


Identifying Target Values of Body Composition for Preventing Frailty: A Descriptive Study in Older Adults

Gerontology & Geriatric Medicine
Volume 8: 1–6
© The Author(s) 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/23337214211064493
journals.sagepub.com/home/ggm


Shigeharu Tanaka, PhD^{1,2} , Hungu Jung, PhD² , and Ryo Tanaka, PhD² 

Abstract

This study investigated the relationship between frailty and body composition and the target values for preventing frailty in body composition. Frailty status and body composition such as the percent body fat and skeletal mass index was measured. Logistic regression analysis was performed by sex. Receiver operating characteristic curve was used to extract the cutoff values for body composition. The participants were 259 in females and 84 in males for 343 of which 75.5% females. Among the females, age was a significant independent variable. Percent body fat was significantly associated with frailty status in males, with a cutoff value of 27.6%. The area under the curve was significant (0.689, $p < 0.01$, sensitivity = 0.574, specificity = 0.784). New target value of percent body fat in males for preventing frailty is identified. Findings of this study could contribute to the establishment of preventive intervention for frailty in clinical practice.

Keywords

frailty, body composition, percent body fat, older adult, Japanese

Manuscript received: October 6, 2021; **final revision received:** November 6, 2021; **accepted:** November 12, 2021.

The world continues to progress into an aging society. Among the developed countries, Japan is one of the top aging societies. It has been projected that one-third of Japanese population will be at least 65 years old and approximately 20% will be at least 75 years of age by 2030 (Akiyama, 2020). Aging causes a decline in physical activities, and this limitation in older adults leads to an increase in social security costs. Thus, it is important to maintain physical activities in older adults for the benefits of the individuals, their families, community, and the nation.

Frailty is one of the problems related to the decline in physical activity in older adults, which warrants appropriate attention. In 1992, Buchner and Wagner (1992) defined frailty as a state of reduced physiologic reserve associated with increased susceptibility to disability. Fried et al. (2001) also defined frailty as a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss (10 lbs. in the past year), self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity. Previous reviews have indicated that frailty is associated with (1) fall risk, with a prevalence of up to 44% among older adults (Fhon et al., 2016) and (2) increased risk of mortality and hospitalization (Yang et al., 2018).

Studies that have examined the relationship between frailty and body composition indicated that there were differences in body fat mass, percent body fat (PBF), skeletal muscle mass, total body water, fat-free mass, and basal metabolic rate between patients with and without frailty and that obesity plays an important role in older adults with frailty (Xu et al., 2020; Reinders et al., 2017; Reinders et al., 2017, 2017). These results suggest that body composition is significantly associated with frailty and can be considered a potential target for the prevention of frailty. However, no study has examined the target values of body composition for preventing frailty.

¹Physical Therapy Major, School of Rehabilitation, Kanagawa University of Human Services, Yokosuka, Japan

²Graduate School of Humanities and Social Sciences, Hiroshima University, Higashihiroshima, Japan

Corresponding Author:

Ryo Tanaka, Graduate School of Humanities and Social Sciences, Hiroshima University, 1-7-1 Kagamiyama, Higashi-Hiroshima City, Higashihiroshima 739-8511, Japan.

Email: ryotana@hiroshima-u.ac.jp



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE

and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

Therefore, it is important to clarify target values and factors associated with frailty prevention, which could help to identify appropriate intervention and management in clinical practice. Hence, this study investigated (1) the relationship between frailty and body composition and (2) the target values for preventing frailty in body composition using cutoff value.

Materials and Methods

Ethical Considerations

Data on sociodemographic information (age and gender), frailty, and body composition were used for analyses. All the measured parameters were essential for assessing the participants' functional status and were not harmful. All procedures were conducted in accordance with the World Medical Association Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects of 1975. All participants provided written informed consent to participate in the study. This research has been approved by the institutional review board in Hiroshima University (approval number: 02–05).

Setting

This was a descriptive study. The participants were recruited through the staff of community centers, regional comprehensive support centers, and gymnasiums in Hiroshima Prefecture in Japan. A flyer outlining the survey was also used for recruitment. Recruitment and data collection were performed between November 2020 and December 2020.

