when applied to a population of community-dwelling Japanese older adults.

Criteria for sarcopenia diagnosis and cut-off points

Muscle mass

The loss of muscle mass and increase in fat mass with aging has been well established in numerous studies.[14–18] The age-related loss of much mass is strongly associated with impaired mobility, greater morbidity and mortality,[7,19,20] and is a principal component in the causal pathway leading to frailty.[21] Therefore, the proper measurement and evaluation of muscle mass in older adults is extremely important.

The most widely used muscle mass cut-off points are those suggested by Baumgartner *et al.*, which used skeletal muscle mass index cut-off points two standard deviations below the mean of a young reference group measured by dual x-ray absorptiometry (DXA), 7.26 kg/m^2 for men and 5.45 kg/m^2 for women.[2] As seen in Table 1, several methods and cut-off points have been used, although many follow Baumgartner's example. The range of cut-off values shown in Table 1 for skeletal muscle index (SMI) or appendicular skeletal muscle mass adjusted by height, was 5.72–8.81 kg/m^2 in men and 4.23–7.36 kg/m^2 in women measured by DXA.[2–6,10,11,14,15,22–36] In addition, although the golden standard method of measurement is dual DXA, bioelectrical impedance analysis (BIA) has also been used, as the method is convenient and cost-effective, making it a more desirable and perhaps appropriate method for large-scale population studies. The range of cut-off values for BIA measurements of muscle mass were 7.00–8.87 kg/m^2 in men and 5.75–6.42 kg/m^2 in women, which are smaller ranges as the number of studies are fewer relative to those using DXA.[7,8,12,19,31,37,38]

It is not uncommon to witness these previously established cut-off points applied to various populations and samples in the literature. However, whether these population-specific cut-points should be used for any sample is questionable.

Muscle strength

Loss of muscle strength can lead to a number of major geriatric syndromes in addition to sarcopenia including frailty, mobility impairment and falls.[20,21,39,44] Low muscle strength is an important public health issue, as it has been associated with poor future health outcomes, and some researchers insist that muscle quality and functionality might be more vital within the elderly population.[39,41,44,48,49] Generally, upper extremity strength is measured using hand grip strength,[20,39,50] and knee flexion or extension is used for lower extremity strength assessments.[37,41] However, leg strength measurements might not be practical for large population studies or in clinical practice, as the equipment can be quite large and inconvenient, and the participants often require practice trials for accurate measurements. Therefore, grip strength is most often used in trials not only for the simplicity, reliability and affordability, but also because grip strength is a valid predictor of physical disability and mobility limitation. Grip strength cut-off points from the literature range from 26.0 to 37.0 kg in men and 18.0 to 21.0 kg in women.[9,13,19–21,31,35,38,39] One study suggested adjusting the cut-off values of grip strength based on body mass index (BMI).[21] Other measures of muscle strength included isokinetic knee extension torque and knee extension strength; however, these are not used as frequently (cut-off values summarized in Table 1).[40,41,48,51]

Physical performance

Among the commonly used available physical performance measures including the Short Physical Performance Battery, usual walking speed, 6-min walk test, timed get-up & go test and the stair climb power test,[52–54] usual walking speed is quick, inexpensive and a reliable measurement of physical function that can be easily implemented in clinical settings.[55] The predictive values of usual walking speed measurements for major health-related outcomes have been well established in the literature.[42,43,55] Determining the cut-off value for walking speed necessary to maintain a healthy, independent lifestyle is very important, which several researchers have investigated (Table 1).

The cut-point of gait speed ranged from 0.65 to 1.22 m/s.[9,19–21,31,38,41–43,45–47,55] Many of the studies found provided the same cut-off value for men and women, which does not take into account the likely height differences between the sexes. Fried *et al.* stratified walking speed by sex and height using the slowest 20% of a 15-ft walk as a cut-point.[21] The cut-points converted into m/s were 0.65 m/s for men ≤173 cm and women ≤159 cm, and 0.76 m/s for men >173 cm and women >159 cm.

Working definition of sarcopenia

The term sarcopenia was originally defined as the age-related loss of muscle mass.[1] Several cut-off points have been used to define sarcopenia based on muscle mass alone. The definition proposed by Baumgartner is the most commonly used definition of sarcopenia based on height-adjusted skeletal muscle mass measured by DXA.[2] Newman suggested a definition with similar cut-off values (7.23 kg/m^2 for men and 5.67 kg/m^2 for women) measured by DXA, defining sarcopenia as those whose muscle mass was in the lowest 20% of the

Table 1 Summary of cut-off values for components of sarcopenia and prevalence of people falling below the suggested cut-off values

