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ORIGINAL RESEARCH

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Relationship between prevalence of cardiometabolic diseases, self-reported memory loss, and self-reported depressed mood of older adults in Korea according to frailty and physical activity status

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Abstract

As the older population increases worldwide, frailty is the area of research that deserve further investigation and is considered a major social and public health concern. Frailty appears physically and mentally, and recently, the term cognitive frailty has been used to combine physical frailty and mild cognitive impairment syndrome. Frailty in older adults is characterized by low physical activity levels and a sedentary lifestyle. Physical activity is essential in managing mental health issues such as depression and can improve the executive function and memory of older adults with mild cognitive impairment. Therefore, this study aimed to examine the prevalence of cardiometabolic diseases, self-reported memory loss, and depression among older adults in Korea according to frailty and physical activity status. Using data from the 2019 Korea National Health and Nutrition Survey, this study analyzed 613 community-dwelling older males aged $\geq$65 years. Physical activity was measured using a Global Physical Activity Questionnaire. A health-related quality of life instrument with eight items (HINT-8) was used to assess self-reported memory loss and depressed mood. Relationships between physical activity levels, self-reported memory loss and depressed mood were analyzed using logistic regression. The incidence of HINT-8 memory (0.52 (95% confidence interval (CI): 0.32–0.85)) was significantly lower in the Physical Activity Level (PAL)-high/pre-frail; the incidence of HINT-8 depression (0.35 (95% CI: 0.21–0.59); 0.29 (95% CI: 0.17–0.52)) was significantly lower in the and PAL-high/pre-frail. We verified that the group with PAL-low/frail had the highest self-reported memory loss and depressed mood, suggesting that more physical activity may reduce self-reported memory loss and depressed mood among frail older males in Korea. However further research is needed to analyze the level of physical activity separately between work and leisure.

Keywords

Older adults; Frailty; Physical activity; Self-reported memory loss; Self-reported depressed mood

1. Introduction

As the older population increases worldwide, frailty is the area of research that deserve further investigation and is considered a major social and public health concern [1, 2]. According to Fried, frailty causes health problems such as mortality, falls, and hospitalization as age increases; if a patient exhibits more than three of the five items used as indicators of frailty (unintentional weight loss, muscle weakness, self-reported exhaustion, slow walking speed, and physical activity reduction), they are frail; if one or two items are included, they are pre-frail; and if none is included, they are robust [3].

Frailty is associated with major cardiometabolic diseases, including cardiovascular disease and diabetes mellitus [3]. Hypertension appears to have the highest prevalence rate among older adults in Korea; in particular, frail older adults have a higher prevalence rate than pre-frail and robust groups [4, 5]. Diabetes mellitus and frailty are closely related to aging mechanisms [6]. The prevalence of diabetes mellitus in older individuals increases with frailty [7]. Dyslipidemia has a high prevalence rate in the frailty elderly [8]. Total cholesterol increases with age; however, high-density lipoprotein cholesterol (HDL-C) decreases [9]. Low HDL-C was seen in the elderly in the pre-frail and frailty [10]. Metabolic syndrome is frequently observed in older adults, and its prevalence increases in older individuals with frailty [11]. Metabolic syndrome is accompanied by insulin resistance and chronic microinflammation, has a strong association with sarcopenia,

and can be estimated to be associated with frailty [12]. Studies have shown that older adults with metabolic syndrome are more likely to be frail than older adults without metabolic syndrome, and this association is very strong [13, 14]. Obesity is associated with frailty; the higher the body mass index (BMI), the higher the likelihood of pre-frailty [15].

As age increases, memory function decreases in older adults; due to these symptoms, some older adults are diagnosed with mild cognitive impairment [16]. Mild cognitive impairment is a symptom of aging, and dementia and memory function are the major factors [17, 18]. Recently, Cognitive frailty is used to describe the co-occurring frailty and mild cognitive impairment, which is also associated with depression [19, 20].

Frailty shows physical and psychological manifestation, and depressive symptoms and frailty are strongly related [21, 22]. Those with frailty are four times more likely to develop depression; similarly, people with depression are approximately four times more likely to develop frailty [23].