Participants

The inclusion criteria for the study were the following: (1) community-dwelling persons aged 65 years or older and (2) persons with independent mobility (Barthel Index mobility score >10 [full score 20]). The exclusion criteria were the following: (1) suspected cognitive impairment (mini-mental state test score <23 [full score 30]) and (2) serious illness (unstable cardiovascular disease, stroke, severe respiratory impairment, Parkinson's disease, diabetic peripheral neuropathy, or rheumatoid/arthritis). The reason for excluding people with suspected cognitive impairment was to ensure the accuracy of the responses to the questionnaire survey. People suspected of having serious diseases were excluded to prevent falls during measurement and to avoid worsening of diseases. A total of 343 people participated in the study.

Outcome

The outcome in this study was frailty status, which was assessed using a revised Japanese version of the Cardiovascular Health Study (J-CHS) criteria (Satake & Arai, 2020). The revised J-CHS criteria are modified criteria in reference to the criteria proposed by Fried and colleagues, which are used to screen for frailty among Japanese individuals. It consists of five items: shrinking, weakness, exhaustion, slowness, and low activity. Shrinking was

measured with the question, "Have you lost 2 or more kg in the past 6 months?" Weakness was defined as grip strength <28 kg in men or 18 kg in women. Exhaustion was measured with the question, "In the past 2 weeks, have you felt tired without a reason?" Slowness was defined as a gait speed of <1.0 m/s. Low activity was surveyed with two questions: "Do you engage in moderate levels of physical exercise or sports aimed at health?" and "Do you engage in low levels of physical exercise aimed at health?" Every positive (yes) answer to each question was assigned one point. Finally, the scores were summed using the established cutoff points to create a composite variable: 0 = robust, 1–2 = pre-frail, ≥ 3 = frail (score range = 0–5).

For the measurement of grip strength, we used a grip strength meter (TKK 5401 Grip-D; Takei, Niigata, Japan). The participants grasped the grip strength meter so that the pointer of the meter was on the outside. Before the measurement, the interphalangeal joints of the fingers were adjusted so that they were almost at right angles. Measurements were taken once on both sides. Records were made in kilograms, and those less than a kilogram were rounded down. The reliability and validity have shown in measuring hand grip strength using a hand-held dynamometer (Abizanda et al., 2012). Additionally, for the measurement of walking speed, the participants walked along a 5-m walking path according to the instructions. A spare path of 1 m was provided for walking. The participants were instructed to "walk forward as if you were always walking." Measurements were taken once. Walking time is reliable and valid method for measuring walking speed (Steffen et al., 2002).

Predictive factors

PBF and skeletal mass index (SMI), indexes of skeletal muscle mass, were measured using multifrequency bioelectrical impedance analysis (MF-BIA; InBody 270, Tokyo, Japan) to ascertain body composition. The SMI was calculated as the skeletal muscle mass of the extremities. The MF-BIA instrument is a versatile, convenient, instantaneous, non-invasive, and highly accurate device for measuring bioelectrical impedance. As such, it is now the most common method for measuring body composition. The MF-BIA instrument can assess changes in body composition. InBody 270 is acceptable for body composition analysis. The high accuracy of measurement in older adults was certified. Additionally, this instrument can be used to monitor the nutritional status of older people and identify people with sarcopenia in the community (Fang et al., 2020).

Statistical analysis

Logistic regression analysis was performed to investigate the relationship between body composition and pre-frailty and/or frailty. PBF and SMI were entered into the regression model as independent variables. To adjust for confounder, age was also entered into the regression model as a confounding variable. Finally, to assess whether the dependent variable was linear in the logit, three methods, as proposed

by Hosmer and Lemeshow, were used: lowess (locally weighted least squares) smoothing curves, design variables, and fractional polynomials.