Criteria	Country	Measurement and index of muscle mass	Cut-off values		Cut-off value criteria	Prevalence		References
			Male	Female		Male	Female	
Muscle mass		***DXA***						
	USA	SMI (kg/m^2)	7.26	5.45	2 SD below young reference mean	13.5–57.8	23.1–60.0	Baumgartner *et al.* (1998)[2]
	USA	Total SMI (kg/m^2)	6.77	4.51	2 SD below young reference mean	11.3	7.3	Melton *et al.* (2000)a[3]
	USA	SMI (kg/m^2)	7.26	5.45	2 SD below young reference mean	5.3	4.6	Melton *et al.* (2000)b[3]
	Denmark	LTM_A/height^2	–	5.40	2 SD below young reference mean	–	12.3	Tanko *et al.* (2002)[4]
	USA	SMI (kg/m^2)	7.26	5.45	2 SD below young reference mean	26.8	22.6	Iannuzzi-Sucich *et al.* (2002)[22]
	France	SMI (kg/m^2)	7.26	5.45	2 SD below young reference mean	–	9.5	Rolland *et al.* (2003)[23]
	USA	SMI (kg/m^2)	–	5.45	2 SD below young reference mean	–	23.8	Kenny *et al.* (2003)[24]
	France	SMI (kg/m^2)	–	5.45	2 SD below young reference mean	–	8.9	Gillette-Guyonnet *et al.* (2003)[14]
	China (Hong Kong)	SMI (kg/m^2)	5.72	4.82	2 SD below young reference mean	12.3	7.6	Lau *et al.* (2005)[25]
	China (Hong Kong)	SMI (kg/m^2)	7.4	6.4	2 SD below young reference mean	2.2	2.6	Woo *et al.* (2009)[26]
	France	SMI (kg/m^2)	–	5.45	2 SD below young reference mean	–	6.8	Rolland *et al.* (2009)[27]
	Korea	SMI (kg/m^2)	7.40	5.14	2 SD below young reference mean	6.3	4.1	Kim *et al.* (2009)a[10]
	Canada	SMI (kg/m^2)	8.51	6.29	2 SD below young reference mean	38.9	17.7	Bouchard *et al.* (2009)[28]
	Korea	SMI (kg/m^2)	6.58	4.59	2 SD below young reference mean	6.3	4.1	Kim *et al.* (2010)[29]
	Japan	SMI (kg/m^2)	6.87	5.46	2 SD below young reference mean	1.7	2.7	Sanada *et al.* (2010)[5]
	Japan	SMI (kg/m^2)	6.58	4.59	2 SD below young reference mean	12.4	0.1	Kim *et al.* (2012)a[15]
	Brazil	SMI (kg/m^2)	–	5.5	2 SD below young reference mean	–	3.7	Domiciano *et al.* (2013)a[30]
	Brazil	SMI (kg/m^2)	7.26	–	2 SD below young reference mean	13.5	–	Figueiredo *et al.* (2014)a[11]
	Asian Consensus	SMI (kg/m^2)	7.00	5.40	AWGS recommendation	–	–	Chen *et al.* (2014)[31]
	China	SMI (kg/m^2)	5.85	4.23	2 SD below young reference mean	0.0	17.9	Wen *et al.* (2011)a[32]
	USA	aLM/height^2 (kg/m^2)	7.23	5.67	Sex-specific lowest 20% of the distribution	0.0–50.4	0.0–51.9	Newman *et al.* (2003)a[6]
	USA	aLM/height^2 (kg/m^2)	7.25	5.67	Sex-specific lowest 20% of the distribution	20.3	20.2	Delmonico *et al.* (2007)a[33]
	Italy	SMI (kg/m^2)	–	5.70	Lowest 2 quintiles in recruited cohort	–	27.2	Zoico *et al.* (2004)[34]
	Korea	SMI (kg/m^2)	8.81	7.36	Lowest 2 quintiles in recruited cohort	54.4	40.5	Kim *et al.* (2009)b[10]
	USA	Residuals method	–2.29	–1.73	Sex-specific lowest 20% of the distribution	11.5–32.8	14.4–23.0	Newman *et al.* (2003)b[6]
	USA	Residuals method	–	–	20th percentile of distribution of residuals	20.2	20.3	Delmonico *et al.* (2007)b[33]
	Korea	Residuals method	–1.87	–1.62	Sex-specific cut-off points of lower 20% of residuals	15.4	22.3	Kim *et al.* (2009)c[10]
	China	Residuals method	–	–	20th percentile of distribution of residuals	33.3	25.6	Wen *et al.* (2011)b[32]
	Brazil	ASM adjusted for fat mass and height	–	–1.45	20th percentile of distribution of residuals	–	19.9	Domiciano *et al.* (2013)b[30]
	Brazil	ASM adjusted for total fat mass	–2.06	–	20th percentile of distribution of residuals	19.8	–	Figueiredo *et al.* (2014)b[11]
	The Netherlands	ASM (kg)	loss >3%		Lowest 15% during 3-year follow up,	15.7		Visser *et al.* (2003)[35]
	Japan	(ASM/weight) × 100 (%)	29.1	23.0	2 SD below young reference mean	9.7	11.8	Kim *et al.* (2012)b[15]
	Korea	(ASM/weight) × 100 (%)	29.1	23.0	2 SD below young reference mean	12.1	11.9	Ryu *et al.* (2013)[36]
		BIA						
	USA	% SMI (muscle mass/body mass × 100)	31.5	22.1	2 SD below young reference mean	7.0	10.0	Janssen *et al.* (2002)[7]
	USA	SMI (kg/m^2)	8.50	5.75	SMI below likelihood ratio for positive result	–	–	Janssen *et al.* (2004)[12]
	Taiwan	SMI (kg/m^2)	8.87	6.42	2 SD below young reference mean	23.6	18.6	Chien *et al.* (2008)[8]
	Japan	SMI (kg/m^2)	7.00	5.80	2 SD below mean young adult values	–	–	Tanimoto *et al.* (2012)[19]
	Japan	SMI (kg/m^2)	–	6.42	Based on Chien's cut-off value	–	–	Kim *et al.* (2012)[37]
	Japan	SMI (kg/m^2)	6.75	5.07	2 SD below young reference mean	21.1–75.0	24.5–71.4	Yamada *et al.* (2013)[38]
	Asian Consensus	SMI (kg/m^2)	7.00	5.70	AWGS recommendation	–	–	Chen *et al.* (2014)[31]

