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Association of physical performance and self-rated health with multimorbidity among older adults: Results from a nationwide survey in Japan

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ABSTRACT

Objectives: To examine the association of physical performance measures and self-rated health with multimorbidity among older Japanese adults aged ≥60 years using cross-sectional data from a nationwide longitudinal survey.

Methods: Using respondents' self-reported data from the 2012 National Survey of the Japanese Elderly, we analyzed multimorbidity involving nine major chronic diseases (heart disease, arthralgia, hypertension, diabetes, stroke, cataract, cancer, respiratory disease, and low back pain). Respondents who reported having two or more of these diseases were identified as having multimorbidity. Multivariate logistic regression analysis was used to examine if physical performance (grip strength and walking speed) and self-rated health were independently associated with multimorbidity after adjusting for potential confounders (e.g., demographic, physiological, and lifestyle-related variables).

Results: The responses of 2525 participants who responded to the survey by themselves (i.e., without proxies) were analyzed (response rate: 57.9%). Among the chronic diseases examined, hypertension had the highest prevalence (44.1%), followed by low back pain (25.7%) and cataract (24.7%). Approximately 44.4% of the respondents had multimorbidity. The regression analysis revealed that multimorbidity was significantly associated with both poor grip strength ($P = 0.006$) and self-rated health ($P < 0.001$), but not with walking speed ($P = 0.479$).

Conclusions: Multimorbidity is prevalent in older Japanese adults, and poor grip strength and self-rated health were independently and significantly associated with multimorbidity. Health assessments that include these indicators may provide insight into the health status patterns of older adults with multimorbidity and inform the development of health management strategies.

1. Introduction

Multimorbidity refers to the concomitant existence of two or more chronic diseases in an individual patient (Wallace et al., 2015). The prevalence of multimorbidity tends to be higher in older adults as people become more susceptible to chronic illnesses with increasing age (Marengoni et al., 2011). Furthermore, multimorbidity has a substantial impact on healthcare resource utilization (Parekh & Goodman, 2013; Parekh, Goodman, Gordon, & Koh, 2011) because patients with multimorbidity are more likely to engage in polypharmacy, receive complex medical care from multiple providers, and consume more resources than patients with only one disease (Xu, Mishra, & Jones, 2017). In Japan, the Ministry of Health, Labour and Welfare regularly compiles and publishes national health statistics on major diseases using disease-specific data (Ministry of Health, Labour & Welfare, 2014). Although this data format provides insight into multimorbidity involving conditions such as dyslipidemia, hypertension, diabetes, chronic kidney disease, and other cerebrovascular diseases, it does not account for patients with other significant geriatric conditions such as cancer, osteoarthritis, and cataracts. Accordingly, should a large proportion of older adults with multimorbidity exist in the Japanese population, these health statistics would be insufficient to accurate reflect the

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population's actual health status.

Epidemiological studies that focus on multimorbidity may guide the development of healthcare systems that can effectively and efficiently manage older patients with multimorbidity (Salisbury, 2012). As the world's foremost super-aging society, it is clear that Japan must ascertain the actual status of multimorbidity (Mitsutake, Ishizaki, Teramoto, Shimizu, & Ito, 2019) and its associated factors in its older population. Numerous epidemiological studies have reported the prevalence of multimorbidity in other countries (Xu et al., 2017), and studies have also rigorously examined factors associated with multimorbidity, including biomedical and individual factors, socioeconomic characteristics, social factors, environmental factors, and health behaviors (Marengoni et al., 2011; Xu et al., 2017). Among these, objective physical performance measures such as grip strength (Cheung, Nguyen, Au, Tan, & Kung, 2013; Volaklis et al., 2016; Welmer, Kareholt, Angleman, Rydwik, & Fratiglioni, 2012; Yorke, Curtis, Shoemaker, & Vangsnes, 2017) and walking speed (Cesari et al., 2006; Ortiz et al., 2018; Welmer et al., 2012) have been identified as important risk factors of multimorbidity through population-based epidemiological studies. Similarly, self-rated health (SRH) (Hudon, Soubhi, & Fortin, 2008; McDaid et al., 2013; Vos, Bor, Rangelrooij-Minkels, Schellevis, & Lagro-Janssen, 2013) has also been identified as a notable risk factor of multimorbidity.