In the first model (Model 1), the dependent variable was the binary value of the existence of pre-frailty or frailty: robust participants were coded as 0 and participants with pre-frailty and frailty were coded as 1. Model 1 was used to identify whether the participant was not robust. In the second model (Model 2), the dependent variable was the binary variable with frailty: robust participants and participants with pre-frailty were coded as 0 and participants with frailty were coded as 1. Model 2 was used to identify whether the participant was frailty. Considering that sex might be a confounding factor in the relationship between body composition and pre-frailty and/or frailty, logistic regression analysis was performed separately for male and female participants. Finally, a total of four models were created.

To extract the cutoff values for body compositions to identify the presence of pre-frailty and/or frailty, we conducted an analysis using the receiver operating characteristic (ROC) curve. This analysis was applied only to body composition that was significant in the logistic regression analysis. In the ROC analysis, the outcome variable was the presence or absence of pre-frailty and/or frailty. The test variable was the body composition that was significantly associated with pre-frailty and/or frailty. Cutoff values were identified using the Yoden index. The area under the curve (AUC), sensitivity, and specificity were calculated to evaluate the accuracy of the identified cutoff values. The AUC could distinguish between nonpredictive (AUC <0.5), less predictive (0.5 <

AUC <0.7), moderately predictive (0.7 < AUC <0.9), and highly predictive (0.9 < AUC <1) values, as well as perfect prediction (AUC = 1) (Swets, 1988).

Sample size

According to a previous study (Fhon et al., 2016) that investigated the prevalence of pre-frailty or frailty in Japanese older adults, 44% of older adults were suspected pre-frailty or frailty. Based on this fundamental data, ratio of the Japanese older adults with pre-frailty or frailty was assumed to be 1 (45%) to 1.2 (55%). The alpha value was set at 0.05, and the power was set at 0.8. The hypothesized and null hypothesis AUC were set at 0.6 (moderate). Consequently, a total of 196 cases were required. In this study, additionally subjects were recruited to ensure that an adequate sample size was obtained.

Results

The background information of the participants is shown in Table 1. Of the 343 participants in this study, 259 were female and 84 were male. The average age for female and male participants was 72.5 years and 75.5 years, respectively. The percentages of participants with pre-frailty and frailty were 43.2% and 3.9% for females and 51.2% and 4.8% for males, respectively. PBF was different among the frailty categories in males but not in females. The walking speeds were different among the frailty categories in both sexes. Results of Kolmogorov–Simonov test showed that, in female, age,

Table 1. Background of the Subjects.

	Female (n = 259)						p-Value	Post-hoc Test
	Robust		Pre-frailty		Frailty			
Number, %	137	52.9	112	43.2	10	3.9		
Age	72.5	(4.9)	75.9	(6.2)	78.5	(2.8)	<.01	R < P,F
BMI (kg/m ²)	22.6	(2.9)	22.7	(3.2)	24.7	(6.2)	.160	
PBF (%)	32.15	(6.21)	32.12	(7.20)	32.16	(11.84)	1.000	
SMI (kg/m ²)	5.81	(0.57)	5.68	(0.53)	5.76	(0.76)	.187	
Walking speed (m/sec)	1.37	(0.20)	1.13	(0.29)	0.95	(0.24)	<.01	P,F < R
Grip strength (kg)	22.6	(3.1)	19.7	(3.9)	14.4	(3.6)	<.01	F < P < R
	Male (n = 84)							
	Robust		Pre-frailty		Frailty		p-Value	Post-hoc Test
Number, %	37	44.0	43	51.2	4	4.8		
Age	75.5	(5.6)	77.7	(6.3)	79.5	(6.2)	.710	
BMI (kg/m ²)	22.56	(2.39)	23.59	(2.78)	23.10	(2.39)	.219	
PBF (%)	23.68	(5.48)	27.15	(7.06)	27.00	(3.30)	<.05	R < P
SMI (kg/m ²)	7.07	(0.60)	6.97	(0.76)	6.53	(0.83)	.322	
Walking speed (m/sec)	1.25	(0.17)	1.08	(0.26)	0.88	(0.18)	<.01	P,F < R
Grip strength (kg)	34.1	(4.8)	31.3	(7.6)	28.2	(6.2)	.065	

() standard deviation; R: Robust, P: Pre-frailty, F: Frailty; BMI; Body mass index, PBF; Percent body fat, SMI: Skeletal mass index.

height, weight, BMI, PBF, and SMI were non-normal distribution. In male, age was non-normal distribution.

