The Association between heart diseases, social factors, and physical frailty in community-dwelling older populations: SONIC study

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Abstract

Objectives Physical frailty is geriatric syndrome and can increase the risk of adverse outcome in the older population. Heart diseases are associated with physical frailty but a few studies in community-dwelling old population. Therefore the aim of this study was to examine the association between heart diseases, social factors, and physical frailty in community-dwelling older populations including the oldest old people.

Methods The cross-sectional study included 1882 participants in community-dwelling older and oldest-old people in three age groups: 73 (±1), 83 (±1), and 93(±1) from both urban and rural areas of Japan. Questionnaires on medical history, psycho-social factors, blood samples, physical examinations, the hand grip strength test, and gait speed were measured at the venue. Physical frailty was defined based on a slow gait speed or weak grip strength. Heart diseases were assessed by self-reported questionnaires. Social interaction was based on the frequency of going outdoors and direct social contact. Analyses were conducted mainly using multiple logistic regression with adjustments for physical frailty risk factors.

Results Heart disease subjects had a higher prevalence of physical frailty than those without heart disease (slow gait speed: 69.6 vs. 56.2%, p<.001; slow gait speed or weak grip strength: 80 vs. 69.6%, p=.002). After adjusting the covariate factors, heart diseases were associated with a slow gait speed (OR=1.5; 95%CI: 1.03-2.20, p=.035). Social interaction was associated with a slow gait speed (frequency of going outdoors: OR=0.87, 95%CI 0.79-0.9, p=.008; frequency of direct social contact: OR=0.88, 95%CI 0.82-0.95, p=.001), a weak grip strength (frequency of going outdoors: OR=0.86, 95%CI 0.77-0.96, p=.005), and with physical frailty (frequency of going outdoors: OR=0.84, 95%CI 0.75-0.94, p=.002; frequency of direct social contact: OR=0.89, 95%CI 0.82-0.97, p=.007). Living alone and frequency of direct social contact were associated with physical frailty among heart disease patients.

Conclusions Our findings indicate that in community-dwelling older people, heart diseases and social interaction were associated with physical frailty. Older people with heart disease, those living alone and the frequency of direct social contact were associated with physical frailty. Future research must involve a longitudinal study to clarify the causal relationship.

Background

Physical frailty is a geriatric syndrome that results from a multi-system reduction in reserve capacity and leads to a negative outcome in older populations [1–3]. Older people with physical frailty need more institutional care and show increased vulnerability, a higher risk of falls, repeated hospitalization, and premature mortality [4, 5]. Physical frailty in older people requires high expenditure and skilled nursing facilities [6, 7]. Heart diseases have a very high prevalence and are leading causes of death in older populations word wide[8]. Recently, medical technology had been advancing. This might reduce premature death from heart disease if patients get appropriate treatment and they can return to the community. Frailty is more common in the old population, which is about 3 times more prevalent among

persons with heart disease compared to older people in the community. The prevalence of frailty in older with heart diseases was presented up to 10–60 percent[9]. A few studies examined the associations among physical frailty and heart diseases in the community-dwelling old population, mainly with a focus on specific types of heart diseases and frailty, especially heart failure[10], myocardial infarction[11], and atrial fibrillation [12] or cardiovascular diseases (including stroke). However, many patients do not have a single type of heart disease. For example, they may have symptoms of many specific types of heart diseases that occur in about the same period, such as arrhythmia, chest pain from myocardial ischemia, and angina pectoris, or the condition may worsen and develop into heart failure. Therefore, studying multiple or combined heart diseases and frailty in older population would be an important issue.

Social factors are elements of society that can influence to older population's health such as education, economic status, social interaction and so on. To date, several studies have shown a strong correlation between social factors, and health, and well-being among older people and have suggested that social isolation may have significant adverse effects on older populations [13, 14] but few studies have focused on social factors and physical frailty in older populations and older people with heart disease.

The purpose of this study was to examine the association between heart diseases, social factors, and physical frailty in community-dwelling old populations.

Methods

Study populations

This was a cross-sectional study, we analyzed data from the SONIC study, a longitudinal cohort study in Japan. The SONIC term stands for the Septuagenarians, Octogenarians, Nonagenarians, and Investigation with Centenarians. The study began in 2010 in the older population aged 69-71-year-old group, with tracking data every 3 years in 4 cities from the west and east areas of Japan cover in the urban and rural [15]. This study recruited 1,882 randomly selected from the participants that enrolled in 2013, 2014, and 2015 in community-dwelling 899 individuals aged 72-74 years (419 males, 480 females), 854 individuals aged 82-84 years (430 males, 424 females), 129 individuals aged 92-94 years (52 males, 77 females), respectively. Severe paralysis Stroke and Parkinson patients were not included in this study[11].

Definition of frailty

Physical frailty was measured using slowness and weakness. Weakness was assessed using the hand grip strength measured two times of the dominant hand and the mean grip strength was used for analysis. A weak grip strength was defined as <26 kg in males and <18 kg in females [16]. Slowness was assessed base on two measurements of gait speed over a 2.44-meter course, and the mean gait speed was used for analysis. A slow gait speed was defined as<1.0 m/s [17]. Participants were classified as physical frailty if they had a slow gait speed or weak grip strength.

Measurement

Heart diseases were defined based on a positive self-reported history according to diagnosis by a doctor and patients were asked about the specific type of heart disease. In the event of those have more than 1 specific type of heart disease, the type was classified based on dominant type or a type of heart disease that was found a significant correlation with frailty in the previous study [10, 11, 18-22]. The heart disease group in this study included those with angina pectoris, myocardial infarction, atrial fibrillation, heart failure, and other types or unknown types, and participants who had only a history of arrhythmia symptoms were excluded from the heart disease group.