Muscle strength	USA	Grip strength (kg)	29.0–32.0	17.0–21.0	Frailty definition, stratified by BMI quartiles	–	–	Fried *et al.* (2001)[21]
	Italy	Grip strength (kg)	30.3	19.3	ROC curve identifying walking disability (speed <0.8 m/s)	–	–	Lauretani *et al.* (2003)a[20]
	The Netherlands	Grip strength (kg)	loss >40.0%		Lowest 15% during 3-year follow up		13.5	Visser *et al.* (2003)[35]
	European Consensus	Grip strength (kg)	30.0	20.0	EWGSOP recommendation based on Lauretani cut-off	–	–	Cruz-Jentoft *et al.* (2010)[9]
	Finland	Grip strength (kg)	37.0	21.0	Risk of mobility limitation	–	–	Sallinen *et al.* (2010)[39]
	Japan	Grip strength (kg)	30.3	19.3	The lowest quartile	–	–	Tanimoto *et al.* (2012)[19]
	Taiwan	Grip strength (kg)	22.4	14.3	Modified EWGSOP definition for Taiwanese population	–	–	Lee *et al.* (2013)[13]
	Japan	Grip strength (kg)	30.0	20.0	EWGSOP recommendation		31.9	Yamada *et al.* (2013)[38]
	Asian Consensus	Grip strength (kg)	26.0	18.0	AWGS suggestion for low hand grip strength	–	–	Chen *et al.* (2014)[31]
	USA	Knee extension torque (Nm/kg m^{-1})	2.5		Maximal voluntary muscle torque threshold	–	–	Cress *et al.* (2003)[40]
	Italy	Knee extension torque (N/dm)	390.9	266.4	ROC curve identifying walking disability (speed <0.8 m/s)	–	–	Lauretani (2003)b[20]
	USA	Knee extension strength (Nm/kg)	1.13	1.01	Deciles with high risk of mobility limitation	9.8	29.7	Manini *et al.* (2007)[41]
	Japan	Knee extension strength (Nm/kg)	–	1.01	Based on Manini's cut-off value	–	–	Kim *et al.* (2012)[37]
Gait speed	USA	Usual walking speed (m/s)	1.22		Speed allotted to cross signaled intersection		99.5	Langlois *et al.* (1997)[42]
	USA	Usual walking speed (m/s)	1.20		Future functional disability		77.9	Brach *et al.* (2001)[43]
	USA	Walking speed (m/s)	0.65 or 0.76†		Slowest 20% of 15-ft walk	–	–	Fried *et al.* (2001)[21]
	Italy	Walking speed (m/s)	0.80		4-m course, ROC curve identifying walking disability	–	–	Lauretani *et al.* (2003)[20]
	USA	Usual walking speed (m/s)	1.00		Onset of persistent lower extremity limitation		24.0	Cesari *et al.* (2005)[55]
	USA	Walking speed (m/s)	0.98 or 1.06‡		6-m course. Based on Fried (2001) criteria	–	–	Cawthon *et al.* (2007)[45]
	USA	Usual walking speed (m/s)	1.22		Speed allotted to cross signaled intersection	19.7	38.5	Manini *et al.* (2007)[41]
	France	Gait velocity (m/s)	0.80		Based on systematic review	–	–	Abellan van Kan *et al.* (2009)[46]
	European Consensus	Gait velocity (m/s)	0.80		EWGSOP recommendation based on Lauretani cut-off	–	–	Cruz-Jentoft *et al.* (2010)[9]
	Japan	Walking speed (m/s)	1.27	1.19	The lowest quartile	–	–	Tanimoto *et al.* (2012)[19]
	Japan	Walking speed (m/s)	0.80		EWGSOP recommendation		4.1	Yamada *et al.* (2013)[38]
	Asian Consensus	Usual walking speed	0.80		6-m course, AWGS recommendation	–	–	Chen *et al.* (2014)[31]
	England	Usual walking speed (m/s)	0.78	0.72	3-m course, self-reported walking speed	3.8	5.0	Syddall *et al.* (2015)[47]

References with several methods and cut-off points within the same criteria have been differentiated using "a,b,c". †0.65 m/s for men ≤173 cm and women ≤159 cm; 0.76 m/s for men >173 cm and women >159 cm. ‡0.98 m/s for men ≤174 cm and 1.06 m/s for men >174 cm. aLM, appendicular lean mass. AWGS, Asian working group on sarcopenia; BIA, bioelectrical impedance analysis; DXA, dual-energy x-ray absorptiometry; EWGSOP, European Working Group on Sarcopenia in Older People; LTM_A, age- and menopause-related variations in appendicular lean tissue; ROC, receiver operating characteristic; SD, standard deviation; SMI, skeletal muscle index.

distribution.[6] Sanada *et al.* reported cut-off values for an Asian sample using Baumgartner's suggested method, two standard deviations below the sex-specific mean of a young population, 6.87 kg/m^2 in Japanese men and 5.46 kg/m^2 in women measured by DXA.[5]

In 2000, Janssen developed and published predictive equations for estimating skeletal muscle mass using BIA,[56] which has since been referred to by many researchers using BIA to define sarcopenia.[8,19,37,57] Janssen *et al.* used the common definition for sarcopenia (i.e. two standard deviations below the sex-specific mean for young adults), measured by BIA, where the muscle mass cut-off points were 8.50 kg/m^2 in men and 5.75 kg/m^2 in women.[12] Chien *et al.* reported muscle mass cut-off values of 8.87 kg/m^2 for men and 6.42 kg/m^2 for women in Taiwanese older adults.[8]

In 2010, the EWGSOP developed a practical clinical definition and consensus diagnostic criteria for age-related sarcopenia combining muscle mass, strength and physical performance.[9] As Manini and Clark summarized, muscle mass alone was not associated with mortality, and muscle strength is a crucial factor in the determination of physical disability and mortality.[58] The combined definition, which includes muscle mass and strength, as well as performance, might be more relevant for investigating the effects of sarcopenia on older adults. Based on the EWGSOP algorithm, walking speed below or equaling 0.8 m/s would be the first step in screening sarcopenic people. Followed by measures of muscle strength and muscle mass.

After the publication of the EWGSOP definition of sarcopenia in 2010, many investigators have applied this definition, even within trials studying populations of different ethnicities. Chen *et al.* summarized the Asian Working Group for Sarcopenia (AWGS), as Asian populations differ from Caucasians in ethnicity, adiposity, size and lifestyle, and the use of previous definitions obtained from varying ethnicities can be inappropriate.[31] The authors reported that a cohort effect might be observed in the use of a cut-off point derived from a young Asian population, as younger people lead a more Westernized lifestyle compared with the older generation, who most likely would have lived a more traditional lifestyle. Regardless, the AWGS recommended the traditionally used two standard deviations below the mean muscle mass of a young reference group or the lowest quintile for cut-off determination. The recommended cut-off value for height-adjusted skeletal muscle were 7.0 kg/m^2 in men and 5.4 kg/m^2 in women using DXA, and 7.0 kg/m^2 in men and 5.7 kg/m^2 in women measured by BIA.[31] Chen *et al.* specifically suggested the use of height-adjusted skeletal muscle mass, although research has shown that this method of measurement can underestimate the prevalence sarcopenia in Korean and Chinese populations.[15,32] The AWGS definition of sarcopenia further suggested low handgrip strength (<26 kg for men and <18 kg for women) in addition to muscle mass to screen for sarcopenia. A walking speed of ≤0.8 m/s was recommended as the cut-off for low physical performance in Asian people. Researchers should be aware and careful of the use of previous cut-off points, as they could have an effect on the prevalence rates of sarcopenia, as well as possible risk factors.