Older adults tend to reduce their physical activity because they usually move less and spend more time sitting [24]. In other words, older adults with features of frailty are less physically active with a more sedentary lifestyle [25]. In frail older individuals, moderate-intensity physical activity (functional exercise such as walking, sitting, standing up, and balancing) can reduce the prevalence of cardiometabolic diseases [26]. In addition, physical activity plays a vital role in managing mental health issues such as depression and can improve the executive function and memory of older adults with mild cognitive impairment [27, 28].

However, no comprehensive studies have been conducted on the prevalence of cardiometabolic diseases, memory function, or depression according to physical activity levels (PALs) in frail older individuals. Therefore, the study aimed to examine the prevalence of cardiometabolic diseases, self-reported memory loss, and depression among older adults in Korea according to frailty and physical activity status. We hypothesized that PALs are related to the prevalence of chronic diseases, memory function, and depression in older males in Korea.

2. Materials and methods

2.1 Participants

This study analyzed community-dwelling older males aged ≥65 years using data from the 2019 Korea National Health and Nutrition Survey published by the Korea Disease Control and Prevention Agency. In 2019, 8110 people completed all the surveys. However, we excluded 7366 participants, including those under 65 years and female participants. Of the remaining 744 participants, 125 with missing data were excluded. Six participants with robustness were further excluded after the frailty criteria evaluation. Finally, 613 participants were included in the study (Fig. 1).

2.2 Measurement analysis data

Data on age, weight, height, educational level, economic activity status, smoking status, and alcohol consumption were collected from the Korea National Health and Nutrition Survey. The prevalence of cardiometabolic diseases were determined by measuring the systolic blood pressure, diastolic blood pressure, fasting glucose, total cholesterol, triglycerides, HDL-C, BMI and waist circumference. A health-related quality of life instrument with eight items (HINT-8) was used to assess self-reported memory loss and depressed mood. The frailty criteria included weight loss per year, grip strength, usual stress awareness questions, Euro Quality of Life 5-Dimensions exercise questions, and leisure physical activity. Physical activity variables were expressed as metabolic equivalent tasks (MET-min/week) min/week.

2.3 Odds of cardiometabolic diseases

The prevalence of hypertension was defined as systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥80 mmHg [29]. Dyslipidemia was defined as total cholesterol ≥240 mg/dL, triglyceride ≥200 mg/dL, or HDL-C <40 mg/dL [30]. Diabetes mellitus was defined as fasting glucose ≥126 mg/dL [31]. Obesity was defined as BMI ≥25 kg/m^2 [32]. Metabolic syndrome was classified according to the guidelines of the National Cholesterol Education Program-Adult Treatment Panel 3 and the Korea Society for the Study of Obesity [33]. This was diagnosed if more than three of the five criteria were met. The metabolic syndrome criteria included waist circumference >90 cm, systolic blood pressure >130 mmHg or diastolic blood pressure >85 mmHg, and triglyceride >130 mg/dL, HDL-C <40 mg/dL, or fasting glucose >100 mg/dL.

2.4 Self-reported memory loss and self-reported depressed mood

Self-reported memory loss and depressed mood were expressed using a HINT-8 memory and depression. Self-reported memory loss was determined when the "I have difficulty remembering" item was selected. Self-reported depressed mood was determined when the item "I felt depressed" was selected. The HINT-8 has proven to be appropriate for health-related measurements in older adults [34].

2.5 Frailty

Based on the criteria for diagnosing frailty proposed by Fried [3], modified frailty criteria were established that could be used for data from the Korea National Health and Nutrition Survey [3, 35]. Unintentional weight loss is ≥3 kg per year [36]. Weakness was applied to the muscle weakness criteria suggested by the Asian Working Group for Sarcopenia 2014 and grip strength of <26 kg [37]. Slow walking speed was assessed using the response to "some difficulty walking" and must lie all day in the Euro Quality of life 5-Dimensions exercise questions [38]. In the usual stress awareness question, self-reported exhaustion was assessed based on the response to "feeling very much" [39]. Low physical activity was usually less than 2 h of leisure-moderate-intensity physical activity per week or less than 1 h of leisure-vigorous-intensity physical activity [40]. Participants who met three or more of the five items were classified as frail, and those who met one or two of the criteria were classified as pre-frail.