To the best of our knowledge, however, there have yet to be any studies that examined the associations of objective physical performance and subjective SRH with multimorbidity using the same subjects. The identification of objective and subjective health indicators of multimorbidity would facilitate a better understanding of the relative relationships between these factors and multimorbidity (National Research Council, 2008), and provide greater insight into the health status of older adults. This study aimed to analyze the association of objective physical performance (grip strength and walking speed) and SRH with multimorbidity using data obtained from a nationwide survey of older Japanese adults aged 60 years or older.

2. Methods

2.1. Data source and study subjects

The data for this study were obtained from the National Survey of the Japanese Elderly (NSJE) conducted in 2012. The NSJE is a longitudinal survey of a nationwide sample of non-institutionalized men and women; the initial wave was conducted in 1987 on 2200 people aged 60 years or older, and subsequent waves were conducted in 1990, 1993, 1996, 1999, 2002, 2006, and 2012. In the NSJE, trained interviewers collect data by visiting respondents' homes to conduct face-to-face interviews based on a structured questionnaire. When respondents were unable to independently answer specific questions, responses were obtained from proxy interviewees. However, the present study excluded data obtained from these proxies, and focused only on respondents who completed the survey by themselves. Approval for this study was obtained from the institutional ethics committee of Tokyo Metropolitan Institute of Gerontology.

2.2. Assessment of multimorbidity

During the survey, the respondents were asked about "the presence/absence of a current illness and its sequelae" for the following nine disease categories: heart disease, arthralgia (e.g., arthritis, rheumatism, and neuralgia), hypertension, diabetes, stroke (e.g., cerebral hemorrhage, cerebral infarction, and subarachnoid hemorrhage), cataract, cancer, respiratory disease (e.g., bronchitis, pulmonary emphysema, asthma, and tuberculosis), and low back pain. Subjects with two or more of these target diseases were identified as having multimorbidity (Wallace et al., 2015).

2.3. Assessment of objective physical performance

Using data from the 2012 survey, we assessed objective physical performance based on the methods developed by the US Health and Retirement Study (Crimmins et al., 2008). These assessments involved grip strength and walking speed, which were measured during the respondents' home visits. Grip strength was measured in the standing position twice for each hand using a Smedley hand dynamometer. In order to minimize measurement errors, the mean value (kg) of the two measurements for each hand was first calculated, and the larger of the two mean values was used in the analysis. We divided the subjects into two groups according to grip strength based on the criteria stipulated by the Asian Working Group for Sarcopenia (AWGS) (Chen et al., 2014). These criteria define poor grip strength as a strength < 26 kg for men and < 18 kg for women, and good grip strength as a strength ≥ 26 kg for men and ≥ 18 kg for women. To assess walking speed, subjects were asked to walk at a normal pace in a clear space either in their homes or outside (if there was insufficient space inside the home). Walking speed was measured thrice over a 2.5-m distance (Crimmins et al., 2008), and the mean speed (m/sec) from the three trials was used in the analysis to minimize measurement errors. We also divided the subjects into two groups according to walking speed based on the AWGS criteria (Chen et al., 2014), which define poor walking speed as a speed < 0.8 m/sec and good walking speed as a speed ≥ 0.8 m/sec.

2.4. Assessment of self-rated health

SRH status was determined using the following question: "How would you currently assess your general health condition?" Participants could answer "excellent," "fairly good," "average," "not very good," or "poor." For the current study, we considered ratings of either "excellent" or "fairly good" to indicate good SRH and ratings of either "not very good" or "poor" to indicate poor SRH. Therefore, SRH was analyzed using the following three categories: good SRH, average SRH, and poor SRH.