Risk factors of sarcopenia components

Muscle mass

Investigation into the risk factors and associated factors of muscle mass decline has been ongoing for several decades. Many of the risk factors assessed for declines in muscle mass, summarized in Table 2, include chronic conditions, such as diabetes, heart disease and hyperlipidemia; arterial stiffness, malnutrition and hematological factors.[57,59,60] Several hematological components have been linked to the loss of muscle mass, such as high creatinine, and high albumin concentration had protective effects.[57,61] BMI and inflammation have also been significantly associated with muscle mass loss.[57,75]

Muscle strength

Factors associated with muscle strength loss have also been investigated. Similar to muscle mass, the literature describes hematological factors including total free-testosterone, insulin-like growth factor-1, high parathyroid hormone, hemoglobin, low 25-hydroxy vitamin D and low serum albumin to be linked to grip strength decline in longitudinal studies.[35,62,63] One study by Stenholm *et al.* found that high concentrations of interleukin-6 and interleukin-1RA, and low levels of dehydroepiandrosterone sulfate were predictors of muscle strength loss over 22 years.[66]

Muscle strength loss has been associated with many chronic conditions and lifestyle factors, such as back pain, diabetes, cardiovascular disease, chronic kidney disease, hypertension, asthma, cognitive function, use of calcium channel blockers, caffeine intake, excess bodyweight, stress and smoking.[57,64,65,67,68,76]

Walking ability

Detailed study into hematological factors linked to declines in walking ability are more limited, and although walking speed decline has been studied extensively, few studies exist that have investigated blood component risk factors. In a recent letter to the editor of the *Journal of the American Geriatrics Society*, Onuoha outlined that red blood cell indices (red blood cell count, hematocrit, white blood cell count) were associated with gait rhythm, but not speed.[77] The author suggested that hematological mechanisms might cause disturbances in

Table 2 Summary of risk factors associated with sarcopenia components

Study design and Participants	Factors	Main results	References
Muscle mass			
Cross-sectional, 142 people aged 70 years and older	Diabetes, malnutrition, inflammation	The presence of diabetes mellitus was the strongest predictor of lean body mass loss (B = −2.302, $P < 0.001$). Malnutrition (B = 1.265, $P = 0.027$) and inflammation (B = −1.321, $P = 0.022$) were also significantly associated with lean body mass loss.	Pupim *et al.* (2005)[59]
Cross-sectional, 175 people aged 65 years or older	CAVI	Higher CAVI was significantly associated with low SMI (OR1.82, 95% CI 1.14–2.90).	Sampaio *et al.* (2014)[60]
Longitudinal (4 years), 3026 people aged 70–79 years	Serum creatinine	High serum creatinine was associated with loss of lean mass in men, but not women.	Fried *et al.* (2007)[61]
Longitudinal (4 years), 538 women aged 75 years or older	Age, BMI, calf circumference, albumin, heart disease, hyperlipidemia	Older age and BMI lower than 21 kg/m2 predicted muscle mass decline. High albumin had protective effects for SMI decline (OR 0.90, 95% CI 0.82–0.98). History of heart disease (OR 2.05, 95% CI 1.19–3.55) and hyperlipidemia (OR 1.74, 95% CI 1.10–2.77) were significant risk factors for decrease in SMI.	Kim *et al.* (2015)[57]
Muscle strength (Grip strength)			
Cross-sectional, 121 men and 180 women aged 65–97 years	Physical activity, IGF1, total free-testosterone	Grip strength had significant positive associations with physical activity, IGF1 and free-testosterone in men; and IGF1 in women.	Baumgartner *et al.* (1999)[62]
Longitudinal (3 years), 331 people aged 65 years or older at baseline	PTH, 25-hydroxy vitamin D	Low 25-OHD was associated with loss of strength (OR 2.57, 95% CI 1.4–4.7). Those with high PTH levels were 1.71-fold (95% CI 1.07–2.73) more likely to experience grip strength loss.	Visser *et al.* (2003)[35]
Longitudinal (3 and 6 years), 676 women and 644 men aged 65–88 years	Serum albumin	Low serum albumin was associated with grip strength decline over 3 years in men (β = 0.57, SE = 0.18) and women (β = 0.37, SE = 0.16). Weaker associations found over 6 years.	Schalk *et al.* (2005)[63]
Longitudinal (7 years), 321 men aged 51–84 years	Age, back pain, use of calcium channel blockers, caffeine intake, height, weight loss	Multivariate analysis showed that greater grip strength at baseline, higher lifetime caffeine intake, use of calcium channel blocker (OR 2.37, 95% CI 1.17–4.17), older age, height loss and back pain were associated with grip strength loss.	Forrest *et al.* (2005)[64]
Longitudinal (25 years), 3522 people aged 71–93 years at follow up	Age, glucose, cognitive function, BMI, hemoglobin	Handgrip strength was inversely associated with age and glucose. Cognitive function, BMI and hemoglobin levels were directly associated with strength.	Charles *et al.* (2006)[65]
Longitudinal (22 years), 716 people aged 65 years and older	IL-6, IL-1RA, DHEA-S	High concentrations of IL-6 and IL-1RA, and low levels of DHEA-S predicted muscle strength decline.	Stenholm *et al.* (2010)[66]
Longitudinal (22 years), 963 people aged 30–73 years at baseline	Excess body weight, smoking, CVD, hypertension, diabetes, asthma, weight loss	Over-weight/obese persons and current and former smokers had greater decline in handgrip strength as well as those with hypertension, diabetes and asthma. People who lost more than 10% of weight during follow-up had greater handgrip declines.	Stenholm *et al.* (2012)[67]
Longitudinal (22 years), 849 men and women aged 50–88 years at baseline	Stress, smoking, dementia, marital status, mean arterial pressure, physical activity at work, chronic disorders	Significant factors for women were stress, smoking and dementia. For men, factors associated with grip strength decline were marital status, mean arterial pressure, physical activity at work, and having a chronic disorder.	Sternang *et al.* (2015)[68]
Longitudinal (4 years), 538 women aged 75 years or older	Age, BMI, BMD, calf circumference, regular exercise habit	Age and low BMI were risk factors for muscle strength decline. Calf circumference (OR 0.65, 95% CI 0.52–0.83) had protective effects for strength. Greater BMD (OR 0.40, 95% CI 0.17–0.91) and regular exercise (OR 0.30, 95% CI 0.12–0.72) also had protective effects for grip strength declines.	Kim *et al.* (2015)[57]
Walking speed			
Cross-sectional, 1002 women aged 65 years and older (of which 129 women had severe walking disability)	Strength, balance	Greater knee extension strength (OR 0.91, 95% CI 0.86–0.97) and balance (OR 0.48, 95% CI 0.37–0.62) had protective effects for severe walking disability.	Rantanen *et al.* (1999)[51]
Cross-sectional, 3075 people aged 70–79 years	Cystatin C	Increase in cystatin C concentration was associated with 1.32 odds (95% CI 1.20–1.46) of walking difficulty (slow walking speed, not completing 400-m walk).	Odden *et al.* (2006)[69]
Cross-sectional and longitudinal (2.3 years), 333 people aged 70 years and older	IL-6	High IL-6 levels were associated with slow walking speed (estimate −4.90 cm/s, $P = 0.008$). Older adults in highest IL-6 quartile had a 1.75 cm/s/year faster decline in walking speed.	Verghese *et al.* (2011)[70]
Longitudinal (22 years), 840 people aged 32–72 years, with no walking ability at baseline	BMI, handgrip strength, physical function	Walking limitation after 22 years was significantly associated with BMI (OR 1.39, 95% CI 1.10–1.75) and grip strength (OR 0.56, 95% CI 0.38–0.81), as well as major difficulties with running and squatting.	Stenholm *et al.* (2007)[71]
Longitudinal (5 years), 909 people mean age 75.2 ± 2.8 years	Global function, verbal memory, memory, executive function	Poor performance in global function, verbal memory, and executive function was associated with walking speed declines.	Watson *et al.* (2010)[72]
Longitudinal (3 years), 434 women aged 63–76 years at baseline and after 3-year follow up	Fear of falling, sensory difficulties, CVD, diabetes, rheumatoid arthritis	OR for incident walking difficulty was 3.5 (95% CI 1.6–7.8) in those with fear of falls. Chronic conditions like CVD, diabetes and arthritis were also significant predictors of walking difficulty.	Viljanen *et al.* (2012)[73]
Longitudinal (mean follow up 6.6 years), 1226 older than 60 years and free of mobility disability at baseline	Chronic kidney disease (using cystatin C-based estimated glomerular filtration rate	Those with chronic kidney disease determined by cystatin C had greater odds of mobility disability (OR 1.55, 95% CI 1.05–2.31).	Liu *et al.* (2014)[74]
Longitudinal (4 years), 538 women aged 75 years or older	Age, BMI, BMD, calf circumference, TUG, albumin, HDL cholesterol, cystatin C, knee pain	Age and low BMI were predictive of walking speed decline. Longer TUG (OR 1.28, 95% CI 1.12–1.48) high HDL cholesterol (OR 1.01, 95% CI 1.00–1.03), cystatin c levels (OR 1.34, 95% CI 1.03–1.74), and knee pain (OR 1.73, 95% CI 1.08–2.76), were risk factors for walking speed decline. Greater BMD and albumin had protective effects.	Kim *et al.* (2015)[57]