Social factors in this study were cover for economic status, education level, living status, and social interaction which based on 2 factors: frequency of going outdoors and frequency of direct social contact. Frequency of going outdoors was assessed by the question, “how often do you usually go outdoors?” (e.g. going shopping, walking, going to the hospital or participating in social activities), assigned as (0) for less than once a week, (1) once or twice a week, (2) three or four times a week, (3) five or six times a day, and (4) every day. Frequency of direct social contact was assessed by asking about the frequency of direct interaction with relatives, neighbors, or friends. The answer was then assigned as (0) not at all, (1) less than once a month, (2) about once a month, (3) two or three times a month, (4) once a week, and (5) more than twice a week. Regarding their economic status, the participants were asked about their level of satisfaction with household income and this was rated on a five-point scale ranging from “not satisfied” (score 1) to “extremely satisfied” (score 5).

Other measurements. Information on demographic data, medications, and medical history was recorded. Physical examination and blood samples were tested by a physician or registered nurses. Serum albumin, Hemoglobin A1c (National Glycohemiglobin Standardization Program (NGSP)), blood glucose, low-density lipoprotein cholesterol (LDL), High-Density Lipoprotein cholesterol (HDL), and triglycerides were determined by biochemical examinations. Hypertension was defined by systolic blood pressure ≥ 140 mmHg and diastolic blood pressure ≥ 90 mmHg or being on antihypertensive treatment according to the Japanese Society of Hypertension guideline 2019 (JSH2019) [23]; diabetes mellitus (DM) was defined by fasting blood glucose ≥ 126 mg/dL or random blood glucose testing ≥ 200 mg/dL, HbA1c (NGSP) ≥ 6.5%, or taking medication for diabetes according to the Japanese Clinical Practice Guideline for Diabetes 2016 [24]. Dyslipidemia was defined based on low-density lipoprotein cholesterol ≥ 140 mg/dL, high-density lipoprotein cholesterol < 40 mg/dL, triglycerides ≥150 mg/dL, or taking medication for dyslipidemia according to the Japan Atherosclerosis Society (JAS) Guidelines for Prevention of Atherosclerotic Cardiovascular Diseases 2017 [25]. Smoking experience was assessed based on a questionnaire and classified into three categories: never, current, and ex-smoker experience. Alcohol consumption behavior was classified into three categories: do not drink or drink only occasionally (less than one day a week), habitually drinking but not excessive (1 - 3 days a week or, 3 units of Japanese sake, 3 bottles of beer, less than 180 mL of whiskey), and habitually excessive drinking (more than 3 days a week, and the average daily amount is three go of sake, three or more bottles of beer, or more with whiskey of 180 mL). The cognitive function was assessed based on the Japanese version of

the Montreal Cognitive Assessment (MoCA-J) [26]. MoCA-J consists of a 30-point test by trained geriatricians and psychologists, with higher scores reflecting a good cognitive function.

Statistical analyses

Clinical and demographic data are summarized using the mean ± SD for continuous variables and percentages for categorical variables. The Kolmogorov-Smirnov test was used to assess the normality of continuous variables. The chi-square test was used for categorical variables, and t-test was used for continuous variables. We used multiple logistic regression to examine the association between heart diseases, social factors, and physical frailty. Covariates were selected according to the scientific literature [27-30]. Associations were considered significant at a 2-tailed p-value <.05. All data were analyzed using SPSS version 24.

Results

Participant Characteristics

Table 1 presents the characteristics of total participants (N=1,882). Most were female (52.1%), 224 had heart disease, and 1,658 were without heart disease. The highest prevalence of heart disease was in the 82-84-year-old group (44.2%), followed by the 72-74-year-old group (40.6%). There were specific types of heart disease including angina pectoris (4.0%), atrial fibrillation (2.5%), myocardial infarction (1.8%), and heart failure (0.7%) (Fig. 1).

Individuals with heart disease were more likely to be male (p=.035), have diabetes (p=.005), hypertension (p<.001), a history of stroke (p=.021), and lower albumin (p=.011), and there was a significant correlation between heart disease and the frequency of going outdoors every day (p=.013). Participants live alone most were heart disease group (22.9%), most education levels of subjects were high school level (44.7%), living in urban areas (61.6%), satisfaction with household income were neutral (57.6%). There were higher rates of those with a slow gait speed (p<.001) and physical frailty (p=.002) in the heart disease group (Fig. 2).

Characteristics of participants according to physical frailty as shown by slow gait speed, weak grip strength, and physical frailty were significantly different in age group (p=<.001, p=<.001, and p=<.001), DM (p=.004, p=<.001, and p=<.001), Stroke (p=<.001, p=.006, and p=.014), Osteoarthritis (p=<.001, p=<.001, and p=<.001), low cognitive

function (p=<.001, p=<.001, and p=<.001), low albumin (p=<.001, p=<.001, and p= <.001), alcohol consumption behavior (p=.003, p=<.001, and p=<.001), frequency of going outdoors (p=<.001, p=<.001, and p=<.001), frequency of direct social contact (p= <.001, p=.004, and p=<.001), and education level (p=.001, p=<.001, and .p=<.001) respectively(see Addition file 1: Table S1).

Association between heart diseases, social factors, and physical frailty

In the total participants, heart diseases were positively associated with slow gait speed (OR=1.5, 95%CI=1.03-2.20, p=.035), but a significant correlation was not observed with weak grip strength and physical frailty. Social interaction as the frequency of going outdoors was negatively associated with all types of physical frailty by slow gait speed (OR=0.87, 95%CI =0.79-0.97, p=.008; weak grip strength OR= 0.86, 95%CI 0.77-0.96, p=.005; physical frailty OR=0.84, 95%CI 0.75-0.94, p=.002). The frequency of direct social contact was negatively associated with slow gait speed (OR= 0.88, 95%CI 0.82-0.95, p<.001; with physical frailty (OR= 0.89, 95%CI 0.82-0.97, p=.007). Age and osteoarthritis were positively associated with all types of physical frailty. Females had a significant association with weak grip strength and physical frailty. Diabetes was positively associated with weak grip strength. Higher cognitive score and serum albumin levels were significantly lower odds of all types of physical frailty. Body mass index was positively associated with slow gait speed but negatively associated with weak grip strength. Higher education had a significantly lower odds ratio of physical frailty than lower education (Table 2).