2.5. Potential confounders of multimorbidity

We included the following potential confounders of multimorbidity in the analysis: demographic variables (age, sex, educational attainment, household structure/living arrangement, and household financial condition), physiological variables (basic activities of daily living [BADL], instrumental activities of daily living [IADL], and body mass index), and lifestyle-related variables (current tobacco and alcohol consumption). Physical functioning was assessed using five items from the BADL list (bathing, dressing, feeding, transferring, and using the toilet) and four items from the IADL list (shopping for daily necessities, using a telephone, using public transportation [bus or train] alone, and housekeeping). People who were independent for four items in BADL/IADL were designated "functionally independent", whereas people who were dependent for at least one item were designated "functionally dependent". Respondents who reported difficulty seeing with or without eye glasses were identified as having a visual impairment, which was analyzed using two categories ("yes" and "no"). Respondents who reported difficulty hearing with or without a hearing aid were identified as having a hearing impairment, which was also analyzed using two categories ("yes" and "no"). The number of household members was categorized into "living alone" or "two members or more." Educational attainment was assessed based on the number of years of formal education completed, and was categorized into "≤ 11 years (i.e., did not graduate from senior high school)" or "12 years (i.e., graduated from senior high school) or more (i.e., received tertiary education)." Household financial condition was categorized into "difficulties" or "no difficulties." Finally, responses to both current alcohol and tobacco consumption were categorized into "yes" or "no".

2.6. Statistical analysis

First, we calculated the prevalence (%) of each chronic disease, the number of chronic diseases per person, and the prevalence of multimorbidity. To investigate multimorbidity status, we identified the proportions (%) of subjects for each of the nine index diseases who also had a co-existing disease. We then used a network graph to visually depict the combinations of all nine diseases. Next, a chi-square test was used to analyze the association between each characteristic and multimorbidity.

To examine whether objective physical performance and SRH are associated with multimorbidity, we performed multivariate logistic regression analysis using multimorbidity as the dependent variable (0 = absent [reference], 1 = present); the independent variables of interest were SRH, grip strength, and walking speed. Other covariates included the 11 potential confounders described in Section 2.5 and the period at which each respondent entered the panel study (the first wave entered in 1987, the second wave in 1990, the fourth wave in 1996, the fifth wave in 1999, and the eighth wave in 2012). It has been proposed that when data are missing for any independent variable (White & Thompson, 2005), the corresponding observations should be assigned to a "no response" category of the missing variable (Amemiya, Fujiwara, Murayama, Tani, & Kondo, 2018; Ashida, Kondo, & Kondo, 2016) in each statistical analysis to maximize statistical power. We therefore included data for the "no response" category for all variables except BADL, IADL, alcohol consumption, and tobacco consumption. This was because both BADL and IADL involve combined scores from multiple items, and a lack of a response for any of the items can be considered to indicate dependence for that activity. For alcohol and tobacco consumption, a total of 17 subjects provided no response regarding being either a current drinker or smoker; of these, 15 provided no response for both drinking and smoking status. When we included these subjects in a preliminary multivariate analysis, the model was unable to produce coefficient estimates and standard errors for these variables as the 15 subjects had provided no response for either query. Consequently, we excluded subjects who did not report whether they were a current drinker or smoker. We then calculated the adjusted odds ratios (aORs) and 95% confidence intervals for each of the independent variables.

All statistical analyses were conducted using SPSS version 20 (IBM SPSS, New York, USA). The network graph was generated semi-automatically with a custom program written using R software version 3.1.2 (The R Foundation for Statistical Computing, Vienna, Austria) with the social network analysis package (sna). *P* values (two-sided) below 0.05 were considered statistically significant.

3. Results

3.1. Respondents' basic characteristics

Table 1 summarizes the basic characteristics of the 2525 respondents (response rate: 57.9%) who completed the survey by themselves.

3.2. Prevalence of chronic diseases and multimorbidity

Among the chronic diseases, hypertension had the highest prevalence (44.1%), followed by low back pain (25.7%) and cataract (24.7%). Table 2 presents the numbers of chronic diseases according to sex and age group (60–69 years, 70–79 years, and ≥80 years); approximately 44.4% of all respondents had multimorbidity.

For each of the nine index diseases, we calculated the proportions of subjects who also had a co-existing condition from another disease category (Table 3). We determined that all diseases showed high proportions of co-existence with hypertension, low back pain, and cataract (all of which also demonstrated a high prevalence). Accordingly, a large

Table 1
Basic characteristics of the survey respondents (n = 2,525).