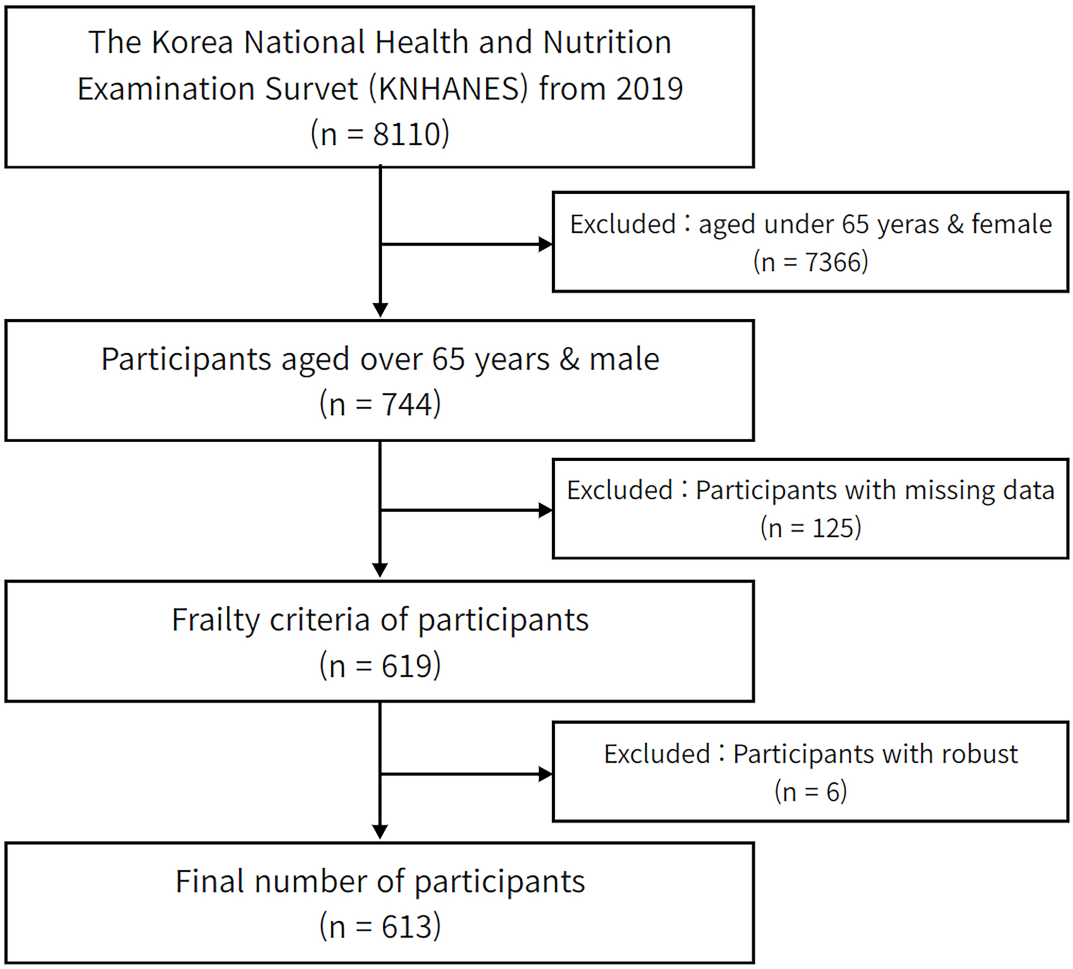

FIGURE 1. Flow diagram for the selection of study participants.

2.6 Physical activity questionnaire

Physical activity was measured using a Global Physical Activity Questionnaire. Work/leisure vigorous-intensity physical activity, moderate-intensity physical activity, and movement were calculated as metabolic equivalents (MET-min/week) [41].

—Moderated-intensity activity (MET-min/week) = 4.0 (MET) × moderate-intensity physical activity minutes × moderate-intensity days.

—Vigorous-intensity activity (MET-min/week) = 8.0 (MET) × vigorous-intensity physical minutes × vigorous-intensity days.

—Movement (MET-min/week) = 4.0 (MET) × movement physical activity minutes × movement days.

