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ORIGINAL RESEARCH

Pet Insects May Improve Physical Performance and Sleep in Community-Dwelling Frail Elderly People with Chronic Diseases: A Single-Arm Interventional Pilot Study

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Purpose: Animal-assisted intervention (AAI) is an effective intervention that improves the mental and physical health. However, few have examined the efficacy of pet insects as a form of AAI for prefrail and frail elderly. This study aimed to ascertain the effects of pet insects on physical performance and psychological health in community-dwelling frail elderly individuals with a chronic disease.

Patients and Methods: This study was an 8 week prospective single-arm interventional pilot study that enrolled prefrail and frail community-dwelling adults aged 70 years and older, all of whom had a chronic disease and attended a daycare facility. Pet insects and appropriate equipment were provided, and supporting programs were used to educate participants about how to rear the insects and how to get close to them. Pre- and post-interventional physical and psychological functions were evaluated.

Results: A total of 23 subjects (mean age, 82.78 years) were enrolled in the final analysis. The timed up-and-go-test (TUG) was used to measure functional mobility, and grip strength was used as a measure of muscle strength; both showed significant changes after the 8-week intervention ($\Delta = -0.35 \pm 0.73$ sec, $P = 0.034$; and $\Delta = 0.73 \pm 0.99$ kg, $P = 0.002$, respectively). In addition, the insomnia severity index (ISI) and average sleep duration improved significantly ($\Delta = -2.91 \pm 5.64$, $P = -0.021$; and $\Delta = 0.87 \pm 1.98$, $P = 0.047$, respectively). There were no significant changes in the results of other psychometric tests. Logistic regression analysis using the forward stepwise selection method revealed that the baseline ISI score and the absence of other comorbidities were significantly associated with the probability of positive changes in both the TUG and HS tests after the intervention.

Conclusion: Pet insects may be an effective and easily applicable type of AAI, which improves physical function and sleep in prefrail and frail elderly individuals.

Keywords: animal-assisted therapy, frail elderly, human-animal interaction, physical functional performance, sleep disorders

Introduction

Frailty is defined as a vulnerable state resulting from age-associated declines in physiological reserves and functions, such that the ability to cope with internal or external stressors is comprised.[1] Frailty increases the risk for poor health outcomes for the elderly, as it directly or indirectly affects morbidity and mortality. Korea became an aged society in 2017; as of 2020, 15.7% of the total population were aged 65 or older. In 2025, 20.3% of the total population will be aged 65 or older and Korea will become a post-aged society.[2] As the elderly population increases in the community, the number of frail elderly people increases, which in turn increases the burden not only on an individual's physical and mental health, but also on public health services. The socioeconomic burden is also a significant issue. Medical expenses for the elderly account for 1/3 of total medical costs in Korea;[2] indeed, in a previous study, the cost of supporting prefrail and frail community-dwelling elderly individuals is increased around \$179 up to \$32,549.96, compared with robust

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individuals.[3] Thus, healthcare providers need to find practical, non-invasive, and cost-effective treatments for the prefrail and frail elderly.

Animal-assisted intervention (AAI) is an effective treatment that improves the mental and physical health of the elderly.[4] However, the majority of AAI methods use mammals such as dogs, cats, or horses (and sometimes fish or birds).[5] A previous study shows that pet insects have a beneficial effect on the psychological health of community-dwelling elderly persons. Rearing pet insects improves depression, cognitive function, and quality of life in relatively healthy elderly persons,[6] and has positive effects on executive functions and performance in elderly women.[7] However, the aforementioned studies only targeted relatively healthy elderly individuals aged 65 to 70; neither included frail elderly individuals of more advanced age.

Pet insects are easy to rear, cost less than other animals, and do not need a large space. Prefrail and frail elderly individuals, especially those aged 75 and older, may lack the physical capability and/or finances to feed and rear mammals; also, they are at increased risk of falls or injuries caused by mammals.[8] To the best of our knowledge, no study has examined the effects of pet insects on the physical and mental health in frail elderly individuals of advanced age. Thus, this pilot study aimed to ascertain the effects of pet insects on physical performance and psychological health in a population of community-dwelling frail elderly individuals living with a chronic disease.