Table 2. Multiple logistic regression of heart diseases associated with physical frailty status

Characteristics	Slow gait speed (n=1,035)		Weak grip strength (n=818)		Slow gait speed or weak grip strength (n=1,277)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Heart diseases	1.50(1.03-2.20)	.035	1.05(0.71-1.55)	.806	1.44(0.94-2.21)	.092
Age	1.09(1.06-1.12)	<.001	1.12(1.10-1.15)	<.001	1.11(1.08-1.15)	<.001
Female	1.21(0.85-1.71)	.288	2.97(2.03-4.35)	<.001	1.86(1.28-2.71)	.001
Smoking status						
Never smoke	Reference		Reference		Reference	
Current smoker	1.00(0.62-1.61)	.989	1.20(0.71-2.04)	.496	1.17(0.71-1.94)	.544
Ex-smoker	0.98(0.70-1.38)	.912	1.19(0.83-1.72)	.347	1.09(0.76-1.56)	.647
Alcohol consumption behavior						
Not drink or drink only occasionally	Reference		Reference		Reference	
Habitually drinking but not excessive	0.82(0.61-1.09)	.167	1.10(0.81-1.50)	.539	0.96(0.71-1.31)	.796
Habitually excessive drinking	1.32(0.61-2.90)	.482	1.18(0.51-2.73)	.704	0.94(0.42-2.11)	.879
Hypertension	1.11(0.84-1.47)	.453	0.99(0.74-1.34)	.967	1.11(0.82-1.50)	.504
Diabetes	1.38(0.97-1.95)	.074	1.63(1.13-2.35)	.009	1.45(0.98-2.13)	.061

Table 2. Multiple logistic regression of heart diseases associated with physical frailty status

Characteristics	Slow gait speed (n=1,035)		Weak grip strength (n=818)		Slow gait speed or weak grip strength (n=1,277)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Dyslipidemia	0.83(0.61-1.15)	.270	0.80(0.56-1.14)	.216	0.89(0.63-1.25)	.489
Stroke	1.00(1.00-1.00)	.848	1.00(1.00-1.01)	.246	1.00(1.00-1.00)	.949
Cancer	0.95(0.69-1.32)	.773	0.81(0.57-1.14)	.223	0.92(0.65-1.31)	.644
Osteoarthritis	1.56(1.22-2.00)	<.001	1.55(1.20-2.00)	.001	1.80(1.37-2.35)	<.001
Cognitive function scale	0.93(0.89-0.96)	<.001	0.92(0.88-0.95)	<.001	0.92(0.89-0.96)	<.001
Serum albumin	0.56(0.38-0.84)	.004	0.49(0.33-0.75)	.001	0.57(0.37-0.89)	.012
Body mass index	1.05(1.01-1.10)	.014	0.91(0.87-0.95)	<.001	0.96(0.92-1.00)	.066
Economic status	1.00(0.86-1.17)	.949	1.16(0.98-1.36)	.076	1.01(0.85-1.18)	.940
Education level	0.90(0.76-1.07)	.228	0.86(0.72-1.03)	.100	0.82(0.68-0.98)	.031
Living alone	0.80(0.59-1.09)	.150	0.95(0.69-1.31)	.752	0.86(0.61-1.21)	.374
Frequency of going outdoors	0.87(0.79-0.97)	.008	0.86(0.77-0.96)	.005	0.84(0.75-0.94)	.002

Table 2. Multiple logistic regression of heart diseases associated with physical frailty status

Characteristics	Slow gait speed (n=1,035)		Weak grip strength (n=818)		Slow gait speed or weak grip strength (n=1,277)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Frequency of direct social contact	0.88(0.82-0.95)	.001	0.94(0.86-1.02)	.115	0.89(0.82-0.97)	.007
Urban area	0.83(0.64-1.07)	.155	1.16(0.88-1.54)	.296	1.10(0.83-1.46)	.514

Association between physical frailty and social factors among subjects with heart disease

Heart disease subjects living alone showed a 10-times higher odds ratio of having slow gait speed (OR=10.13, 95% CI=2.25-45.53, p=.003; with physical frailty OR=14.95, 95%CI=1.75-127.65). The subjects who more frequency had direct social contact had a significantly lower odds-ratio of all cases slow gait speed (OR=0.56, 95%CI=0.38-0.81, p=.002 and physical frailty OR=0.67, 95%CI=0.46-0.98, p=.039). There were no significant correlations between any types of physical frailty and the frequency of going outdoors, education level, satisfaction with household economic status, and residential area in community-dwelling old peoples with heart diseases (Table 3).

Table 3. Multiple logistic regression of social factors associated with physical frailty in subjects with heart diseases.

Characteristics	Slow gait speed (N=142)		Weak grip strength (N=108)		Slow gait speed or weak grip strength(N=168)	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
Living alone	10.13(2.25-45.53)	.003	1.57(0.61-4.01)	.346	14.95(1.75-127.65)	.013
Frequency of going outdoors	0.70(0.45-1.09)	.118	0.95(0.70-1.30)	.756	0.96(0.61-1.50)	.845
Frequency of direct social contact	0.56(0.38-0.81)	.002	0.87(0.67-1.13)	.288	0.67(0.46-0.98)	.039
Education level	0.91(0.43-1.93)	.805	0.94(0.53-1.64)	.816	0.87(0.40-1.89)	.718
Economic status	0.96(0.41-2.23)	.920	0.98(0.50-1.94)	.955	0.88(0.34-2.27)	.793
Urban area	0.35(0.10-1.22)	.101	1.20(0.48-2.98)	.694	0.43(0.12-1.54)	.195

Discussion

This study revealed that the prevalence of physical frailty among subjects with heart disease was higher than those without heart disease, consistent with a previous study [9]; the physical frailty of older people with heart disease has a high prevalence (10–60%) and varies according to the instrument used for assessment. In our study, slow gait speed showed a high prevalence in the heart disease group but a significant difference was not found in grip strength. This may suggest that gait speed can be a surrogate marker of physical frailty to detect heart diseases in community-dwelling older populations in order to provide intervention to delay a negative outcome of physical frailty.