25-OHD, 25-hydroxy vitamin D; BMD, bone mineral density; BMI, body mass index; CAVI, cardio-ankle vascular index; CI, confidence interval; CVD, cardiovascular disease; DHEA-S, dehydroepiandrosterone sulfate; HDL, high-density lipoprotein; IGF, insulin-like growth factor; IL-1RA, interleukin-1 receptor antagonist; IL-6, interleukin-6; OR, odds ratio; PTH, parathyroid hormone; SE, standard error; SMI, skeletal muscle index; TUG, timed up & go.

separate aspects of gait, but not overall gait performance. Some studies have shown that kidney function, specifically the increase in cystatin C, was associated with increased risk of mobility disability.[57,69,74] Interleukin-6 was also associated with walking ability, being one of the hematological factors associated across all the components of sarcopenia.[70]

Reports have found that walking speed declines are associated with strength, balance, fear of falling, sensory difficulties, cardiovascular disease, diabetes, rheumatoid arthritis, global function, verbal memory and executive function (Table 2).[51,57,71–73]

Risk factors of sarcopenia

Sarcopenia is a systemic condition, and as such, the risk factors reported vary greatly. Age and BMI are evident risk factors for sarcopenia. Landi *et al.* found that sarcopenia was more likely seen in men,[78] whereas Yu *et al.* reported that the female sex was a risk factor for sarcopenia (Table 3).[83] Perhaps the difference in ethnicity between the populations might explain the conflicting results. Greater calf circumference has been reported to be protective against sarcopenia, whereas slow timed up & go test was associated with sarcopenia development longitudinally.[57] One investigation showed that higher education increased the likelihood of sarcopenia.[84] Chewing ability has also been reported to be associated with sarcopenia defined by the AWGS definition.[85] Murakami *et al.* state that while relationships between muscle strength, physical function and chewing ability have been reported previously, the association between muscle mass and chewing ability had not, and further suggested that the changes in general muscle mass and muscle mass related to chewing ability might have been the reason for the notable relationship between chewing ability in the study.[85] More detailed investigation into the causal relationship between sarcopenia and chewing-related muscle function decline are required.

Researchers have sought to identify blood biomarkers for sarcopenia. Currently in the literature, the associated hematological factors include low 25-hydroxy-vitamin D, insulin-like growth factor 1, albumin and testosterone, as well as high gamma-glutamyl transferase and cystatin C (Table 3).[22,35,57,62,79–81,84,86]

Several chronic conditions and lifestyle factors have also been associated with sarcopenia. As summarized in Table 3, older adults with high blood pressure, instrumental activities of daily living impairment, chronic obstructive pulmonary disease, chronic kidney disease, hyperlipidemia, osteoporosis and stroke are at risk for sarcopenia.[57,80,82,83,87] Furthermore, BMI, pain, being overweight, lacking exercise (sedentariness), and high fat and protein intake also increase the likelihood of being sarcopenic.[80,88]

Comparison of sarcopenia prevalence and risk factors associated with sarcopenia based on different suggested definitions

The literature is inconsistent in the application of sarcopenia definitions using previously established muscle mass cut-off points or the EWGSOP definition, which combines muscle mass, strength and physical performance. Some studies have examined the differences in prevalence rates using different sarcopenia definitions; however, there are few studies, if any, that investigate both sarcopenia prevalence and associated risk factors with differing definitions in a sample population.[3,10,11,15,30,32,33]

The prevalence of sarcopenia was determined in a sample of 1464 community-dwelling Japanese elderly men ($n = 246$) and women ($n = 1218$, mean age men 74.3 ± 5.17 years; women 79.9 ± 4.43 years) using each definition described in the previous section (Table 4). The data analyzed in the present review was obtained using protocol that has been approved by the Tokyo Metropolitan Institute of Gerontology Ethics Committee, and all participants gave informed consent. As seen in Table 4, sarcopenia prevalence in this sample varied greatly depending on the definition used. Within the DXA-measured definitions, the prevalence ranged from 2.5 to 28.0% in men and 2.3 to 11.7% in women, which is not unlike previously reported prevalence values.