Materials and Methods

Study Design

The protocol for this 8-week prospective single-arm interventional pilot study was complied with Declaration of Helsinki and approved by the institutional review board of Kyungpook National University Hospital (protocol no. KNUH 2021–08-021). Prefrail and frail community-dwelling adults attending a daycare facility for the elderly, located in Gochang County, South Korea, were enrolled. All subjects were asked to submit informed consent to participate in this research. An interventional program using pet insects was conducted from October 2021 to December 2021.

Subject Eligibility

The inclusion criteria were as follows: (i) adults aged 70 years and older; (ii) frailty index ≥1 on the Korean version of the FRAIL (K-FRAIL) scale;[9] (iii) able to move and walk by him/herself with or without equipment; (iv) no limitation in activities of daily living (ADL);[10] (v) diagnosed or treated for at least one of the following diseases: hypertension, diabetes, dyslipidemia, cardiovascular disease, cerebrovascular disease, peripheral vascular disease, chronic liver disease, chronic kidney disease, neurodegenerative disease, or malignant neoplastic disease; (vi) regardless of psychiatric diseases, including major depression, insomnia, cognitive impairment, bipolar disorder; and (vii) completed both pre- and post-tests.

The exclusion criteria were as follows: (i) patients with limited self-care, (ii) confined to a bed or chair for more than 50% of waking hours (ie, Eastern Cooperative Oncology Group (ECOG) performance status ≥3);[11] (iii) hospitalized due to an acute illness (including pneumonia, acute myocardial infarction, cerebral infarction, and cerebral hemorrhage) within the previous month; (iv) severe dementia corresponding to a Clinical Dementia Rating (CDR) score ≥3;[12] (v) changes in medications that affect mood or sleep during the study period; (vi) entomophobia; and (vii) withdrawal of written consent to participate.

Study Intervention

The pet insect intervention was an 8-week program comprising six face-to-face meetings (a baseline visit and five supportive sessions). At the baseline visit (visit 0), screening tests for physical performance and psychometric assessments were performed. Next, family medicine specialists provided education about the importance of exercise and diet to prevent frailty, and provided individual health counseling if requested.

On the next day (visit 1), entomologists provided the pet insects. Based on a previous study, the oriental garden cricket (*Teleogryllus emma*) was chosen as the pet insect because its chirping sound is familiar to the elderly and is easy to care for.[6] The entomologists provided five to eight adult crickets, shortly after fully grown with wings (Figure 1), and

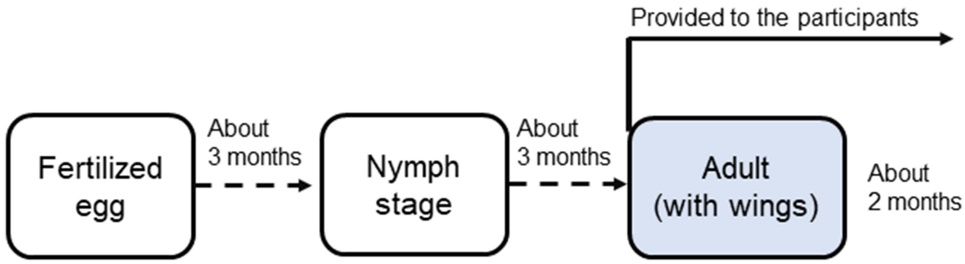

Figure 1 The lifespan of the oriental garden cricket (Teleogryllus emma). Fully-grown adult crickets, shortly after their wings were grown, were provided to the participants.

related equipment, including properly designed cages, sufficient fodder, and care instructions. The pet insects were provided to each participant, and to the daycare facility, so that the participants could make contact with the crickets during the whole study period. Every 2 weeks, the participants attended support programs (2 h/session). The five sessions were as follows. (i) visit 1: "how to rear crickets", "building a cage for the crickets", (ii) visit 2: "how to get close to crickets", (iii) visit 3: "the ecology of insects", (iv) visit 4: "observing the crickets closely", "how crickets make sounds", and (v) visit 5: "sharing our experiences with pet insects". Through weekly phone calls, researchers checked compliance with insect rearing and any inconveniences or side effects related to pet insects.

During the last visit, the family medicine specialists conducted individual counseling about test results, and also performed follow-up tests.