Sex	Men		46.3%
	Women		53.7%
Age (years)	Mean (SD)		76.9 (8.7)
Age group	60–69 years		27.2%
	70–79 years		35.4%
	≥80 years		37.4%
Number of household members	≥2		83.0%
	Living alone		17.0%
Number of years of education	≥12 years		46.3%
	≤11 years		53.7%
Household financial condition	No difficulties		79.3%
	Difficulties		15.9%
	No response		4.8%
Basic activities of daily living	Independent		92.5%
	Dependent		7.5%
Instrumental activities of daily living	Independent		85.7%
	Dependent		14.3%
Visual impairment	No		93.5%
	Yes		5.8%
	No response		0.7%
Hearing impairment	No		89.2%
	Yes		7.3%
	No response		3.5%
Body mass index (kg/m^2)	Mean (SD)	n = 2,085	23.1 (3.4)
Body mass index group	< 18.5 kg/m^2		6.5%
	18.5–24.9 kg/m^2		53.4%
	≥25 kg/m^2		22.7%
	Missing		17.4%
Current drinker	No		62.0%
	Yes		38.0%
Current smoker	No		89.8%
	Yes		10.2%
Self-rated health	Good		37.9%
	Average		43.2%
	Poor		18.6%
	No response		0.3%
Grip strength (kg)	Men, mean (SD) [IQR]	n = 1,068	29.4 (6.9) [24.8 – 34.3]
	Women, mean (SD) [IQR]	n = 1,195	18.4 (4.6) [15.3 – 21.7]
	Good[a]	n = 1,418	56.2%
	Poor[a]	n = 845	33.5%
	No measurement	n = 262	10.3%
Walking speed (m/sec)	Men, mean (SD) [IQR]	n = 945	0.90 (0.27) [0.73 – 1.07]
	Women, mean (SD) [IQR]	n = 1,017	0.84 (0.28) [0.65 – 1.02]
	Good[b]	n = 1,176	46.6%
	Poor[b]	n = 786	31.1%
	No measurement	n = 563	22.3%
Period when respondents entered the panel study	First wave (1987)		8.5%
	Second wave (1990)		5.5%
	Fourth wave (1996)		19.0%
	Fifth wave (1999)		14.6%
	Eighth wave (2012)		52.4%
Proportion of respondents with each chronic disease	Hypertension		44.1%
	Low back pain		25.7%
	Cataract		24.7%
	Arthralgia		15.6%
	Heart disease		14.2%
	Diabetes		12.5%
	Respiratory disease		7.2%
	Stroke		6.1%
	Cancer		5.0%

SD: standard deviation, IQR: interquartile range.
[a] Grip strength: poor (< 26 kg for men and < 18 kg for women), good (≥26 kg for men and ≥18 kg for women).
[b] Walking speed: poor (< 0.8 m/sec), good (≥0.8 m/sec).

Table 2
Number of chronic conditions according to sex and age group (n = 2,525).

		Number of chronic conditions				
		None	1	2	3	≥4
Total	n = 2,525	24.2%	31.4%	22.6%	12.5%	9.3%
Sex	Men (n = 1,168)	25.0%	32.6%	21.9%	11.8%	8.6%
	Women (n = 1,357)	23.4%	30.4%	23.2%	13.1%	9.8%
Age group	60–69 years (n = 687)	34.5%	36.2%	19.2%	6.7%	3.3%
	70–79 years (n = 893)	22.2%	30.3%	25.5%	12.2%	9.7%
	≥80 years (n = 945)	18.5%	29.0%	22.3%	17.0%	13.1%

proportion of respondents had two-disease combinations that included at least one of these highly prevalent conditions. For combinations comprising two diseases from these three categories (e.g., low back pain and heart disease), the proportions of respondents for each index disease differed; for example, in the low back pain–heart disease combination, 35.7% of subjects with heart disease had co-existing low back pain, whereas 19.8% of subjects with low back pain had co-existing heart disease.

The five most common two-disease combinations in the study population are presented in Table 4. In particular, we observed a relatively high proportion of combinations involving hypertension and either low back pain or cataract. To facilitate a visual understanding of all the disease combinations, we created a network graph (Fig. 1). Hypertension, low back pain, and cataract had notably high morbidity rates (illustrated by the sizes of the nodes) and frequently occurred together with other diseases (illustrated by the thickness of the lines connected to these nodes).

3.3. Association of physical performance and self-rated health with multimorbidity

Table 5 shows the results of the multivariate logistic regression analysis that was conducted to examine the associations of objective physical performance measures and SRH with multimorbidity. After adjusting for the various confounders, poor grip strength was found to be significantly associated with multimorbidity (reference: good grip strength; aOR = 1.36, P = 0.006); however, walking speed was not significantly associated with multimorbidity. Average and poor SRH were significantly associated with multimorbidity (reference: good SRH; aOR = 2.67 for average SRH, aOR = 6.46 for poor SRH, $P < 0.001$).