The results of logistic regression analysis are shown in Table 2. In females, age was a significant independent variable in models 1 (odds ratio = 1.127, $p < 0.05$) and 2 (odds ratio = 1.102, $p < 0.05$). In males, PBF was significantly associated with frailty status in model 1 (odds ratio = 1.087, $p < 0.05$). The Hosmer–Lemeshow test gave p -values of 0.413 for model 1 and 0.530 for model 2 in females, and 0.063 for model 1 and 0.608 for model 2 in males.

The results of ROC analysis can be found in Table 3 and Figure 1. Based on the results of logistic regression, this analysis was performed on the data of male participants only, for which PBF was significantly related to pre-frailty or frailty. Our results showed that the cutoff value was 27.6% in PBF. The AUC was significant (0.689, $p < 0.01$, sensitivity = 0.574, specificity = 0.784).

Discussion

This study examined the relationship between frailty and body composition, as well as the cutoff value in significant factors. In females, age was a significant variable in models 1 and 2, whereas in males, PBF was a significant variable in model 1. This study also showed that the cutoff value was 27.6% in PBF. These results can be leveraged to support healthcare providers to develop appropriate preventive programs for frailty in clinical practice.

In the two models for females, age was a significant factor. The odds ratios were 1.127 for model 1 and 1.102 for model 2. This finding is consistent with the high incidence of frailty in older adults. Although age is not a factor that healthcare providers can intervene in, it is important to recognize that being older is a factor in frailty. Whereas, PBF was significantly related to frailty in males. A previous cross-sectional study in Chinese older adults (Xu et al., 2020) indicated that body fat mass was associated with a higher risk of frailty, and a national database in the US (Crow et al., 2019) also showed that PBF was significantly associated with frailty. The result of our study reports similar findings in the Japanese population. Previous systematic reviews (Yin et al., 2021; Talar et al., 2021) have reported that nutritional advice and exercise intervention were effective in reducing body weight and fat mass. This indicates that PBF can be altered by interventions such as advice and exercise. This study revealed a new finding on the cutoff value in PBF, which was 27.6%. This target value might contribute to the establishment of preventive intervention for frailty in clinical practice.

This study analyzed the data by sex because sex was considered as a confounding factor. PBF was a significant factor in males but not in females. The reason for this discrepancy is not clear but indicates a sex variation in PBF with aging. In a previous study (Whitaker et al., 2016) that evaluated sex differences in adipose tissue, although subcutaneous adipose tissue and visceral adipose tissue decreased linearly with age in both sexes, visceral adipose tissue

Table 2. Results of Logistic Regression Analyses.

Dependent Variable	Female							
	Model 1				Model 2			
	Pre-frailty or Frailty				Frailty or Not			
	Odds ratio	95% Lower	95% Upper	P	Odds ratio	95% Lower	95% Upper	P
Age	1.127	1.071	1.186	.000	1.102	1.041	1.166	.001
PBF (%)	1.011	.972	1.051	.599	1.027	.976	1.081	.301
SMI (kg/m ²)	.818	.500	1.339	.425	1.004	.538	1.873	.991
Hosmer–Lemeshow χ^2	8.213			.413	7.066			.530
Nagelkerke R^2	.136				.080			
Dependent Variable	Male							
	Model 1				Model 2			
	Pre-frailty or Frailty				Frailty or Not			
	Odds ratio	95% Lower	95% Upper	P	Odds ratio	95% Lower	95% Upper	P
Age	1.061	.975	1.155	.171	1.061	.975	1.155	.618
PBF (%)	1.087	1.010	1.171	.027	1.087	1.010	1.171	.209
SMI (kg/m ²)	.943	.455	1.955	.875	.943	.455	1.955	.951
Hosmer–Lemeshow χ^2	14.816			.063	6.351			.608
Nagelkerke R^2	.132				.040			

PBF: Percent body fat, SMI: skeletal mass index.