The BIA-measured definitions, however, resulted in sarcopenia prevalence ranging from 7.1 to 98.0% in men and 19.8 to 88.0% in women. These largely wide ranges within the same population are problematic, as it brings into question the results of the existing studies, and the sarcopenia prevalence we understand as a research community. In the existing literature, some studies refer to these previously established definitions of sarcopenia without providing reasoning beyond its common use. Ideally, each trial should determine population-specific cut-off points; however, this would be very expensive and impractical. Large population-based studies are required for Japanese people to establish appropriate cut-off values for Japanese older adults. The seemingly arbitrary use of published cut-off values can affect the resulting prevalence rates of sarcopenia and associated factors.

We investigated the risk factors of sarcopenia in the same Japanese community-dwelling population using multiple step-wise logistic regressions. Table 5 shows that the risk factors associated with sarcopenia varied depending on the definition for sarcopenia assessment used.

BMI was predominantly associated with sarcopenia in men and women across most definitions, where greater BMI was inversely associated with the likelihood of

Table 3 Summary of risk factors associated with sarcopenia

Study design and Participants	Factors	Main results	References
Cross-sectional study			
Cross-sectional, 121 men and 180 women aged 65–97 years	Serum free-testosterone, physical activity, CVD, IGF1, fat mass	Muscle mass had significant positive associations with physical activity, IGF1 and free testosterone in men; and total fat mass and energy intake in women.	Baumgartner *et al.* (1999)[62]
Cross-sectional, 195 women aged 64–93 years and 142 men aged 64–92 years	BMI, serum estrone, estradiol, 25-hydroxy vitamin D, physical performance	Serum estrone, estradiol, and Physical Performance Test total score were significantly correlated with ASM/Ht^2. 25-OHD was inversely related to muscle mass.	Iannuzzi-Sucich (2002)[22]
Longitudinal (3 years), 331 people aged 65 years or older at baseline	PTH, 25-hydroxy vitamin D	Low 25-OHD was significantly associated with ASM loss (OR 2.25, 95% CI 1.11–4.56) Those with high PTH levels were 2.35 times (05% CI 1.05–5.28) more likely to have ASM loss.	Visser *et al.* (2003)[35]
Longitudinal (5 years), 1882 men and women aged 70–79 years	Albumin concentration	Lower albumin concentrations are associated with future loss of ASM and is a risk factor for sarcopenia.	Visser *et al.* (2005)[79]
262 community-dwelling men and 265 women aged over 70 years	BMI	BMI < 18.5 was a significant risk factor for sarcopenia in men (OR 39.1, 95% CI 11.3–134.6) and women (OR 9.7, 95% CI 2.8–33.8).	Lau *et al.* (2005)[25]
13 770 men and women aged over 20 years	Age; overweight; lack of exercise; low carbohydrate, fat, and protein intake; hyperglycemia; low 25- OHD3; high diastolic BP; insulin resistance	Prevalence of sarcopenia rose with declining kidney function. Older age; low income-to-poverty ratio; overweight; lack of exercise; low carbohydrate, fat and protein intake; hyper-calcemia; low 25-OHD3; higher diastolic BP; and insulin resistance were factors associated with sarcopenia for subjects with glomerular filtration rate <60 mL/min/1.73 m^2 or a urinary albumin-to-creatine ratio >30 mg/g.	Foley *et al.* (2007)[80]
1380 men and 1789 women aged 50 years or older, community-dwelling people	Vitamin D	The highest quartile (≥24.1) , OR 0.47 (95% CI 0.30–0.73), strong inverse association between 25-OHD level and sarcopenia.	Kim *et al.* (2011)[81]
313 women (mean age 79.7 ± 7.4 years)	Osteoporosis	Sarcopenia was significantly associated with osteoporosis (OR 1.8, 95% CI 1.07–3.02).	Di Monaco *et al.* (2011)[82]
122 people aged 70 years and older living in nursing homes	Male sex, cerebrovascular dis-ease, osteoarthritis, BMI	High risk of sarcopenia was seen in men (OR 13.39, 95% CI 3.51–50.63), those with cerebrovascular disease (OR 5.16, 95% CI 1.03–25.87), osteoarthritis (OR 7.24, 95% CI 2.02–25.95). High BMI had protective effects.	Landi *et al.* (2012)[78]
4000 community-dwelling Chinese men and women over 65 years or older	Age, stroke, physical activity, IADL impairments, BMI, female sex, COPD	Stroke OR 2.56 (95% CI 1.32–4.95); IADL impairment OR 2.12 (95% CI 1.49–3.02); COPD OR 1.84 (95% CI 1.02–3.31); physical activity and BMI had protective effects. Protein and vitamin D not associated with sarcopenia incidence.	Yu *et al.* (2014)[83]
730 participants 74% aged 65 years and older (age range 27–97 years)	Education, IGF-1, testosterone	Higher education (OR 0.85; 95% CI 0.74–0.98), low IGF-1 (lowest tertile: OR 3.89; 95% CI 1.03–14.1), low bioavailable testosterone (OR 2.67; 95% CI 1.31–5.44) were associated with the likelihood of being sarcopenic.	Volpato *et al.* (2014)[84]
761 community-dwelling people aged 65–85 years	Age, BMI, chewing ability	Sarcopenia was significantly associated with age (OR 2.37, 95% CI 1.52–3.70), BMI (OR 0.75, 95% CI 0.69–0.81) and chewing ability (OR 2.18, 95% CI 1.21–3.93).	Murakami *et al.* (In Press)[85]
3193 community-dwelling people aged ≥50 years	Gamma-glutamyl transferase	Overall, OR 1.35 (95% CI 1.15–1.58), elevated serum GGT activity was independently associated with sarcopenia.	Hong *et al.* (2015)[86]
11 625 community-dwelling people aged 40 years or older,	Chronic kidney disease	CKD 3–5, OR 1.93 (95% CI 1.02–3.68) in men, stage of CKD was associated with an increased prevalence of sarcopenia in men, but not women.	Moon *et al.* (2015)[87]
Longitudinal study			
2928 people aged 70–79 years at baseline (9 years follow up)	Age, pain, BMI	Increasing age (OR 1.12, 95% CI 0.80–1.18, $P < 0.001$), history of pain (OR 1.18, 95% CI 1.01–1.39) and higher BMI (OR 1.30, 95% CI 1.25–1.36) were predictive of transition from normal state into sarcopenic state.	Murphy *et al.* (2014)[88]
538 community-dwelling women aged >75 years (4 years follow up)	Age, BMI, calf circumference, TUG, hyperlipidemia, cystatin C	Low BMI and slow TUG were significantly associated with sarcopenia development. Cystatin C was significantly associated with severe sarcopenia (OR = 1.83, 95%CI = 1.08–3.12).	Kim *et al.* (2015)[57]