4. Discussion

Using cross-sectional data from a nationwide survey of Japanese adults aged 60 years or older, we examined the prevalence of multimorbidity in this population with regard to nine major chronic diseases, and investigated the association of physical performance and SRH with multimorbidity. Through this analysis, we determined that approximately two-fifths of the respondents had multimorbidity, and that the proportion of older adults with multimorbidity increased with age. Most notably, poor grip strength and SRH were found to be significantly and independently associated with the presence of multimorbidity after adjusting for various confounders.

4.1. Objective physical performance and multimorbidity

Our study showed that grip strength, but not walking speed, was significantly associated with multimorbidity. These objective physical performance measurements have been reported to be important biomarkers of older adults' health statuses (Cooper, Kuh, & Hardy, 2010). Although previous studies have examined and reported associations of either weak grip strength (Cheung et al., 2013; Volaklis et al., 2016; Welmer et al., 2012; Yorke et al., 2017) or slow walking speed (Ortiz et al., 2018; Welmer et al., 2012) with multimorbidity, there have been no studies that examined the associations of both these factors with multimorbidity using a single statistical model. To assess the possibility of multicollinearity between grip strength and walking speed in our multivariate model, we developed additional models that used only one or the other of these variables as the physical performance measure. We found that while grip strength alone was significantly associated with multimorbidity, walking speed alone showed no such association (data not shown). This indicates that there was no multicollinearity between these two physical performance measures.

Grip strength can be measured while the subject is either standing or sitting (Roberts et al., 2011), and the different positions may affect measurements. A previous study reported grip strength among college students to be stronger when measured in the standing position as opposed to the sitting position (Balogun, Akomolafe, & Amusa, 1991), whereas another study found no significant difference in grip strength between the standing and sitting positions among non-older adults (Shechtman, MacKinnon, & Locklear, 2001). Although we are unable to directly compare grip strength values between our study participants and those in previous studies that used seated measurements, the measuring position is unlikely to significantly affect our findings because grip strength was mostly measured in the standing position.

4.2. Self-rated health and multimorbidity

Our analysis showed that subjects with poor and average SRH were independently and significantly more likely to have multimorbidity than those with good SRH. Previous studies conducted in Europe have reported that the poorer the SRH status of a sample, the higher the risk of multimorbidity (Hudon et al., 2008; Mavaddat, Valderas, van der Linde, Khaw, & Kinmonth, 2014; McDaid et al., 2013; Vos et al., 2013). Furthermore, Ishizaki et al. reported a significant association between chronic diseases and poor SRH in a longitudinal data analysis (Ishizaki, Yoshida, Suzuki, & Shibata, 2009).

Table 3
Proportions of participants for each of the nine index chronic diseases with a co-existing disease (n = 2,525).

Index disease	n	Proportion of participants with a co-existing disease								
		Hypertension	Low back pain	Cataract	Arthralgia	Heart disease	Diabetes	Respiratory disease	Stroke	Cancer
Hypertension	1,113	100.0%	30.2%	30.2%	20.0%	17.2%	13.6%	7.5%	8.5%	5.5%
Low back pain	648	51.9%	100.0%	36.9%	29.2%	19.8%	15.3%	8.6%	8.3%	4.9%
Cataract	623	53.9%	38.4%	100.0%	22.3%	22.5%	17.0%	10.3%	9.6%	6.3%
Arthralgia	394	56.6%	48.0%	35.3%	100.0%	17.8%	14.0%	11.9%	6.9%	5.1%
Heart disease	359	53.2%	35.7%	39.0%	19.5%	100.0%	19.5%	9.5%	12.5%	7.2%
Diabetes	315	47.9%	31.4%	33.7%	17.5%	22.2%	100.0%	7.3%	8.9%	6.7%
Respiratory disease	181	45.9%	30.9%	35.4%	26.0%	18.8%	12.7%	100.0%	8.3%	7.7%
Stroke	153	62.1%	35.3%	39.2%	17.6%	29.4%	18.3%	9.8%	100.0%	6.5%
Cancer	126	48.4%	25.4%	31.0%	15.9%	20.6%	16.7%	11.1%	7.9%	100.0%

Table 4
Five most common two-disease combinations.