Heart diseases and social interaction are associated with physical frailty based on slow gait speed independently of age, sex, and, other risk factors of physical frailty in older populations. Heart disease subjects had a 1.5-times risk of slow gait speed than those without heart disease but this was not associated with the grip strength. Social interaction was independently associated with physical frailty based on the frequency of going outdoors and was negatively associated with all types of physical frailty, and the frequency of direct social contact was negatively associated with gait speed and physical frailty but not associated with grip strength. In heart disease subjects, the results indicate that living alone and direct social contact were independently associated with physical frailty. This finding indicates that heart diseases and social interaction such as going outdoors and direct social contact influence physical frailty in general community-dwelling older populations. For heart disease subjects, living alone and frequent direct social contact were associated with physical frailty, particularly slow gait speed. This result is in line with previous studies on the role of cardiovascular disease associated with physical frailty-related criteria, such as gait speed, grip strength, and fatigue [11,12, 31, 32]. Furthermore, this study has a novel that the associations between heart diseases and physical frailty that we found were interesting because this study also included the oldest old population while previous studies, a few studies specifically enrolling the oldest age people in community-dwelling. To the best of our knowledge, this is the first time found that in older people with heart diseases, some social factors: living alone and frequency of direct social contact significantly associated with physical frailty, especially slow gait speed.

The present findings of social interaction (frequency of going outdoors and frequency of direct social contact) being associated with physical frailty in older populations also support findings of a cross-sectional study involving 1,200 Koreans aged 70–85 whereby the frequency of social contact was strongly associated with frailty [33]. However, this study generated the new finding that the frequency of direct social contact is associated with physical frailty in older people with heart disease.

The potential mechanisms that could explain the association between heart diseases and slow gait speed can be divided into three different pathways. Firstly, heart diseases represent a chronic illness and have an impact on functional decline; as a by-product of the extra energy generated by mitochondria, they produce excessive amounts of free radicals. This is the oxidative stress pathway and it leads to inflammation due to the elevated level of inflammatory cytokines causing many cellular and tissue changes, including the mobilization of amino acids from muscle tissue to other organ systems resulting in muscle loss and sarcopenia, which has also been associated with physical frailty [34, 35]. Secondly, heart diseases are associated with slow gait speed occurrence due to atherosclerosis, as a state of chronic inflammation that is the major cause of heart diseases. Atherosclerosis refers to the accumulation of fatty and fibrous in the arterial wall, the cause of reduced blood flow at myocardial, which is an impact on end-organ reserve, and reduced physiological function, these reasons are leading cause of slow gait speed [31]. Because walking requires multiple organ functions such as heart, lung, brain function, and musculoskeletal muscles work together and require energy more than grip strength. Finally, the mechanism could explain by those with heart disease who had a low physical activity may be the result of symptoms of heart diseases such as fatigue, chest pain, dyspnea, loss of diet appetite, and so on, are leading cause loss of muscle mass and strength called sarcopenia. Sarcopenia is a major

component of physical frailty [36]. On the other hand, physical frailty also could be a cause of physical inactivity, which is an important risk factor of heart diseases, a recent longitudinal study with 3,896 older adults in 60-year-old during a median 14 year of follow-up, revealed that frail participants were less physically active than a robust group and adequate physical activity was associated with lower risk of all-cause and CVD mortality in this population [32]. Another study found that sarcopenia was significantly correlated with left ventricular (LV) mass in a community-dwelling older population. Older people with sarcopenia had a lower ventricular mass and lower left atrium (LA) volume than those who without sarcopenia [37] being consistent with the Cardiovascular Health Study indicating that LV mass was associated with coronary heart disease in older participants [38].

These and our results suggest that heart diseases have linked to physical frailty by physical activity and sarcopenia. In part of social interaction, frequency of going outdoors and frequency to contact social directly were associated with physical frailty, could explain the association by those who had more often going outdoors and more often contact social directly can get benefit from increase a physical activity causal to improve muscle strength could prevent physical frailty [39]. Moreover, a recent study suggested that a lower frequency of going outdoors could be a cause of physical and mental frailty [40].

In older patients with heart diseases, social factors such as living alone associated with physical frailty could explain the association by a psychophysiology mechanism with those living alone being more likely to have lower physical activity levels than those living with others [41]. Physical inactivity is a cause of losing muscle mass and strength. Recent studies in the Japanese older population have revealed that older who live alone more likely poor social support and had a decline in dietary variety included difficulty to provide a healthy diet [42] and they had poor appetite more than those who not living alone [43]. Our study found that older people with heart disease had a significantly lower albumin level than those without heart disease (Table 1). These reasons may be the cause of muscle strength weakness due to malnutrition. This is the first study to find that living alone is significantly correlated with physical frailty in older patients with heart disease, but this result is in line with frailty and living alone in older populations which indicated that men living alone have a high risk of frailty [44]. The association between frequency of direct social contact and physical frailty could explain the association by those had more frequency of direct social contact have a more physical activity that will improve muscle strength. This result supports a previous study reporting that social frailty (including social role, social network, and social activity) is an important factor that is a leading cause of physical frailty, especially in those with a slow walking speed in the cohort study [45].

According to the results of the present and previous studies in older populations, heart diseases and social interaction were associations with physical frailty. Older people with heart disease, living alone and direct social contact were significant associations with physical frailty.

The study has important strengths. The study was based on older populations in the community including the oldest populations and used gait speed and grip strength as surrogate markers of physical frailty, which are simple tools and powerful predictors of a negative outcome in community-dwelling older

populations. In addition, the covariates that are studied were common variables covering physical factors, biological factors, lifestyle-related factors, and socio-demographic factors.