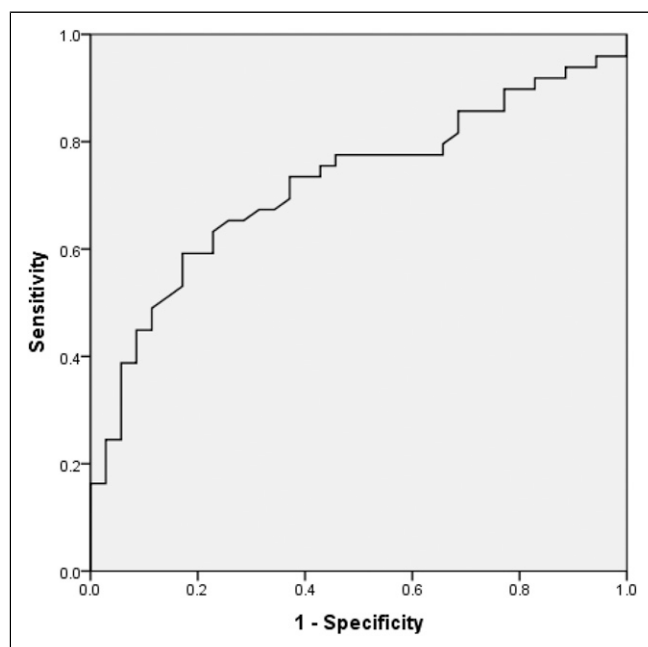


Figure 1. ROC analysis for the PBF in male. ROC: Receiver operating characteristic. Note: PBF: Percent body fat.

Table 3. Results of ROC Analysis.

	Cutoff Value	AUC	Sensitivity	Specificity
PBF	27.6	.689 ^a	.574	.784

^a $p < 0.01$.

ROC: Receiver operating characteristic, AUC: Area under the curve, PBF: Percent body fat.

Note. The data of male was used only.

was maintained in males more often than in females. Furthermore, [Stevens et al. \(2010\)](#) showed that there are large differences in the body composition of males and females, with males having a relatively more central distribution of fat (waist circumference was relatively longer in males than in females). In fact, a previous longitudinal study in older adults ([Bouchard et al., 2011](#)) indicated that waist circumference was the significant factor associated with mobility function related with frailty. These results might explain the sex discrepancy in PBF in our study and suggest a need to consider effective interventions that would mainstream sex into such interventions.

The sample in this study can be regarded as approximating the population. According to the data from the Ministry of Education, Culture, Sports, Science and Technology in Japan ([Japan Sports Agency, n.d.](#)[Japan Sports Agency](#)), the average grip strength was 22.5 kg for females and 35.0 kg for males in Japan aged above 75 years. Previous study ([Matsushita et al., 2016](#)) using the same Japanese sample as ours, the grip strength of robust female was 23.6 kg and that of robust male was 36.6 kg. The average grip strength in our data

was 22.6 kg for females and 34.1 kg for males. These values do not appear to be distinctly different among studies. Similarly, in pre-frail, the values of grip strength were similar in this study and previous studies. Therefore, the sample in this study can be considered to be representative of the population.

In our study, the percentage of subjects with pre-frailty and frailty were 43.2% and 3.9% for females and 51.2% and 4.8% for males, respectively. This compares well with a previous study among 2206 Japanese older adults ([Murayama et al., 2020](#)), which reported a pre-frailty and frailty prevalence of 40.8% and 8.7%, respectively. With reference to previous studies, the percentage of frailty included in this study may be small. However, the presence or absence of frailty was determined by standard criteria in this study. Therefore, we believe that the small percentage of frailty is not a serious problem.

The results of this study imply to clinical practice that PBF in males should assess carefully in clinical practice. In males, the sensitivity of this cutoff value was 0.574, which was lower than the specificity value. In other words, it would be myopic to assume that a PBF of less than 27.6% means that the older adults are not pre-frail or above. Clinicians need to have an attitude of not judging robustness based on low PBF alone.