	Total (n = 2,525)		Men (n = 1,168)		Women (n = 1,357)
1	Hypertension – Low back pain (13.3%)	1	Hypertension –Low back pain (10.5%)	1	Hypertension – Cataract (16.2%)
1	Hypertension – Cataract (13.3%)	2	Hypertension – Cataract (9.9%)	2	Hypertension – Low back pain (15.7%)
3	Low back pain – Cataract (9.5%)	3	Hypertension – Diabetes (7.9%)	3	Low back pain – Cataract (11.5%)
4	Hypertension – Arthralgia (8.8%)	4	Hypertension – Heart disease (7.7%)	4	Hypertension – Arthralgia (11.3%)
5	Hypertension – Heart disease (7.6%)	5	Low back pain – Cataract (7.1%)	5	Low back pain – Arthralgia (9.1%)

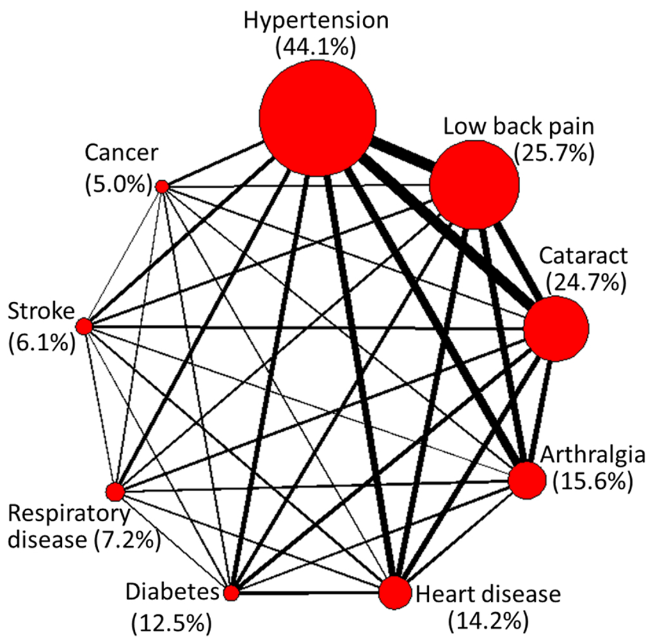

Fig. 1. Network graph of all two-disease combinations for the nine chronic diseases (n = 2,525).
The size of each disease node is proportional to the number of respondents with that disease, and the thickness of each line connecting two disease nodes is proportional to the number of respondents with both diseases.

However, due to the cross-sectional design of the present study, we were unable to unequivocally conclude that a causal relationship exists between multimorbidity and SRH. Nevertheless, it is logical to assume that multimorbidity would result in poor SRH, rather than poor SRH causing multimorbidity. We hypothesize that the increased treatment burden in people with multimorbidity causes their generally poorer SRH.

4.3. Strengths and limitations of the data source

The identification of the target diseases in this study was based on self-reported data obtained from a nationwide home-visit survey of community-dwelling older adults in Japan. The use of this survey enabled us to acquire information from both healthy and frail older persons. Previous studies on multimorbidity (Fortin, Stewart, Poitras, Almirall, & Maddocks, 2012) have been conducted using a variety of data sources, including self-reported data from interviews and questionnaire surveys (similar to that used in our study), medical record data, and health insurance claims data. Each of these data sources has advantages and disadvantages. The advantage of self-reported data is that it allows us to broadly ascertain disease statuses that the subjects themselves acknowledge, regardless of whether they have been diagnosed by a healthcare professional. Previous studies have reported that for many common chronic diseases (e.g., hypertension and diabetes) and low-incidence diseases that represent seminal events (e.g., stroke and cancer), which were present among our study's subjects, there is a substantial agreement between self-reported information and medical records (Cigolle, Nagel, Blaum, Liang, & Quinones, 2018; Okura, Urban, Mahoney, Jacobsen, & Rodeheffer, 2004; Singh, 2009). However, for other disease categories, such as depression and dementia (which were not included in this study), we postulate that the subjects' responses may not always be accurate.