This study has limitations, this is a cross-sectional study that is difficult to determine the causal direction and there are some variables that were not measured as confounding factors such as physical activity level or psychological factors that cannot be overlooked. Our study data were collected from community-dwelling older populations that have assessed the participants that visited at the community center, therefore the subjects with a moderate or severe symptom of physical frailty may not participate that could make the prevalence of physical frailty was underestimated. There was a small sample size of heart disease group that made we could not examine the association between a specific type of heart disease and physical frailty. The data of heart disease experience were obtained from self-report that could not be avoiding recall bias. The lack of data on cardiac examination such as echocardiography, ECGs, or other tests means that we could not confirm the diagnosis or explain the heart function.

Conclusions

Heart disease and social interaction were associated with physical frailty in community-dwelling older populations. Living alone and social contact were directly associated with physical frailty, especially slow gait speed in heart disease subjects. A further longitudinal study is required to clarify the causal relationship between heart diseases, social factors, and physical frailty to examine whether social factors can protect against physical frailty in community-dwelling older populations and heart disease patients.

Abbreviations

OR: Odds Ratio; CI: Confidence interval; SD: standard deviation; NGSP: National Glycohemiglobin Standardization Program; LDL: low-density lipoprotein cholesterol; HDL: High-Density Lipoprotein cholesterol; JSH: Japanese Society of Hypertension guideline; SONIC: The Septuagenarains, Octogenarians, Nonagenarians Investigation with Centenarians study; JAS: Japan Atherosclerosis Society; MoCA-J: The Japanese version of the Montreal Cognitive Assessment; DM: Diabetes Mellitus; CVD: Cardiovascular disease; LV: left ventricular; ECG: electrocardiogram; AP: Angina Pectoris; AF: Atrial fibrillation; MI: Myocardial Infarction; HF: Heart Failure.

Declarations

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Author Contributions: Conceptualized and designed the study: NK, MK, YG, HR, and KK. Performed data acquisition: all authors. Performed analysis and interpretation: NK, EK, and YA. Prepared the manuscript and figures: NK, MK, and KK. All authors approved the final version for submission.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Osaka University Graduate School of Medicine, Dentistry and Human Sciences and the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology (approval numbers 266, H22-E9, 22 018, and 38, respectively). All participants provided written informed consent to participate on-site prior to starting the survey.

Consent for publication

Not application

Competing interests

The Authors declare that they have no competing interests

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References

1. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in Older Adults: Evidence for a Phenotype. J Gerontol A Biol Sci Med Sci. 2001;56(3):M146-M57.
2. Xue Q-L. The frailty syndrome: definition and natural history. Clin Geriatr Med. 2011;27(1):1-15.
3. Vaes B, Depoortere D, Van Pottelbergh G, Matheï C, Neto J, Degryse J. Association between traditional cardiovascular risk factors and mortality in the oldest old: untangling the role of frailty. BMC Geriatrics. 2017;17(1):234.
4. Buckinx F, Rolland Y, Reginster J-Y, Ricour C, Petermans J, Bruyère O. Burden of frailty in the elderly population: perspectives for a public health challenge. Arch Public Health. 2015;73(1):19.
5. Makizako H, Shimada H, Doi T, Tsutsumimoto K, Suzuki T. Impact of physical frailty on disability in community-dwelling older adults: a prospective cohort study. BMJ Open. 2015;5(9):e008462.
6. Ensrud KE, Kats AM, Schousboe JT, Taylor BC, Cawthon PM, Hillier TA, et al. Frailty Phenotype and Healthcare Costs and Utilization in Older Women. J Am Geriatr Soc. 2018;66(7):1276-83.
7. Roe L, Normand C, Wren M-A, Browne J, O'Halloran AM. The impact of frailty on healthcare utilisation in Ireland: evidence from the Irish longitudinal study on ageing. BMC Geriatrics. 2017;17(1):203.
8. Roth GA, Forouzanfar MH, Moran AE, Barber R, Nguyen G, Feigin VL, et al. Demographic and Epidemiologic Drivers of Global Cardiovascular Mortality. N Engl J Med. 2015;372(14):1333-41.
9. Von Haehling S, Anker SD, Doehner W, Morley JE, Vellas B. Frailty and heart disease. Int J Cardiol. 2013;168(3):1745-7.
10. Fung E, Hui E, Yang X, Lui LT, Cheng KF, Li Q, et al. Heart Failure and Frailty in the Community-Living Elderly Population: What the UFO Study Will Tell Us. Front Physiol. 2018;9:347-.
11. Matsuzawa Y, Konishi M, Akiyama E, Suzuki H, Nakayama N, Kiyokuni M, et al. Association Between Gait Speed as a Measure of Frailty and Risk of Cardiovascular Events After Myocardial Infarction. J Am Coll Cardiol. 2013;61(19):1964.
12. Polidoro A, Stefanelli F, Ciacciarelli M, Pacelli A, Di Sanzo D, Alessandri C. Frailty in patients affected by atrial fibrillation. Arch Gerontol Geriatr. 2013;57(3):325-7.
13. Luo Y, Hawkley LC, Waite LJ, Cacioppo JT. Loneliness, health, and mortality in old age: a national longitudinal study. Soc Sci Med. 2012;74(6):907-14.
14. Steptoe A, Fancourt D. Leading a meaningful life at older ages and its relationship with social engagement, prosperity, health, biology, and time use. Proc Natl Acad Sci U S A. 2019;116(4):1207.
15. Gondo Y, Masui Y, Kamide K, Ikebe K, Arai Y, Ishizaki T. SONIC Study, A Longitudinal Cohort Study of the Older People as Part of a Centenarian Study. In: Pachana NA, editor. Encyclopedia of Geropsychology. Singapore: Springer Science+Business Media Singapore, Singapore; 2016. https://doi.org/10.1007/978-981-287-080-3_182–1. (e-pub ahead of print).
16. Chen L-K, Liu L-K, Woo J, Assantachai P, Auyeung T-W, Bahyah KS, et al. Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc. 2014;15(2):95-101.