Physical Performance Tests

In accordance with standardized protocols, trained physicians evaluated physical performance using the timed up-and-go (TUG) test for functional mobility and the handgrip strength test for muscle strength. The TUG test was performed as follows: after showing participants how to do the test, each participant was observed and timed while he/she rose from a standard armchair, walked to a line 3 meters away, turned around, walked back to the chair, and sat down again. After repeating the TUG twice, the average time (s) was noted.[13]

The handgrip strength test was performed using a digital hand dynamometer (Model EH101, Camry LLC, El Monte, CA, USA). The participant was instructed to sit with his/her shoulders adducted, elbows flexed at 90°, and forearms in a neutral position; they then squeezed the dynamometer with maximum isometric effort for at least 5 seconds, using his/her dominant hand.[14] Maximal force (kg), stratified by gender and age, was noted; the average value after two attempts was used.

Psychometric Assessment Tests

The psychometric assessment was conducted by skilled physicians and research assistants via direct interview. The Patient Health Questionnaire-9 (PHQ-9) was used to identify depression. PHQ-9 is a valid and reliable instrument for measuring depression, and the degree of changes in depressive symptoms. A PHQ-9 score lower than 5 is considered normal; a score of 10 or higher is the recommended cut-off score for detecting major depressive disorders.[15]

The Korea Dementia Screening Questionnaire-Cognition (KDSQ-C) and Mini-Cog test were utilized to evaluate cognitive function. The KDSQ-C is a screening tool for dementia in the elderly, which has high validity and reliability. It comprises 15 cognitive dysfunction items, with a maximum score of 30; a higher score indicates poorer function and greater frequency. The cut-off point of 8 has a sensitivity of 0.75 and specificity of 0.73 for dementia.[16,17] The Mini-Cog test, which combines two cognitive tasks (three item word memory and clock drawing), is useful for screening dementia. A total score of five points is calculated by summing the score of the 3 item recall (0–3 points) and clock drawing exercise (0 or 2 points). A cut-off < 3 has been validated for dementia screening.[18–20]

The Brief Encounter Psychosocial Instrument (BEPSI) was used to measure interactional models of stress. It comprises five items, and the scores for each item (Likert's scale 1–5 points) are summed to calculate an average. A score < 1.8 corresponds to low stress. The validity of the Korean version of the BEPSI has been reported previously.[21–23]

The Profile of Mood States (POMS) is an instrument used to identify transient and variable affective states. A total of 65 questions (Likert's scale, 0–4 points) are divided into six subscales: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment. The validity and reliability of the Korean version of POMS have been confirmed.[24,25]

The Insomnia Severity Index (ISI) and average sleep duration for the last 2 weeks were evaluated. The ISI, a screening questionnaire for insomnia, comprises seven items. A total score of 0–7 is interpreted as an absence of insomnia, 8–14 as sub-threshold insomnia, 15–21 as moderate insomnia, and 22–28 as severe insomnia.[26,27] Sleep duration was also assessed through an open-ended question: "How many hours did you sleep on an average night during the recent 2 weeks?" Self-reported sleep duration shows good agreement with accelerometer or polysomnography data.[28]

Laboratory Tests

Laboratory tests were performed using blood samples obtained after an 8 h fast (baseline). The following parameters were measured: high sensitivity C-reactive protein; thyroid function (free T4, thyroid stimulating hormone); hemoglobin A1c; the erythrocyte sedimentation rate; complete blood count; liver function (aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, total bilirubin, direct bilirubin, albumin, total protein, lactate dehydrogenase); uric acid levels; calcium, phosphorus, and glucose levels; renal function (blood urea nitrogen, creatinine; sodium; potassium); and lipids (total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglyceride).

Statistical Analysis

A paired *t*-test was used to compare data obtained before and after the 8-week intervention. Spearman correlation analysis was utilized to examine the relationships between psychometric tests and physical function. Logistic regression analysis using the forward stepwise selection method was performed to identify factors that contribute significantly to physical performance. A P-value < 0.05 was considered significant. All statistical analyses were performed using the IBM SPSS (version 25.0) program (IBM SPSS Statistics, Armonk, NY, USA).

Results

Baseline Characteristics

A total of 31 elderly subjects were recruited and screened during the enrollment period. After excluding eight participants who withdrew written consent (N = 3) or were lost to follow-up (N = 5), a total of 23 elderly subjects were selected for the final analysis. The mean age was 82.78 years; 78.3% were women; 43.5% lived with one or more cohabitants; 52.2% did not have any formal education; and 30.4% had been diagnosed with hypertension, 13.0% with dyslipidemia, and 69.9% with other comorbidities (including osteoporosis, stroke, stable angina, rheumatoid arthritis, dementia, and malignancies). Laboratory test results were generally fair; none of the subjects had severe abnormal findings that required emergency treatment or hospitalization (Table 1).