—Total Physical Activity (MET-min/week) = moderate-intensity activity + vigorous-intensity activity + movement.

PALs were classified as PAL-low (0–599 MET-min/week) or PAL-high (≥600 MET-min/week).

2.7 Physical activity levels and frailty status group

We divided into four groups. PAL-low/frail was defined low physical activity level and frail status. PAL-low/pre-frail was defined low physical activity level and pre-frail status. PAL-high/frail was defined high physical activity level and frail status. PAL-high/pre-frail was defined high physical activity level and pre-frail status.

2.8 Statistical analysis

All analyses were performed using stratified cluster sampling, and standard plots and weights were used for the data. The chi-square test was used to analyze categorical and continuous variables to compare general characteristics. Continuous variables were presented as means and standard deviations. One-way analysis of variance was used to compare the differences between PALs and frailty status. Moreover, the relationship between physical activity, frailty status, odds of cardiometabolic diseases, self-reported memory loss, and self-reported depressed mood was determined using logistic regression after controlling for covariates using unadjusted and adjusted regression models. The covariate adjustment was implemented in two stages. Model 1 was unadjusted, while Model 2 was adjusted for age, smoking, alcohol consumption, education and economic activity status. Logistic regression findings are presented as odds ratios (ORs) and their associated 95% confidence intervals (CIs). All statistical analyses were performed using the IBM Statistical Package for Social Science (SPSS) version 28.0 for Windows (IBM Corporation, Armonk, NY, USA). Statistical significance was set at $p < 0.05$.

3. Result

3.1 Characteristics of the study sample

A total of 613 older Korean males aged ≥65 years (mean age, 72.68 ± 5.10 years) were included in this study. For education level, elementary school or below (31.8%) was the highest, followed by high school (28.1%), middle school (21.5%), and college or above (18.6%). The marital status of the majority of the participants was married (99.3%), while a few patients were single (0.7%). Economic activity was lower among the employed participants (42.4%) than among the unemployed group (57.6%). Smoking and alcohol consumption were reported by 18.4% and 68.4% of the participants, respectively. HINT-8 memory and HINT-8 depression were observed in 65.7% and 33.4% of the participants, respectively. The odds of hypertension, dyslipidemia, diabetes mellitus, obesity and metabolic syndrome was 45.7%, 38.0%, 16.3%, 32.6% and 33.9%, respectively (Table 1).

3.2 Differences in characteristics according to PALs and frailty status

Self-reported memory loss, according to HINT-8 memory, was highest in the PAL-low/frail group and lowest in the PAL-high/pre-frail group, 75.5% and 55.7%, respectively (χ^2 = 19.535, $p < 0.001$). Similarly, self-reported depressed mood, according to HINT-8 depression, was highest in the PAL-low/frail group and lowest in the PAL-high/pre-frail group, 46.8% and 21.5%, respectively (χ^2 = 26.549, $p < 0.001$). Odds of diabetes mellitus was highest in the PAL-high/frail group at 25.8% and lowest in the PAL-low/frail group at 11.2% (χ^2 = 8.570, p = 0.036). Alcohol consumption was highest in the PAL-high/pre-frail group at 77.8% and lowest in the PAL-low/frail group at 58.5% (χ^2 = 15.279, p = 0.002) (Table 2).

3.3 Differences in body composition and risk factors for cardiometabolic diseases according to PALs and frailty status

The weight of the PAL-high/pre-frail group was higher than those of the PAL-low/pre-frail, PAL-low/frail, and PAL-high/pre-frail groups (p = 0.009). Diastolic blood pressure was lower in the PAL-low/frail group than in the PAL-low/pre-frail group, and it was also lower in the PAL-high/frail group than in the PAL-high/pre-frail group (p = 0.002) (Table 3).

