk walking, walking uphill, up and down stairs, and standing on tiptoes are other good choices for increasing the strength of lower extremities and physical activities to prevent frailty for older adults.

This study still has several limitations. First, this study included more women (70.8%) than men; thus, the overall prevalence of frailty may be overestimated. The results are not generalizable to the general population. Second, our study was conducted in a long-term care community in a city in southern Taiwan (Kaohsiung), and participants who did not complete the intervention were excluded; thus, selection bias may exist. Third, a one-group pretest–posttest design cannot rule out the influence of factors on the effect of the intervention. Despite these limitations, this study suggests that in addition to encouraging the development of regular exercise at a young age, the prevention of frailty should also focus on the maintenance of basic daily living skills. Because daily living skills could not be improved in a short period of time through multidomain interventions, future research on ageing should therefore focus on the maintenance of daily living skills.

Conclusions

Age, disability, depressive symptoms, cognitive function, mobility and living skills were associated with physical activity and frailty. The results of the present study showed that physical activity, mobility, and depression predicted frailty. The multidomain interventions enhanced cognitive function and diminished frailty, especially slowness, exhaustion, and physical activity. Physical activity has an important role in frailty, may be a predictor of frailty, and strongly contributes to reducing frailty through multidomain intervention. Policies that encourage healthy aging should focus on increasing physical activity, maintaining basic daily living skills and reducing frailty. Further structural studies are needed to confirm the relationship between physical activity, daily living skills and frailty aspects.

Author contributions The authors of this study contributed as follows: Conceptualization, MYC; Methodology, TZH, MYC, CKL, YTL and RYC; Software, TZH and PFW; Validation, MYC and PFW; Formal analysis, TZH and PFW; Investigation, TZH, MYC, CKL, YTL and RYC; Writing—original draft preparation, TZH; Writing—review and editing, PFW.

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Data availability The data from this study are not publicly available due to ethical concerns, but can be requested from the corresponding author.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethics approval The study was approved by the Ethics Review Board of Kaohsiung Veterans General Hospital and was conducted in accordance with the committee's recommendations.

Informed consent All participants signed an informed consent form before the study began. The researcher explains the content of the consent form to the participant and also signs the consent. Participants are aware of the possible risks and benefits of participating in the study and that their privacy will be kept confidential if the results of the study are published. Participants are aware that they can withdraw from the programme at any time during the process and that this will not affect the doctor's future medical care. Participants are also aware of who they can approach for advice and questions during their participation in the study. All participants have a copy of the signed informed consent form. This study was approved by the Ethics Review Board of Kaohsiung Veterans General Hospital (VGHKS18-CT6-10).

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