In contrast, studies based on medical record data can identify multimorbidity through physician-diagnosed injuries and diseases. However, the secondary use of clinical diagnostic information to ascertain multimorbidity may be negatively influenced by discrepancies in the categorization of conditions within medical care records, which can vary depending on the specialties of the medical institutions that provide these data. In addition, studies that use data sourced from medical records and health insurance claims are limited to patients who have visited a medical institution. Our survey-based data involved the participation of non-institutionalized people, thereby presenting a more general representation of older adults in the Japanese population. Health insurance claims data also have another limitation, as these data are formulated for the purpose of reimbursing healthcare providers for services covered by health insurance. As a result, they do not always include important clinical information such as vital signs and laboratory results. In consideration of these points, it is clear that none of the data sources in their current form represent a clearly superior option for analyzing multimorbidity.

Although this study analyzed cross-sectional data from a nationwide survey involving older adults in Japan aged between 60 and 92 years, the analyzed respondents (who had the ability to respond and complete an interview survey in Japan) cannot be considered to be completely representative of older Japanese adults. This is because respondents aged 80 years or older were the dominant age group in this study (accounting for 37.4% of all analyzable respondents), which may have led to an overestimation of the prevalence of each chronic condition and multimorbidity. Using the NSJE respondent population weights to adjust for the differential probability of non-responses (Cesari et al., 2016), we estimated the weighted prevalence of multimorbidity to be 38.0%. On the other hand, because we excluded responses obtained from proxies in this study, this may have resulted in an underestimation of the prevalence of multimorbidity if respondents who used proxies had poorer health conditions than those who were able to respond by themselves. By examining the NSJE respondent population weights that included all respondents (i.e., those that completed the survey by themselves or through a proxy), we estimated the weighted prevalence of multimorbidity to be 38.5%. Thus, it is unlikely that the exclusion of proxy respondents had any substantial influence on the weighted prevalence of multimorbidity.

Finally, we did not ask the participants about their mental conditions (e.g., depression and dementia), which may have led to an underestimation of multimorbidity prevalence. Because older adults with mental conditions are more likely to have poor grip strength (Fukumori et al., 2015; McDowell, Gordon, & Herring, 2018) and SRH, the selective exclusion of patients with these conditions may cause us to underestimate the associations of grip strength and SRH with multimorbidity. We therefore posit that the inclusion of mental conditions in this study would generate stronger associations between these indicators and multimorbidity.

Table 5
Factors associated with multimorbidity: Results from bivariate and multivariate logistic regression analyses (n = 2,525).

Independent variable	Category	n	Participants with multimorbidity	*P*-value[a]	aOR	95% CI		*P*-value[b]
Sex	Men (reference)	1,168	42.4%	0.059	1.00			
	Women	1,357	46.1%		.94	.77	1.14	.506
Age group	60–69 years (reference)	687	29.3%	< .001	1.00			
	70–79 years	893	47.5%		1.93	1.48	2.52	< .001
	≥80 years	945	52.5%		1.82	1.25	2.63	.002
Number of household members	≥2 (reference)	2,095	43.3%	0.019	1.00			
	Alone	430	49.5%		1.07	.84	1.36	.573
Number of years of education	≥12 years (reference)	1,357	50.7%	< .001	1.00			
	≤11 years	1,168	37.1%		1.27	1.05	1.55	.014
Household financial condition	No difficulties (reference)	2,002	43.1%	0.038	1.00			
	Difficulties	401	49.1%		1.13	.89	1.44	.319
	No response	122	50.0%		.84	.55	1.27	.397
Basic activities of daily living	Independent (reference)	2,336	42.4%	< .001	1.00			
	Dependent	189	68.8%		1.25	.80	1.97	.324
Instrumental activities of daily living	Independent (reference)	2,165	41.3%	< .001	1.00			
	Dependent	360	63.1%		.97	.69	1.37	.871
Visual impairment	No (reference)	2,360	42.9%	< .001	1.00			
	Yes	147	68.0%		1.73	1.17	2.56	.006
	No response	18	44.4%		.90	.32	2.55	.849
Hearing impairment	No (reference)	2,252	43.7%	< .001	1.00			
	Yes	184	58.2%		1.17	.83	1.64	.360
	No response	89	34.8%		.90	.55	1.49	.685
Body mass index group	18.5–24.9 kg/m^2 (reference)	1,349	42.3%	0.011	1.00			
	< 18.5 kg/m^2	164	38.4%		.64	.44	.93	.019
	≥25 kg/m^2	572	47.6%		1.25	1.01	1.56	.039
	Missing data	440	49.1%		1.07	.76	1.50	.688
Current drinker	No (reference)	1,565	47.7%	< .001	1.00			
	Yes	960	39.0%		1.09	.89	1.33	.400
Current smoker	No (reference)	2,267	46.0%	< .001	1.00			
	Yes	258	30.2%		.58	.42	.79	.001
Period when respondents entered the panel study	First wave (1987) (reference)	214	58.9%	< .001	1.00			
	Second wave (1990)	140	55.0%		.83	.52	1.33	.430
	Fourth wave (1996)	480	46.7%		.81	.51	1.28	.367
	Fifth wave (1999)	369	47.4%		.61	.42	.88	.009
	Eighth wave (2012)	1,322	39.3%		.91	.60	1.38	.656
Grip strength[c]	Good (reference)	1,418	36.8%	< .001	1.00			
	Poor	845	54.7%		1.36	1.09	1.70	.006
	No measurement	262	52.3%		1.30	.85	1.98	.228
Walking speed[d]	Good (reference)	1,176	35.7%	< .001	1.00			
	Poor	786	51.9%		1.08	.87	1.35	.479
	No measurement	563	52.0%		.87	.64	1.19	.384
Self-rated health	Good (reference)	956	25.4%	< .001	1.00			
	Average	1,092	49.1%		2.67	2.19	3.25	< .001
	Poor	470	72.1%		6.46	4.89	8.52	< .001
	No response	7	42.9%		1.55	.32	7.61	.586