Physical Performance

The mean baseline TUG test time (s) was 13.16 ± 6.53. After the intervention, the mean time fell significantly to 12.81 ± 6.22 s (Δ = −0.35 ± 0.73 s, P = 0.034). The mean handgrip strength (kg) test result was 15.81 ± 7.10 kg at baseline, which increased to 16.54 ± 6.67 kg after the intervention (Δ = 0.73 ± 0.99 kg, P = 0.002) (Table 2).

Psychological Assessment

The ISI score for severity of sleep disturbance was 9.48 ± 8.54 at baseline and 6.57 ± 7.12 after the 8-week intervention (Δ = −2.91 ± 5.64, P = −0.021). Average sleep duration (h) was 6.48 ± 2.06 at baseline, increasing to 7.35 ± 1.87 (Δ = 0.87 ± 1.98, P = 0.047) after the intervention. Other psychological tests did not reveal significant changes (Table 3).

Table 1 Baseline Characteristics

Characteristic		Value (N = 23)
Age, years		82.78 ± 6.89
Sex	Male	5 (21.7%)
	Female	18 (78.3%)
Smoking status	Non-smoker	18 (78.3%)
	Ex- or current smoker	5 (21.7%)
Alcohol consumption	None	15 (65.2%)
	Social or heavy	8 (34.8%)
Exercise	None	10 (43.5%)
	Regular	13 (56.5%)
Educational level	Uneducated	12 (52.2%)
	Elementary school	2 (8.7%)
	Middle school	3 (13.0%)
	High school	1 (4.3%)
	College	5 (21.7%)
Marital status	Married or cohabiting	10 (43.5%)
	Unmarried or widowed	13 (56.5%)
Clinically diagnosed underlying disease	Hypertension	7 (30.4%)
	Diabetes mellitus	3 (13.0%)
	Dyslipidemia	7 (30.4%)
	Other comorbidities*	16 (69.6%)
Laboratory tests	hs-CRP (mg/dL)	0.40 ± 1.19
	Free T4 (ng/dL)	0.96 ± 0.06
	TSH (μIU/mL)	1.94 ± 1.17
	HbA1c (%)	5.89 ± 0.53
	ESR (mm/h)	17.05 ± 14.30
	WBC (10^3/μL)	6.75 ± 1.81
	RBC (10^6/μL)	3.98 ± 0.60
	Hemoglobin (g/dL)	12.18 ± 1.63
	Hematocrit (%)	36.81 ± 4.84
	Platelet (10^3/μL)	216.27 ± 61.82
	Total protein (g/dL)	6.94 ± 0.47
	Albumin (g/dL)	4.61 ± 0.30
	Total bilirubin (mg/dL)	0.41 ± 0.021
	Direct bilirubin (mg/dL)	0.17 ± 0.07
	AST (U/L)	20.43 ± 5.67
	ALT (U/L)	15.95 ± 6.24
	ALP (U/L)	79.86 ± 26.65
	GGT (U/L)	23.71 ± 20.80
	Uric acid (mg/dL)	5.60 ± 2.58
	LDH (U/L)	211.19 ± 34.52
	Ca (mg/dL)	9.42 ± 0.42
	P (mg/dL)	3.69 ± 0.57
	Glucose (mg/dL)	112.86 ± 23.92
	BUN (mg/dL)	17.35 ± 10.25
	Creatinine (mg/dL)	1.00 ± 0.62
	Na (mmol/L)	139.52 ± 2.25
	K (mmol/L)	4.62 ± 0.51
	Total cholesterol (mg/dL)	174.33 ± 48.03
	HDL-C (mg/dL)	56.57 ± 16.20
	LDL-C (mg/dL)	104.10 ± 42.42
	Triglyceride (mg/dL)	140.24 ± 71.20

Notes: Values are presented as the mean ± standard deviation or as number (%). *Other comorbidities included osteoporosis, stroke, stable angina, peripheral vascular disease, rheumatoid arthritis, dementia, chronic kidney disease, and malignancies.
Abbreviations: hsCRP, high sensitivity C-reactive protein; TSH, thyroid stimulating hormone; ESR, erythrocyte sedimentation rate; WBC, white blood cell count; RBC, red blood cell count; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; GGT, gamma-glutamyltransferase; LDH, lactate dehydrogenase; BUN, blood urea nitrogen; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