3.4 Odds ratios for chronic diseases, HINT-8 memory, and HINT-8 depression according to physical activity levels and frailty status (95% CI)

The ORs for cardiometabolic diseases, HINT-8 memory, and HINT-8 depression according to PAL and frailty status were as follows: the prevalence of diabetes mellitus (3.28 (95% CI: 1.52–7.10); 3.47 (95% CI: 1.56–7.69); 2.31 (95% CI: 1.22–4.40); 2.74 (95% CI: 1.35–5.58)) was significantly higher in the PAL-high/frail and PAL-high/pre-frail; the prevalence of obesity (1.99 (95% CI: 1.02–3.87); 2.18 (95% CI: 1.10–4.33)) was significantly higher in the PAL-high/frail; the incidence of HINT-8 memory (0.61 (95% CI: 0.39–0.98); 0.52 (95% CI: 0.32–0.85)) was significantly lower in the PAL-low/pre-frail and PAL-high/pre-frail; the incidence of HINT-8 depression (0.53 (95% CI: 0.34–0.82); 0.47 (95% CI, 0.30–0.76); 0.35 (95% CI: 0.21–0.59); 0.29 (95% CI: 0.17–0.52)) was significantly lower in the PAL-low/pre-frail and PAL-high/pre-frail (Table 4).

TABLE 1. Baseline characteristics of the participants.

Variables	Participants (n = 613)
Age (yr)	72.68 ± 5.10
Height (cm)	166.05 ± 5.72
Weight (kg)	65.90 ± 9.58
BMI (kg/m^2)	23.86 ± 2.98
Waist circumference (cm)	89.30 ± 8.77
Fasting glucose (mg/dL)	110.09 ± 27.05
TC (mg/dL)	177.32 ± 38.64
HDL-c (mg/dL)	47.12 ± 11.24
TG (mg/dL)	139.91 ± 108.10
SBP (mmHg)	127.23 ± 15.72
DBP (mmHg)	72.61 ± 9.46
Education (%)	
≤Elementary school	195 (31.8)
Middle school	132 (21.5)
High school	172 (28.1)
≥College	114 (18.6)
Marriage status (%)	
Married	609 (99.3)
Single	4 (0.7)
Economic activity status	
Employed	260 (42.4)
Unemployed	353 (57.6)
Smoking (%)	113 (18.4)
Alcohol (%)	419 (68.4)
HINT-8 memory (%)	403 (65.7)
HINT-8 depression (%)	205 (33.4)
Hypertension (%)	280 (45.7)
Dyslipidemia (%)	233 (38.0)
Diabetes mellitus (%)	100 (16.3)
Obesity (%)	200 (32.6)
Metabolic syndrome (%)	208 (33.9)

Values are expressed as means ± standard deviation; BMI: body mass index; TC: total cholesterol; HDL-C: high-density lipoprotein cholesterol; TG: triglyceride; SBP: systolic blood pressure; DBP: diastolic blood pressure; HINT-8: health-related quality of life instrument with eight items.

TABLE 2. Baseline characteristics by PALs and frailty status among older Korean males.

Characteristics	Categories	MET-min/week				χ^2	*p*-value
		PAL-low		PAL-high			
		Pre-frail (n = 205, %)	Frail (n = 188, %)	Pre-frail (n = 158, %)	Frail (n = 62, %)		
Education							
	≤Elementary school	59 (28.8)	86 (45.7)	23 (14.6)	27 (43.5)	77.137	<0.001***
	Middle school	42 (20.5)	50 (26.6)	26 (16.5)	14 (22.6)		
	High school	61 (29.8)	42 (22.3)	59 (37.3)	10 (16.1)		
	≥College	43 (21.0)	10 (5.3)	50 (31.6)	11 (17.7)		
Smoking							
	Smokers	37 (18.0)	36 (19.1)	31 (19.6)	9 (14.5)	0.865	0.834
	Non-smokers	168 (82.0)	152 (80.9)	127 (80.4)	53 (85.5)		
Alcohol consumption							
	Yes	142 (69.3)	110 (58.5)	123 (77.8)	44 (71.0)	15.279	0.002**
	None	63 (30.7)	78 (41.5)	35 (22.2)	18 (29.0)		
HINT-8 Memory							
	Normal	79 (38.5)	46 (24.5)	70 (44.3)	16 (25.9)	19.535	<0.001***
	Abnormal	126 (61.5)	142 (75.5)	88 (55.7)	46 (74.1)		
HINT-8 Depression							
	Yes	61 (29.8)	88 (46.8)	34 (21.5)	22 (35.5)	26.549	<0.001***
	None	144 (70.2)	100 (53.2)	124 (78.5)	40 (64.5)		
Hypertension							
	Yes	103 (50.2)	79 (42.0)	72 (45.6)	26 (41.9)	3.086	0.379
	None	102 (49.8)	109 (58.0)	86 (54.4)	36 (58.1)		
Dyslipidemia							
	Yes	68 (33.2)	78 (41.5)	58 (36.7)	29 (46.8)	5.138	0.162
	None	137 (66.8)	110 (58.5)	100 (63.3)	33 (53.2)		
Diabetes mellitus							
	Yes	33 (16.1)	21 (11.2)	30 (19.0)	16 (25.8)	8.570	0.036*
	None	172 (83.9)	167 (88.8)	128 (81.0)	46 (74.2)		
Obesity							
	Yes	71 (34.6)	54 (28.7)	50 (31.6)	25 (40.3)	3.419	0.331
	None	134 (65.4)	134 (71.3)	108 (68.4)	37 (59.7)		
Metabolic syndrome							
	Yes	71 (34.6)	66 (35.1)	50 (31.6)	21 (33.9)	0.529	0.912
	None	134 (65.4)	122 (64.9)	108 (68.4)	41 (66.1)		