25-OHD, 25-hydroxy vitamin D; ASM, appendicular skeletal muscle mass; BMI, body mass index; BP, blood pressure; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; GGT, gamma-glutamyl transferase; Ht, height; IADL, instrumental activities of daily living; IGF, insulin-like growth factor; OR, odds ratio; PTH, parathyroid hormone; TUG, timed up & go.

Table 4 Sarcopenia prevalence based on different suggested definitions in Japanese community-dwelling older adults

Reference study	SMI measurement	Cut-off values						Prevalence	
		SMI		Muscle strength		Walking speed			
		Male	Female	Male	Female	Male	Female	Male	Female
Baumgartner *et al.* (1998)[2]	DXA	7.26	5.45	–	–	–	–	28.0	5.7
Newman *et al.* (2003)[6]	DXA	7.23	5.67	–	–	–	–	25.6	11.7
Sanada *et al.* (2010)[5]	DXA	6.87	5.46	–	–	–	–	11.0	6.3
EWGSOP (2010)[9]	DXA	7.26	5.45	30.0	20.0	0.8	0.8	13.2	3.2
AWGS (2014)[31]	DXA	7.00	5.40	26.0	18.0	0.8	0.8	2.5	2.3
Janssen *et al.* (2004)[12]	BIA	8.50	5.75	–	–	–	–	95.1	57.3
Chien *et al.* (2008)[8]	BIA	8.87	6.42	–	–	–	–	98.0	88.0
EWGSOP (2010)[9]	BIA	8.87	6.42	30.0	20.0	0.8	0.8	24.2	39.0
AWGS (2014)[31]	BIA	7.00	5.70	26.0	18.0	0.8	0.8	7.1	19.8

AWGS, Asian Working Group for Sarcopenia; BIA, bioelectrical impedance analysis; DXA, dual-energy X-ray absorptiometry; EWGSOP, European Working Group on Sarcopenia in Older People; SMI, skeletal muscle index (appendicular muscle mass/height^2).

Table 5 Risk factors (odds ratios and 95% confidence intervals) associated with sarcopenia based on differing definitions

Reference definition for sarcopenia	Risk factors	
	Male	Female
DXA		
Baumgartner *et al.* (1998)[2]	BMI: 0.60 (0.48–0.75) TG: 1.01 (1.0–1.01) HbA1c: 3.34 (1.26–8.82)	BMI: 0.45 (0.35–0.57) Knee OA: 3.89 (1.27–11.91)
Newman *et al.* (2003)[6]	BMI: 0.65 (0.53–0.80) HbA1c: 2.04 (0.96–4.31)	BMI: 0.51 (0.43–0.60) TG: 1.01 (1.00–1.01)
Sanada *et al.* (2010)[5]	BMI: 0.52 (0.37–0.72) TG: 1.01 (1.00–1.01)	BMI: 0.52 (0.43–0.63)
EWGSOP (2010)[9]	BMI: 0.79 (0.66–0.94) HbA1c: 1.84 (0.96–3.52)	BMI: 0.48 (0.36–0.63) HDL-C: 0.95 (0.92–0.99) Falls: 3.84 (1.00–14.73)
AWGS (2014)[31]	BMI: 0.40 (0.21–0.78) HDL-C: 0.90 (0.82–0.99) Falls: 3.90 (2.82–5.40)	BMI: 0.56 (0.43–0.73) Falls: 5.05 (1.26–20.28)
BIA		
Janssen *et al.* (2004)[12]	BMI: 0.58 (0.37–0.90)	BMI: 0.66 (0.61–0.71) Creatinine: 4.36 (1.46–13.01)
Chien *et al.* (2008)[8]	–	BMI: 0.60 (0.53–0.68) Diabetes: 3.68 (1.53–8.84)
EWGSOP (2010)[9]	BMI: 0.87 (0.76–1.00) Diabetes: 2.99 (0.99–9.03)	BMI: 0.91 (0.87–0.96) Falls: 2.78 (1.71–4.50) Albumin: 0.31 (0.16–0.60)
AWGS (2014)[31]	Falls: 6.0 (1.81–19.99) Hypertension: 3.37 (1.02–11.14)	BMI: 0.79 (0.74–0.85) Falls: 2.21 (1.33–3.68) Albumin: 0.28 (0.13–0.61) Hyperlipidemia: 1.52 (1.00–2.30)

AWGS, Asian Working Group on Sarcopenia; BIA, bioelectrical impedance analysis; BMI, body mass index; DXA, dual-energy X-ray absorptiometry, EWGSOP, European working group on sarcopenia in older people, TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; OA, osteoarthritis.

sarcopenia (Table 5). In men, high glycated hemoglobin level was a significant risk factor for sarcopenia using the Baumgartner (OR 3.34, 95% CI 1.26–8.82) definition. High high-density lipoprotein cholesterol (OR 0.90, 95% CI 0.82–0.99) was protective from sarcopenia in Japanese men according to the AWGS definition using DXA. The chronic conditions associated with sarcopenia in men based on AWGS were falls (DXA: OR 3.90, 95% CI 2.82–5.40; BIA: OR 6.0, 95% CI 1.81–19.99) and hypertension (OR 3.37, 95% CI 1.02–11.14).