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Table 2 Changes in Physical Performance Before and After the 8-Week Pet Insect Intervention

	Pre-Intervention	Post-Intervention	Δ (Post-Pre)	P-value*
Timed up-and-go test (sec)	13.16 ± 6.53	12.81 ± 6.22	−0.35 ± 0.73	0.034
Handgrip strength (kg)	15.81 ± 7.10	16.54 ± 6.67	0.73 ± 0.99	0.002

Notes: Values are presented as the mean ± standard deviation. * Paired *t*-test.

Table 3 Changes in Psychological Assessments Before and After the 8-Week Pet Insect Intervention

	Pre-Intervention	Post-Intervention	Δ (Post-Pre)	P-value*
PHQ-9	6.30 ± 6.80	4.78 ± 5.17	−1.52 ± 5.70	0.213
KDSQ-C	7.26 ± 6.39	6.30 ± 5.60	−0.957 ± 3.97	0.260
Mini-Cog Total	2.48 ± 2.00	2.43 ± 1.97	−0.043 ± 1.80	0.909
Mini-Cog 3-item	1.65 ± 1.34	1.48 ± 1.20	−0.17 ± 1.47	0.575
Mini-Cog Clock	0.83 ± 0.98	0.96 ± 0.93	0.13 ± 0.76	0.418
BEPSI	1.90 ± 1.00	1.85 ± 0.97	−0.052 ± 1.01	0.806
POMS	10.43 ± 18.54	9.83 ± 20.62	−0.61 ± 18.46	0.876
ISI	9.48 ± 8.54	6.57 ± 7.12	−2.91 ± 5.64	0.021
Sleep duration (hours)	6.48 ± 2.06	7.35 ± 1.87	0.87 ± 1.98	0.047

Notes: Values are presented as the mean ± standard deviation. * Paired *t*-test.
Abbreviations: PHQ-9, Patient Health Questionnaire-9; KDSQ-C, Korea Dementia Screening Questionnaire-Cognition; Mini-Cog Total, Mini-Cognitive Total; Mini-Cog 3-item, Mini-Cognitive 3-item recall score; Mini-Cog Clock, Mini-Cognitive Clock drawing score; BEPSI, Brief Encounter Psychosocial Instrument; POMS, Profile of Mood States; ISI, Insomnia Severity Index.

Relationship Between Psychometric Assessment and Physical Performance Tests

Spearman's rank correlation coefficient analysis was performed to compare changes in psychometric data and physical performance test results before and after the intervention. There was a positive correlation between the KDSQ-C and TUG test scores (Spearman's $\rho = 0.470$, $P = 0.024$), and a negative correlation between the ISI and handgrip strength test scores (Spearman's $\rho = -0.447$, $P=0.033$). There were no significant correlations between other psychometric assessment and physical performance tests (Table 4).

Factors Related to Improvements in Physical Performance

Logistic regression analysis using the forward stepwise selection method were conducted using TUG and handgrip strength test data as dependent variables, and other covariates as independent variables. In step 1 of the forward stepwise selection, the baseline ISI score (OR=1.323; 95% CI, 1.025–1.708, P = 0.031) was significantly associated with the probability of positive changes in both the TUG and handgrip strength tests after the intervention. In step 2, the baseline ISI score (OR=1.413; 95% CI, 1.069–1.869, P = 0.015) and the presence of other comorbidities (OR=0.036; 95% CI, 0.002–0.832, P = 0.038) were significantly associated with the probability of positive changes in both the TUG and handgrip strength tests after the intervention (Table 5).

Discussion

Frailty is a vulnerable state caused by an age-associated decline in physical and psychological function. It is important to develop an efficacious, cost-effective, and easily applicable intervention for frailty. This study is a single-arm 8-week

Table 4 Correlation Between Differences in Psychometric Assessment Scores and Physical Performance Test Scores