*PAL: physical activity level; MET: metabolic equivalents; HINT-8: health-related quality of life instrument with eight items; *p < 0.05, **p < 0.01, ***p < 0.001.*

TABLE 3. Cardiometabolic disease risk factors according to PALs and frailty status among older Korean males.

Variables	MET-min/week				*F*-value	*p*-value
	PAL-low		PAL-high			
	Pre-frail (n = 205)	Frail (n = 188)	Pre-frail (n = 158)	Frail (n = 62)		
Weight (kg)	66.61 ± 8.96	64.01 ± 10.21	67.23 ± 9.05	65.89 ± 9.58	3.882	0.009**
BMI (kg/m^2)	23.98 ± 2.76	23.58 ± 3.16	23.96 ± 2.94	24.09 ± 3.23	0.837	0.474
Waist circumference (cm)	89.01 ± 8.22	89.46 ± 9.52	88.92 ± 8.26	90.79 ± 9.41	0.790	0.500
Fasting glucose (mg/dL)	109.55 ± 27.16	108.00 ± 24.69	112.28 ± 28.66	112.65 ± 29.32	0.930	0.426
TC (mg/dL)	175.74 ± 39.79	175.74 ± 36.51	181.26 ± 38.93	177.29 ± 60.51	0.765	0.514
HDL-C (mg/dL)	48.09 ± 10.30	45.41 ± 11.92	47.97 ± 11.61	46.98 ± 10.84	2.254	0.081
TG (mg/dL)	134.72 ± 99.28	151.24 ± 14.17	132.37 ± 83.90	141.92 ± 72.76	1.110	0.344
SBP (mmHg)	127.60 ± 15.16	126.81 ± 17.06	126.68 ± 13.30	128.65 ± 18.97	0.331	0.818
DBP (mmHg)	73.95 ± 8.67	70.85 ± 10.29	73.63 ± 9.13	70.92 ± 9.30	4.913	0.002**

*PAL: physical activity level; MET: metabolic equivalents; BMI: body mass index; FG: fasting glucose; TC: total cholesterol; HDL-C: high-density lipoprotein cholesterol; TG: triglycerides; SBP: systolic blood pressure; DBP: diastolic blood pressure; **$p < 0.01$.*

4. Discussion

The study aimed to examine the prevalence of cardiometabolic diseases, self-reported memory loss, and depression among older adults in Korea according to frailty and physical activity status. In the present study, the PAL-low/frail group had the highest levels of HINT-8 memory and HINT-8 depression. Regarding the ORs of cardiometabolic diseases, HINT-8 memory, and HINT-8 depression according to PALs and frailty status, the prevalence of diabetes mellitus was significantly higher in PAL-high/frail and PAL-high/pre-frail (*vs.* PAL-low/frail). the prevalence of obesity was significantly higher in PAL-high/frail (*vs.* PAL-low/frail). However, the incidence of HINT-8 memory and HINT-8 depression was significantly lower in PAL-low/pre-frail and PAL-high/pre-frail (*vs.* PAL-low/frail).