This study has several limitations. First, it was a descriptive study, which was not sufficient to examine a strict causal relationship between body composition and frailty. Second, although this study had a large sample of 259 older females, the sample size of 84 older males was relatively small. Third, this study indicated cutoff values in PBF for males in Japan. However, Japan has a population with one of the lowest body mass index values among the Organization for Economic Co-operation and Development countries ([GBD 2015 Obesity Collaborators, 2017](#)). The second and third limitations highlight the limited generalization of this study's findings. Hence, the results of this study need to be interpreted with caution.

Conclusion

This study examined the relationship between frailty and body composition, and it determined the target values for potential predictive factors. Our results showed that the association between body composition and frailty differs between females and males. In males, PBF was significantly associated with frailty in model 1, and the target value of PBF was 27.6%. These findings could contribute to the establishment of preventive intervention for frailty in clinical practice.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Shigeharu Tanaka  <https://orcid.org/0000-0003-4397-0130>

Hungu Jung  <https://orcid.org/0000-0001-7500-7029>

Ryo Tanaka  <https://orcid.org/0000-0002-1349-3102>

References

- Abizanda, P., Navarro, J. L., García-Tomás, M. I., López-Jiménez, E., Martínez-Sánchez, E., & Paterna, G. (2012). Validity and usefulness of hand-held dynamometry for measuring muscle strength in community-dwelling older persons. *Arch Gerontol Geriatr*, *54*(1), 21–27. <https://doi.org/10.1016/j.archger.2011.02.006>
- Akiyama, H. (2020). Aging well: An update. *Nutrition Reviews*, *78*(12). <https://doi.org/10.1093/nutrit/nuaa084>, Suppl. 2, 3–9
- Bouchard, D. R., Choquette, S., Dionne, I. J., & Brochu, M. (2011). Is fat mass distribution related to impaired mobility in older men and women? Nutrition as a determinant of successful aging: The quebec longitudinal study. *Experimental Aging Research*, *37*(3), 346–357. <https://doi.org/10.1080/0361073X.2011.568848>
- Buchner, D. M., & Wagner, E. H. (1992). Preventing frail health. *Clinics in Geriatric Medicine*, *8*(1), 1–17. [https://doi.org/10.1016/S0749-0690\(18\)30494-4](https://doi.org/10.1016/S0749-0690(18)30494-4)
- Crow, R. S., Lohman, M. C., Titus, A. J., Cook, S. B., Bruce, M. L., Mackenzie, T. A., Bartels, S. J., & Batsis, J. A. (2019). Association of obesity and frailty in older adults: NHANES 1999–2004. *Journal of Nutrition, Health and Aging*, *23*(2), 138–144. <https://doi.org/10.1007/s12603-018-1138-x>
- Fang, W. H., Yang, J. R., Lin, C. Y., Hsiao, P. J., Tu, M. Y., Chen, C. F., Tsai, D. J., Su, W., Huang, G. S., Chang, H., & Su, S. L. (2020). Accuracy augmentation of body composition measurement by bioelectrical impedance analyzer in elderly population. *Medicine*, *99*(7), e19103. <https://doi.org/10.1097/MD.00000000000019103>
- Fhon, J. R. S., Rodrigues, R. A. P., Neira, W. F., Huayta, V. M. R., & Robazzi, M. L. C. (2016). Fall and its association with the frailty syndrome in the elderly: Systematic review with meta-analysis. *Revista da Escola de Enfermagem da U S P*, *50*(6), 1005–1013. <https://doi.org/10.1590/S0080-623420160000700018>
- Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W. J., Burke, G., & McBurnie, M. A. (2001). Cardiovascular health study collaborative research group frailty in older adults: Evidence for a phenotype. *Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *56*(3), M146–M156. <https://doi.org/10.1093/gerona/56.3.m146>