	ΔTUG Test		ΔHandgrip Strength	
	Spearman's ρ	***P*-value***	**Spearman's ρ**	***P*-value***
ΔPHQ-9	0.392	0.064	−0.224	0.304
ΔKDSQ-C	0.470	0.024	−0.105	0.635
ΔMini-Cog Total	0.076	0.732	0.064	0.773
ΔMini-Cog 3-item	0.049	0.825	0.048	0.829
ΔMini-Cog Clock	−0.032	0.884	0.211	0.334
ΔBEPSI	0.075	0.734	−0.172	0.433
ΔPOMS	−0.006	0.979	−0.009	0.967
ΔISI	0.309	0.151	−0.447	0.033
ΔSleep duration	−0.157	0.475	0.322	0.134
ΔTUG test	NA	NA	−0.047	0.831
ΔHandgrip strength	0.102	0.642	NA	NA

Note: *Spearman's rank correlation coefficient analysis.
Abbreviations: PHQ-9, Patient Health Questionnaire-9; KDSQ-C, Korea Dementia Screening Questionnaire-Cognition Mini-Cog Total, Mini-Cognitive Total; Mini-Cog 3-item, Mini-Cognitive 3-item recall score; Mini-Cog Clock, Mini-Cognitive Clock drawing score; BEPSI, Brief Encounter Psychosocial Instrument; POMS, Profile of Mood States; ISI, Insomnia Severity Index; TUG test, Timed up-and-go test.

Table 5 Factors Related to Improvements in the Physical Performance of Prefrail and Frail Elderly People After the 8-Week Intervention

Selected Variable		OR	95% CI	*P*-value
Step 1	Baseline ISI score	1.323	1.025–1.708	0.031
Step 2	Baseline ISI score	1.413	1.069–1.869	0.015
	Presence of other comorbidities	0.036	0.002–0.832	0.038

Notes: Logistic regression analysis using the forward stepwise selection method; positive changes in both the Timed Up-and-Go-test and the handgrip strength test after the intervention were dependent variables; age, sex, smoking, alcohol, exercise, educational level, marital status, hypertension, diabetes mellitus, dyslipidemia, and other comorbidities, Patient Health Questionnaire-9 scores, Korea Dementia Screening Questionnaire-Cognition scores, Mini-Cog Total scores, Brief Encounter Psychosocial Instrument scores, Profile of Mood States scores, Insomnia Severity Index scores, and sleep duration (all at baseline) were independent variables.

interventional pilot study designed to assess the efficacy of pet insects on physical function and psychological health among frail and prefrail elderly Koreans. Interestingly, we noted small but significant changes in physical function of the upper and lower extremities, as well as in the quality and duration of sleep, after the individuals spent 8 weeks rearing pet insects. Among various factors, we found that the ISI and the presence of other comorbidities were significantly related to improvements in both the TUG test and handgrip strength. Thus, pet insects are an effective and easily applicable AAI for prefrail and frail elderly people, especially those with sleep disorders.

The TUG and handgrip strength tests are useful for evaluating the frailty of the elderly.[29–33] As frailty progresses, the elderly tend to show decreased physical ability and cognitive function, increased fall risk, loss of autonomy, and increased mortality.[34–36] In this regard, evaluating frailty can allow provision of targeted treatment options; thus diagnosis and evaluation of frailty are of clinical importance. The TUG is an easily applicable, reliable, and time-efficient method of assessing physical performance and mobility.[37] The reference values for the elderly are 8.1 seconds for those in their 60s, 9.2 seconds for those in their 70s, and 11.3 for those in their 80s–90s.[38] Handgrip strength is a tool for assessing physical performance and detecting poor mobility among the elderly; low handgrip strength might be associated with cognitive decline.[39,40]

The cut-off values for low handgrip strength are <26–30 kg for men and <16–20 kg for women.[41] The participants in this study are older, frailer, and have more comorbidities than those in previous studies, as indicated by the TUG (13.16 s) and handgrip strength (15.81 kg) results, which were below the reference values. Therefore, the results of this study are meaningful because they reflect the effect of rearing pet insects on the physical and mental status of vulnerable elderly people.