17. Shimada H, Makizako H, Doi T, Yoshida D, Tsutsumimoto K, Anan Y, et al. Combined Prevalence of Frailty and Mild Cognitive Impairment in a Population of Elderly Japanese People. J Am Med Dir Assoc. 2013;14(7):518-24.
18. Graham MM, Galbraith PD, O'Neill D, Rolfson DB, Dando C, Norris CM. Frailty and Outcome in Elderly Patients With Acute Coronary Syndrome. Can J Cardiol. 2013;29(12):1610-5.
19. Frisoli A, Ingham SJM, Paes ÂT, Tinoco E, Greco A, Zanata N, et al. Frailty predictors and outcomes among older patients with cardiovascular disease: Data from Fragicor. Arch Gerontol Geriatr. 2015;61(1):1-7.
20. Buttery AK, Busch MA, Gaertner B, Scheidt-Nave C, Fuchs J. Prevalence and correlates of frailty among older adults: findings from the German health interview and examination survey. BMC Geriatrics. 2015;15(1):22.
21. Shi J, Song X, Yu P, Tang Z, Mitnitski A, Fang X, et al. Analysis of frailty and survival from late middle age in the Beijing Longitudinal Study of Aging. BMC Geriatrics. 2011;11(1):17.
22. Tamura Y, Ishikawa J, Fujiwara Y, Tanaka M, Kanazawa N, Chiba Y, et al. Prevalence of frailty, cognitive impairment, and sarcopenia in outpatients with cardiometabolic disease in a frailty clinic. BMC Geriatrics. 2018;18(1):264.
23. Umemura S, Arima H, Arima S, Asayama K, Dohi Y, Hirooka Y, et al. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2019). Hypertens Res. 2019;42(9):1235-481.
24. Haneda M, Noda M, Origasa H, Noto H, Yabe D, Fujita Y, et al. Japanese Clinical Practice Guideline for Diabetes 2016. J Diabetes Investig. 2018;9(3):657-97.
25. Kinoshita M, Yokote K, Arai H, Iida M, Ishigaki Y, Ishibashi S, et al. Japan Atherosclerosis Society (JAS) Guidelines for Prevention of Atherosclerotic Cardiovascular Diseases 2017. J Atheroscler Thromb. 2018;25(9):846-984.
26. Fujiwara Y, Suzuki H, Yasunaga M, Sugiyama M, Ijuin M, Sakuma N, et al. Brief screening tool for mild cognitive impairment in older Japanese: Validation of the Japanese version of the Montreal Cognitive Assessment. Geriatr Gerontol Int. 2010;10(3):225-32.
27. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of Frailty in Community-Dwelling Older Persons: A Systematic Review. J Am Geriatr Soc. 2012;60(8):1487-92.
28. Feng Z, Lugtenberg M, Franse C, Fang X, Hu S, Jin C, et al. Risk factors and protective factors associated with incident or increase of frailty among community-dwelling older adults: A systematic review of longitudinal studies. PLoS One. 2017;12(6):e0178383.
29. Samper-Ternent R, Al Snih S, Raji MA, Markides KS, Ottenbacher KJ. Relationship Between Frailty and Cognitive Decline in Older Mexican Americans. J Am Geriatr Soc. 2008;56(10):1845-52.
30. Ma L, Tang Z, Zhang L, Sun F, Li Y, Chan P. Prevalence of Frailty and Associated Factors in the Community-Dwelling Population of China. J Am Geriatr Soc. 2018;66(3):559-64.
31. Newman AB, Gottdiener JS, McBurnie MA, Hirsch CH, Kop WJ, Tracy R, et al. Associations of Subclinical Cardiovascular Disease With Frailty. J Gerontol A Biol Sci Med Sci. 2001;56(3):M158-

M66.

32. Higueras-Fresnillo S, Cabanas-Sánchez V, Lopez-Garcia E, Esteban-Cornejo I, Banegas JR, Sadarangani KP, et al. Physical Activity and Association Between Frailty and All-Cause and Cardiovascular Mortality in Older Adults: Population-Based Prospective Cohort Study. J Am Geriatr Soc. 2018;66(11):2097-103.
33. Chon D, Lee Y, Kim J, Lee K-E. The Association between Frequency of Social Contact and Frailty in Older People: Korean Frailty and Aging Cohort Study (KFACS). J Korean Med Sci. 2018;33(51):e332-e.
34. Inglés M, Gambini J, Carnicero JA, García-García FJ, Rodríguez-Mañas L, Olaso-González G, et al. Oxidative Stress Is Related to Frailty, Not to Age or Sex, in a Geriatric Population: Lipid and Protein Oxidation as Biomarkers of Frailty. J Am Geriatr Soc. 2014;62(7):1324-8.
35. Harkness K, Heckman GA, McKelvie RS. The older patient with heart failure: high risk for frailty and cognitive impairment. Expert Rev Cardiovasc Ther. 2012;10(6):779-95.
36. Afilalo J. Conceptual Models of Frailty: The Sarcopenia Phenotype. Can J Cardiol. 2016;32(9):1051-5.
37. Keng BMH, Gao F, Teo LLY, Lim WS, Tan RS, Ruan W, et al. Associations between Skeletal Muscle and Myocardium in Aging: A Syndrome of “Cardio-Sarcopenia”? J Am Geriatr Soc. 2019; 67(12): 2568-73.
38. Gardin Julius M, Siscovick D, Anton-Culver H, Lynch James C, Smith Vivienne E, Klopfenstein HS, et al. Sex, Age, and Disease Affect Echocardiographic Left Ventricular Mass and Systolic Function in the Free-Living Elderly. Cir. 1995;91(6):1739-48.
39. Umberson D, Montez JK. Social relationships and health: a flashpoint for health policy. J Health Soc Behav. 2010;51 Suppl(Suppl):S54-S66.
40. Soones T, Federman A, Leff B, Siu AL, Ornstein K. Two-Year Mortality in Homebound Older Adults: An Analysis of the National Health and Aging Trends Study. J Am Geriatr Soc. 2017;65(1):123-9.
41. Chen Y, While AE, Hicks A. Physical activity among older people living alone in Shanghai, China. Health Educ J. 2015;74(2):156-67.
42. Fukuda Y, Ishikawa M, Yokoyama T, Hayashi T, Nakaya T, Takemi Y, et al. Physical and social determinants of dietary variety among older adults living alone in Japan. Geriatr Gerontol Int. 2017;17(11):2232-8.
43. Ishikawa M, Yokoyama T, Takemi Y, Fukuda Y, Nakaya T, Kusama K, et al. Association between satisfaction with state of health and meals, physical condition and food diversity, health behavior, and perceptions of shopping difficulty among older people living alone in Japan. J Nutr Health Aging. 2017;21(5):514-20.
44. Hirotomo Y, Yuji S, Nelson M, Koyamatsu J, Mako N, Koichiro K, et al. The association between living alone and frailty in a rural Japanese population: the Nagasaki Islands study. J Prim Health Care. 2015;7(4):269-73.
45. Makizako H, Shimada H, Doi T, Tsutsumimoto K, Hotta R, Nakakubo S, et al. Social Frailty Leads to the Development of Physical Frailty among Physically Non-Frail Adults: A Four-Year Follow-Up