- GBD 2015 Obesity Collaborators. (2017). Health effects of overweight and obesity in 195 countries over 25 years. *The New England Journal of Medicine*, *377*(1), 13–27. <https://doi.org/10.1056/NEJMoa1614362>
- Japan Sports Agency. https://www.mext.go.jp/prev_sports/comp/b_menu/other/_icsFiles/afeldfile/2016/10/11/1377988_005.pdf
- Matsushita, E., Okada, K., Ito, Y., Satake, S., Shiraiishi, N., Hirose, T., & Kazuya, M. (2016). Characteristics of physical prefrailty among Japanese healthy older adults. *Geriatrics Gerontology International*, *17*(10), 1568–1574. <https://doi.org/10.1111/ggi.12935>
- Murayama, H., Kobayashi, E., Okamoto, S., Fukaya, T., Ishizaki, T., Liang, J., & Shinkai, S. (2020). National prevalence of frailty in the older Japanese population: findings from a nationally representative survey. *Archives of Gerontology and Geriatrics*, *91*, 104220. <https://doi.org/10.1016/j.archger.2020.104220>
- Reinders, I., Visser, M., & Schaap, L. (2017). Body weight and body composition in old age and their relationship with frailty. *Current Opinion in Clinical Nutrition and Metabolic Care*, *20*(1), 11–15. <https://doi.org/10.1097/MCO.0000000000000332>
- Satake, S., & Arai, H. (2020). The revised Japanese version of the cardiovascular health study criteria (revised J-CHS criteria). *Geriatrics and Gerontology International*, *20*(10), 992–993. <https://doi.org/10.1111/ggi.14005>
- Steffen, T.M., Hacker, T.A., & Mollinger, L. (2002). Age- and gender-related test performance in community-dwelling elderly people: Six-minute walk test, berg balance scale, timed up & go test, and gait speeds. *Physical Therapy*, *82*(2), 128–137. <https://doi.org/10.1093/ptj/82.2.128>
- Stevens, J., Katz, E. G., & Huxley, R. R. (2010). Associations between gender, age and waist circumference. *European Journal of Clinical Nutrition*, *64*(1), 6–15. <https://doi.org/10.1038/ejcn.2009.101>
- Swets, J. A. (1988). Measuring the accuracy of diagnostic systems. *Science*, *240*(4857), 1285–1293. <https://doi.org/10.1126/science.3287615>
- Talar, K., Hernández-Belmonte, A., Vetrovsky, T., Steffl, M., Kalamacka, E., & Courel-Ibáñez, J. (2021). Benefits of resistance training in early and late stages of frailty and sarcopenia: A systematic review and meta-analysis of randomized controlled studies. *Journal of Clinical Medicine*, *10*, 1630. <https://doi.org/10.3390/jcm10081630>
- Whitaker, K. M., Choh, A. C., Lee, M., Towne, B., Czerwinski, S. A., & Demerath, E. W. (2016). Sex differences in the rate of abdominal adipose accrual during adulthood: the fels longitudinal study. *International Journal of Obesity*, *40*(8), 1278–1285. <https://doi.org/10.1038/ijo.2016.48>
- Xu, L., Zhang, J., Shen, S., Hong, X., Zeng, X., Yang, Y., Liu, Z., Chen, L., & Chen, X. (2020). Association between body composition and frailty in elder inpatients. *Clinical Interventions in Aging*, *15*, 313–320. <https://doi.org/10.2147/CIA.S243211>
- Yang, X., Lupón, J., Vidán, M. T., Ferguson, C., Gastelurrutia, P., Newton, P. J., Macdonald, P. S., Bueno, H., Bayés-Genis, A., Woo, J., & Fung, E. (2018). Impact of frailty on mortality and hospitalization in chronic heart failure: A systematic review and meta-analysis. *Journal of the American Heart Association*, *7*(23), e008251. <https://doi.org/10.1161/JAHA.117.008251>
- Yin, Y. H., Liu, J. Y. W., Fan, T. M., Leung, K. M., Ng, M. W., Tsang, T. Y., Wong, K. P., & Välimäki, M. (2021). Effectiveness of nutritional advice for community-dwelling obese older adults with frailty: A systematic review and meta-analysis. *Frontiers in Nutrition*, *8*, 619903. <https://doi.org/10.3389/fnut.2021.619903>