HINT-8 memory was highest in the PAL-low/frail group. This finding supports the concept of cognitive frailty, in which physical frailty and mild cognitive impairment symptoms co-occur [19]. In a study investigating the link between physical activity and mild cognitive impairment, the lower the level of physical activity, the higher the risk of mild cognitive impairment [42]. Conversely, increased participation in physical activity can increase the size of the frontal lobe and hippocampal brain regions, resulting in decreased memory malfunction [43]. Regarding the OR of HINT-8 memory according to PAL and frailty status, the incidence of HINT-8 memory was significantly lower in the PAL-low/pre-frail and PAL-high/pre-frail (*vs.* PAL-low/frail) group. This means that the odds of self-reported memory loss decreased in the pre-frail elderly rather than the frail. However, it was not possible to confirm the difference according to the level of physical activity. In a study that analyzed plasma brain-derived neurotrophic factor (BDNF) levels in older adults in Korea, the level of BDNF was low in older adults with frailty, and the level of frailty was significantly related to plasma BDNF [44]. BDNF is a neurotrophic factor that plays a vital role in neuronal survival and growth and participates in neuroplasticity, which is essential for learning and memory [45]. Physical activity, such as aerobic exercise, increases BDNF levels, improving memory function [46].

HINT-8 depression was highest in the PAL-low/frail group, consistent with the finding that depression and frailty are linked [22]. In addition, the results showed that groups with low PALs had a higher probability of developing depression [47]. It is also associated with BDNF between physical activity and depression. Decreased BDNF levels and altered functions can contribute to increased depression, and BDNF currently acts as a biomarker for patients with depression, with application in diagnosis and treatment [48]. In patients with depression, physical activity is recognized as a nonpharmacological strategy for improving depressive symptoms by increasing blood BDNF levels [49]. Regarding the OR of HINT-8 depression according to PAL and frailty status, the incidence of HINT-8 depression was significantly lower in the PAL-low/pre-frail and PAL-high/pre-frail (*vs.* PAL-low/frail) group. This means that odds of self-reported depressed mood decreased in the pre-frail elderly rather than the frail. However, it was not possible to confirm the difference according to the level of physical activity. A study on the transition from frailty to depressive symptoms in older adults in Korea found that the transition of frailty in older adults was related to depressive symptoms [50]. One of the physiological changes associated with frailty is an increase in the levels of the inflammatory cytokine interleukin 6 (IL-6) [51]. IL-6 is a cytokine with multiple effects on inflammation, immune responses, and hematopoietic blood [52]. Inflammation is a characteristic of aging and is associated with age-related diseases, including depression [53]. An increase in IL-6 levels is associated with depressive symptoms in older adults [54].

Diabetes mellitus was highest in the PAL-high/frailty group, consistent with the finding that the prevalence of diabetes mellitus increases with frailty [7]. However, this was inconsistent with a previous study showing that physical activity can reduce

TABLE 4. Odds ratio (95% CI) for the odds of cardiometabolic diseases, HINT-8 memory, and HINT-8 depression according to PALs and frailty status.