Longitudinal Cohort Study. Int J Environ Res Public Health. 2018;15(3):490.

Table 1

This table (Table 1) should appear at the end of Participant Characteristics section paragraph.

Table 1. Characteristics of participants according to heart diseases

Characteristic	Total n (%)	Without heart disease(n=1,658)	With heart disease(n=224)	P-Value
Female, %	981(52.1)	53.0%	45.5%	.035
Age, y, %				
72-74	899 (47.8)	48.7%	40.6%	<.001
82-84	854 (45.4)	45.5%	44.2%	
92-94	129 (6.9)	5.7%	15.2%	
Comorbidities				
Diabetes, %	283 (15.8)	14.9%	22.4%	.005
Hypertension, %	1371(74.2)	72.9%	84.1%	<.001
Dyslipidemia, %	1430 (82.0)	82.1%	80.9%	.649
Cancer, %	285 (15.3)	15.0%	17.4%	.371
Stroke, %	127 (6.8)	6.3%	10.5%	.021
Osteoarthritis, %	761 (42.4)	41.9%	46.1%	.240
Cognitive function scale, mean ± SD	22.6±4.1	22.7±4.0	22.3±4.8	.265
Body mass index, kg/m^2, mean ± SD	22.8±3.1	22.7±3.1	23.1±3.0	.110
Albumin, g/dL, mean ± SD	4.3±0.3	4.3±0.3	4.2±0.3	.011
Gait speed, mean ± SD	0.95±0.2	1.0±0.2	0.9±0.2	<.001
Grip strength, m/s, mean ± SD	22.67±8.0	22.6±8.0	22.9±8.5	.657
Smoking status, %				.600
Current smoker	146 (8.0)	8.0%	8.3%	
Ex-smoker	564 (30.9)	30.5%	33.6%	

Table 1. Characteristics of participants according to heart diseases

Characteristic	Total n (%)	Without heart disease(n=1,658)	With heart disease(n=224)	P-Value
Alcohol consumption behavior, %				.773
Not drink or drink only occasionally	1207 (65.8)	66.0%	64.1%	
Habitually drinking but not excessive	580 (31.6)	31.4%	33.6%	
Habitually excessive drinking	47 (2.6)	2.6%	2.3%	
Frequency of going outdoors, %				.013
Less than once week	122 (6.5)	6.1%	9.9%	
1-2 times a week	267 (14.3)	14.2%	15.2%	
3-4 times a week	447 (23.9)	23.8%	25.1%	
5-6 times a week	380 (20.4)	19.8%	24.2%	
Everyday	651 (34.9)	36.1%	25.6%	
Frequency of direct social contact, %				.151
Not at all	178 (9.7)	9.3%	13.3%	
Less than once a month	261 (14.3)	14.2%	15.1%	
About once a month	290 (15.9)	16.2%	13.3%	
2-3 times a month	306 (16.7)	17.0%	15.1%	

Table 1. Characteristics of participants according to heart diseases

Characteristic	Total n (%)	Without heart disease(n=1,658)	With heart disease(n=224)	P-Value
About once a week	335 (18.3)	17.8%	22.0%	
More than twice a week	457 (25.0)	25.5%	21.1%	
Live alone, %	376 (21.2)	22.9%	21.2%	.496
Residential area, %				.191
Urban	1160 (61.6)	61.1%	65.6%	
Rural	722 (38.4)	38.9%	34.4%	
Education, %				.588
Junior high school graduate	501 (26.8)	26.6%	28.4%	
High school	835 (44.7)	44.5%	45.9%	
Above high school	534 (28.6)	28.9%	25.7%	
Economic status, %				.146
Not satisfied	78 (4.4)	4.2%	5.5%	
Slightly satisfied	267 (15.1)	14.6%	18.3%	
Neutral	1021 (57.6)	58.7%	49.5%	
Very satisfied	344 (19.4)	19.0%	22.0%	
Extremely satisfied	64 (3.6)	3.5%	4.6%	