aOR: adjusted odds ratio; CI: confidence interval.
[a] *P* values calculated from the chi-square test.
[b] *P* values calculated from the logistic regression analysis.
[c] Grip strength: poor (< 26 kg for men and < 18 kg for women); good (≥26 kg for men and ≥18 kg for women).
[d] Walking speed: poor (< 0.8 m/sec); good (≥0.8 m/sec).

4.4. The annual health examination as an opportunity for integrating information on health and healthcare

Older adults with multimorbidity have higher levels of complexity in health status and healthcare management due to polypharmacy and the use of medical care from multiple providers (Wallace et al., 2015). Diseases that were determined in this study to be common in multimorbidity combinations were hypertension (an internal condition), low back pain (an orthopedic condition), and cataract (an ophthalmological condition). To adequately and comprehensively manage patients with multimorbidity, the different specialists treating a single patient must be able to share medical information. However, the need for several healthcare providers to treat multiple diseases across different medical facilities makes it difficult to integrate such information. As a result, the Japanese healthcare system requires further modifications to accurately identify and efficiently manage patients with multimorbidity.

The Japanese government provides adults aged 40 years or older with annual health examinations designed to screen for and prevent lifestyle-related diseases. These examinations include physical measurements (e.g., height and body weight), basic physical examinations, blood pressure measurements, and blood/urine tests. For older adults (especially old-old adults aged ≥75 years), we believe that it may be useful for these annual examinations to also collect information regarding chronic diseases, which would enable assessments of multimorbidity. In this way, these annual health examinations can become more useful and efficient for gathering information on subjective health status, objective physical performance, and multimorbidity than specific disease-based screening (Cesari et al., 2016; Tinetti & Fried, 2004).

5. Conclusions

Multimorbidity is prevalent in older Japanese adults aged 60 years or older, and disease combinations frequently include hypertension, low back pain, and cataract. We identified poor grip strength and SRH as being independently associated with multimorbidity after adjusting for potential confounding factors, such as demographic variables, socioeconomic status, body mass index, lifestyle factors, BADL/IADL, and sensory impairment (Fabbri et al., 2015). Multimorbidity results in increased complexity in the health status of older adults (Wallace et al., 2015). Health assessments that evaluate subjective health status and objective physical performance may provide a better understanding of the complex health status patterns of older adults with multimorbidity and inform the development of health and healthcare management strategies.

CRediT authorship contribution statement

Tatsuro Ishizaki: Conceptualization, Data curation, Formal analysis, Writing - original draft. **Erika Kobayashi:** Data curation, Project administration, Writing - review & editing. **Taro Fukaya:** Data curation, Writing - review & editing. **Yoshimitsu Takahashi:** Formal analysis, Writing - review & editing. **Shoji Shinkai:** Funding acquisition, Supervision, Writing - review & editing. **Jersey Liang:** Supervision, Writing - review & editing.

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