Variables	Group	Model 1		Model 2	
		OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Hypertension					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	1.47 (0.94–2.30)	0.091	1.54 (0.96–2.47)	0.076
	PAL-high/frail	1.28 (0.67–2.44)	0.449	1.34 (0.69–2.60)	0.381
	PAL-high/pre-frail	1.31 (0.81–2.12)	0.278	1.33 (0.78–2.28)	0.293
Dyslipidemia					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	0.78 (0.48–1.26)	0.306	0.83 (0.49–1.39)	0.476
	PAL-high/frail	1.61 (0.81–3.18)	0.173	1.82 (0.90–3.69)	0.096
	PAL-high/pre-frail	1.01 (0.60–1.70)	0.974	1.15 (0.64–2.05)	0.664
Diabetes mellitus					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	1.70 (0.92–3.14)	0.092	1.82 (0.95–3.48)	0.072
	PAL-high/frail	3.28 (1.52–7.10)	0.003**	3.47 (1.56–7.69)	0.002**
	PAL-high/pre-frail	2.31 (1.22–4.40)	0.011*	2.74 (1.35–5.58)	0.005**
Obesity					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	1.52 (0.95–2.44)	0.081	1.59 (0.96–2.63)	0.071
	PAL-high/frail	1.99 (1.02–3.87)	0.044*	2.18 (1.10–4.33)	0.026*
	PAL-high/pre-frail	1.43 (0.85–2.38)	0.178	1.45 (0.82–2.58)	0.199
Metabolic syndrome					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	0.79 (0.45–1.39)	0.415	0.70 (0.38–1.27)	0.240
	PAL-high/frail	0.45 (0.20–1.03)	0.060	0.37 (0.16–0.89)	0.025*
	PAL-high/pre-frail	0.62 (0.34–1.15)	0.130	0.51 (0.26–1.01)	0.053
HINT-8 Memory					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	0.61 (0.39–0.98)	0.040*	0.66 (0.40–1.07)	0.094
	PAL-high/frail	1.08 (0.29–1.03)	0.883	1.08 (0.53–2.22)	0.834
	PAL-high/pre-frail	0.52 (0.32–0.85)	0.009**	0.61 (0.35–1.05)	0.075
HINT-8 Depression					
	PAL-low/frail	1.00 (reference)		1.00 (reference)	
	PAL-low/pre-frail	0.53 (0.34–0.82)	0.004**	0.47 (0.30–0.76)	0.002**
	PAL-high/frail	0.55 (0.29–1.03)	0.062	0.52 (0.27–1.00)	0.050
	PAL-high/pre-frail	0.35 (0.21–0.59)	<0.001***	0.29 (0.17–0.52)	<0.001***

Values are expressed as odds ratio (95% confidence interval).
*OR: odds ratio; CI: confidence interval; PAL: physical activity level; HINT-8: health-related quality of life instrument with eight items; Model 1, not adjusted; Model 2, adjusted for age, smoking, alcohol consumption, education, and economic activity status; *p < 0.05, **p < 0.01, ***p < 0.001.*

the prevalence of chronic diseases [26]. Regarding the OR of chronic diseases according to PAL and frailty status, the prevalence of diabetes was significantly higher in the PAL-high/frail and PAL-high/pre-frail (*vs.* PAL-low/frail) group. This means that the odds of diabetes mellitus increased in the elderly with high physical activity level. In this study, the level of physical activity was calculated, including work, movement, and leisure; 42.4% of the 613 participants engaged in economic activity. In a study on the effect of work-related physical activity on diabetes mellitus risk in Korean adults, work-related physical activity was found to increase the risk of diabetes mellitus [55].

However, the odds of cardiometabolic diseases, excluding diabetes mellitus, was inconsistent with previous studies. A possible explanation for this is that patients with cardiometabolic diseases sometimes increase their physical activity for healthcare purposes [56]. The more economically active the disease, the lower the prevalence of chronic diseases [57]. In this study, 42.4% of participants were engaged in economic activities; therefore, there would have been no difficulty using the hospital.

The potential limitations of this study were identified memory function and depression indicators using items from HINT-8, a comprehensive tool. In addition, the calculation of physical activity level was the sum of work, leisure, and moving, and in this study, 42.4% were participants in economic activities, and the amount of physical activity related to work was high. In the future, it is recommended to conduct research using clinical tools to evaluate memory function and depression. And it is recommended to use the amount of physical activity separately from work and leisure.

5. Conclusions

The present study demonstrated that the group with PAL-low/frail had the highest self-reported memory loss and depressed mood, suggesting that more physical activity may reduce self-reported memory loss and depressed mood among frail older males in Korea. However further research is needed to analyze the level of physical activity separately between work and leisure.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

YHL, WJK and HYP—conceived and designed this study; conducted the data analysis; discussed the results and concluded. YHL, WJK, CHS and HYP—collected data for analysis. YHL and WJK—wrote the original draft of the manuscript. All the authors have read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study used data from the 2019 Korea National Health and Nutrition Survey, published by the Korea Disease Control and Prevention Agency. This study was approved by the Institutional Review Board of the Korea Center for Disease Control and Prevention Institutional Review Board (IRB number: 2018-10-03-C-A). All participants received information regarding the purpose and process of the study and provided informed consent after receiving sufficient explanation regarding the experiment.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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