Figures

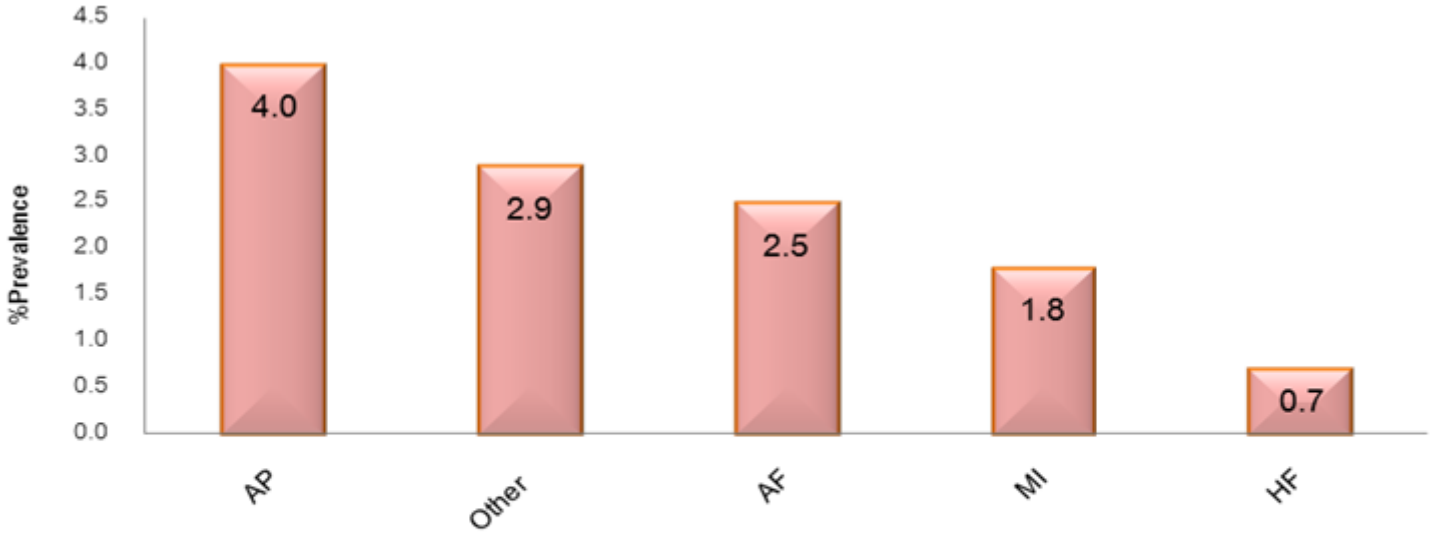

Fig. 1. The prevalence of specific types of heart disease in this study. The other types included: valvular heart disease, cardiomegaly, pacemaker implantation, supraventricular tachycardia and patients with unknown types of heart disease. Patients with more than one specific type were classified by the one type that was.

Figure 1

The prevalence of specific types of heart disease in this study.

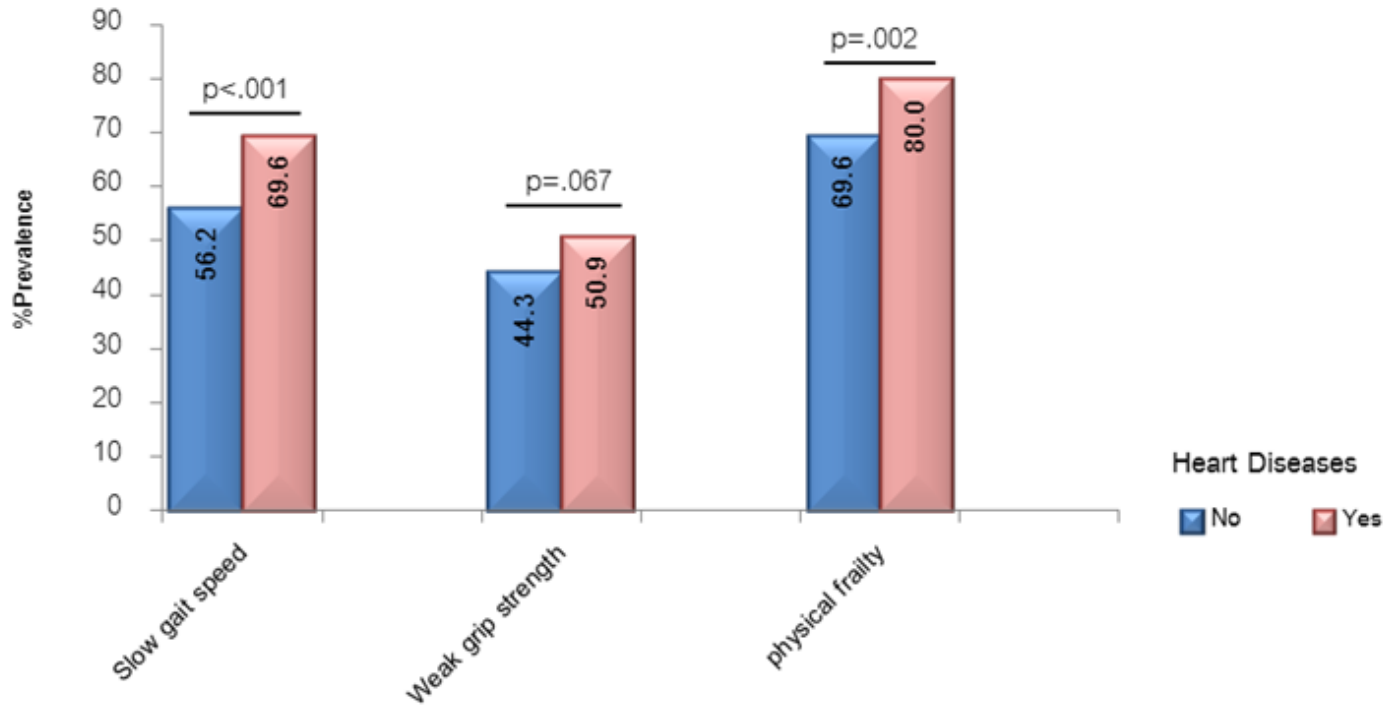

Fig. 2. The prevalence of physical frailty (slow gait speed was defined as<1.0 m/s), weak grip strength (was defined as <26 kg in male and <18 kg in female) and physical frailty (slow gait speed or weak grip strength) (was defined as one or two physical frailty types) in patients with and without heart disease with each type of physical frailty.

Figure 2

The prevalence of physical frailty, weak grip strength, and physical frailty in patients with and without heart disease with each type of physical frailty.

Supplementary Files

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- AdditionalfileTableS1.docx