AAI has a positive influence on the physical function of older adults. Older adult pet-owners have fewer limitations with regard to ADL, fewer visits to a doctor, engage in more frequent physical exercise, and have a more heightened sense of community.[42,43] Despite these benefits, mammals such as dogs and cats may be associated with an increased risk of falls, injuries, and infectious diseases.[8] In this regard, pet insects are a safe and effective choice for improving the physical function of vulnerable older adults. The frail adults in this study showed a significant improvement in both the TUG and handgrip strength tests after the intervention. The possible reasons for these results are as follows. First, animal-human interaction using pet insects may improve cognitive function through the focus required to care for and feed them regularly, or arrange/clean their environment.[6,7] In addition, animal-human interactions improve emotional health; indeed, pet insects might have certain benefits with respect to improving cognitive function.[8] Considering that maintaining balance and mobility is closely linked to complex integration and coordination, including cognitive and motor processes,[44] the improvement in physical functions noted in this study are reasonable. Second, impairment of balance and mobility are associated with decreased balance confidence.[44] AAI with pet insects could increase balance confidence by motivating the elderly to perform more daily physical activity and to attempt new tasks, including feeding and rearing pets. Third, the TUG and handgrip strength tests are good indicators of sarcopenia. Although rearing insects does not need a strong physical effort, it requires sophisticated executive activities to handle the small insects. Executive function activities are related to attention, problem-solving, and working memory. In a previous study, the rearing of pet insects had an advantageous effect on executive function in older women.[7] Improvements in TUG and handgrip strength might reflect increased daily physical activity involving both the upper and lower extremities.

The ISI score decreased and sleep duration increased, which were significant improvements; indeed, the environment, nutritional status, and amount of activity affect regular sleep patterns.[45,46] A previous study involving 100 elderly people in nursing homes showed that AAI has a transient beneficial effect on sleep duration.[46] AAI has beneficial effects in that it encourages the elderly to move more as they care for their pets; these improvements might help sleep patterns. However, we found no significant changes in other psychological parameters, including depression, cognitive function, stress, or mood. Although changes were generally positive, the number of participants was too small to achieve statistical significance. Further studies with a larger study population are warranted.

One interesting result of this study was that changes in KDSQ-C correlated positively with the TUG, and changes in ISI correlated negatively with handgrip strength. A previous observational study used measurements of sleep and physical performance to show an association between sleep behaviors and neuromuscular performance in older women; shorter sleep duration and longer waking time at night are related to a greater risk of poorer physical performance.[47] Physical function is linked closely to psychological health; thus cognitive function and sleep should be considered when providing appropriate medical services for the frail elderly.

Logistic regression analysis, using all factors as dependent variables, was conducted to identify factors associated with significant improvement in physical function after the intervention. It turned out that the baseline ISI score, as well as comorbidities (osteoporosis, stroke, stable angina, rheumatoid arthritis, dementia, malignancies), were all related factors. Baseline ISI was associated with a higher probability of improved physical performance, whereas the presence of other comorbidities was associated with a lower probability. In other words, elderly people with insomnia, but without complicating comorbidities, are more likely to show improved physical function after AAI using pet insects. This is interesting since the participants in the present study showed a significant improvement in physical function, ISI, and sleep duration after the intervention. Considering that elderly people with psychoneurological diseases show improved sleep patterns and reduced anxiety after AAI,[48,49] and that anxiety and insomnia are closed linked mental disorders,[50] AAI might improve physical performance by improving mental health. This result suggests that AAI will have beneficial effects on the physical and psychological health of mobile frail patients without advanced disease.

This study has several limitations. First, the number of participants was small and there was no control group. The period of recruitment coincided with the COVID-19 pandemic period, and social distancing measures had strengthened. This restricted the recruitment numbers. Thus, this study was designed as a pilot study prior to further randomized controlled trials. Second, we could not perform laboratory tests after the intervention because only a limited number of researchers were allowed to revisit the facility. Third, the 8 week study period was relatively short. A short study duration may not be sufficient to confirm improvements in physical and psychological function after AAI. However, this period was inevitable because in general crickets live only for up to 2 months. Further studies with extended study periods are needed using different pet insects which have longer life expectancies.

Despite these limitations, this study has certain strengths. To the best of our knowledge, it is the first study to assess the effects of AAI using pet insects on both the physical and psychological function of the frail elderly people. Furthermore, various biomarkers were utilized to obtain objective baseline characteristics, despite the COVID-19 pandemic.

Conclusion

In conclusion, this pilot study provides evidence that pet insects are an effective AAI and have beneficial effects on the physical function and sleep patterns of prefrail and frail elderly people. It is expected that frail elderly people with sleep disorders, but without complicated comorbidities, are more likely to benefit from AAI. AAI using pet insects is easily applicable, cost-effective, less space occupying, and simple. Further randomized controlled trials of AAI using pet insects, with larger diverse populations and extended study periods, are necessary.

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Disclosure

The authors report no conflicts of interest in this work.

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