Based on the EWGSOP and AWGS definitions of sarcopenia using both DXA and BIA, falls were a significant risk factor for sarcopenia in women (Table 5). Similarly, high albumin levels had protective effects in the EWGSOP (OR 0.31, 95% CI 0.16–0.60) and AWGS (OR 0.28, 95% CI 0.13–0.61) definitions, although only using BIA. Other risk factors for sarcopenia in women included knee OA, TG levels, high-density lipoprotein cholesterol, creatinine, diabetes and hyperlipidemia.

The results presented in Table 5 show disparities in risk factors of sarcopenia vary greatly depending on the definition used to define sarcopenia in the same sample population. BMI was the only factor associated with sarcopenia across all definitions within the Japanese population studied, and a predominant risk factor for sarcopenia in previous studies (Table 5). Herein lies the problem with the many available definitions currently used in the literature. Without a clear consensus, the risk factors of sarcopenia differ, not only with varying definitions, but also with methods of measurement; that is, DXA or BIA. The discrepancies in prevalences and associated factors of sarcopenia in the existing literature can negatively affect the understanding of sarcopenia within the research community.

Conclusion

In summary, the inconsistencies in sarcopenia definitions, cut-off values and risk factors are apparent within the literature. Ideally, cut-off values should detect people with risk factors, and using cut-off values obtained from a vastly different population should be avoided. The application of the different sarcopenia definitions further shows that sarcopenia prevalence and risk factors vary greatly depending on the definition. Further studies and discussions are necessary in order to confirm the discrepancies in prevalence and particular risk factors, and develop a consensus definition or cut-off points for sarcopenia in Japanese older adults.

Disclosure statement

The authors declare no conflict of interest.

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原　著

認知症グループホーム入居高齢者における認知症重症度と口腔機能および栄養状態の関連

Relationship between severity of dementia and oral health status, nutritional status among older people with dementia in group homes

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和文抄録

認知症は，その進行に伴って，様々な生活上の不具合を生じやすく，口腔のセルフケアへの自立や食行動にも影響を与えるとされている。そこで，本研究では，認知症グループホーム19施設に入所中の高齢者150名（男性25名，女性125名，平均年齢84.2 ± 7.2歳）を対象に，認知症重症度と口腔機能および栄養状態の関連について検討することを目的に，調査を実施した。

調査内容は，基本情報（性別，年齢，認知症の類型），認知症重症度，簡易栄養状態評価，四肢筋肉量、口腔内診査（歯数，口腔衛生状態），咀嚼機能評価，嚥下機能評価，オーラルディアドコキネシス，うがいの可否とした。

その結果，認知症重症度との間で有意差が認められた項目は，プラークの付着，食物残渣の残留，咬筋緊張度，誤嚥のリスク，リンシングおよびガーグリングの可否，簡易栄養状態評価，オーラルディアドコキネシスの回数，反復唾液嚥下テストの30秒間の回数であった（$p<0.05$）。

認知症高齢者の口腔機能および栄養状態は，認知症重症度による差異が認められた。認知症によって生じる生活上の不具合を考慮し，その進行度に応じたアセスメントと対応が必要であることが示唆された。

キーワード　認知症，臨床的認知症尺度，機能評価，認知症グループホーム

【緒　言】

近年，急速な少子高齢化が進む我が国において，認知症高齢者数は増加の一途をたどっており，2025年にはその患者数は470万人にのぼると推計されている[1]。認知症は，その進行に伴って，様々な生活上の不具合を生じやすく，口腔のセルフケアへの自立や食行動にも影響を与えるとされている。

特にアルツハイマー型認知症患者においては，食事が始められないなどの食行動の障害や摂食嚥

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下障害などの問題が指摘されており[2~4]，口腔機能と栄養状態の評価と適切な介入は，認知症高齢者のQOLを考える上できわめて重要な課題であると考えられる。認知機能と口腔機能の関連性について検討している先行研究では，認知症療養病棟入院患者や重度認知症高齢者を対象としており[5~7]，日常生活を営む認知症高齢者に特に注目し，認知症の進行に伴う変化の実態を調査した報告は少ないのが現状である。認知症高齢者グループホームは，小規模な生活の場において認知症高齢者が家庭的な雰囲気の中でその人らしい生活を再構築していくことを目的としている居宅サービスのひとつとして位置づけられており[8]，ある程度の介助が必要ながらも，日常生活に比較的近い環境で生活をしている。比較的介護依存度が低い段階における認知症高齢者の口腔保健と栄養状態の実態を明らかにすることは，口腔機能低下や低栄養といったQOLを低下させる要因を検討する上で非常に重要であると考えられる。そこで，本研究では，認知症グループホームに入居している認知症高齢者を対象に，口腔機能と栄養状態の実態について検討することを目的とした。

【対象および方法】

Ⅰ．対象

K県Y市内の認知症グループホーム19施設に入居中の高齢者のうち，研究参加への同意が得られた150名（男性25名，女性125名，平均年齢84.2 ± 7.2歳）を対象とした。

Ⅱ．評価項目

1．基本情報

対象者の年齢，性別，身長，体重，認知症の類型，介護保険の認定状況等について，主たる介護者である施設職員に記入を依頼した。

2．認知症の評価

認知症重症度の評価は，臨床的認知症尺度であるClinical Dementia Rating（以下，CDRと記す）によって評価した[9]。CDRは，「記憶」，「見当識」，「判断力と問題解決能力」，「地域社会の活動」，「家庭状況および趣味・関心」，「介護状況」の6つの項目について，対象者の日常生活を十分把握している施設職員がそれぞれ5段階で評価し，総合評価については研究者らが，健康（CDR0），認知症の疑い（CDR0.5），軽度認知症（CDR1），中等度認知症（CDR2），高度認知症（CDR3）のいずれかで判定を行った。

3．栄養評価

対象者の栄養状態の評価には，簡易栄養状態評価（Mini Nutritional Assessment-Short Form®，以下MNA®と記す）を用いた[10,11]。MNA®は，65歳以上の高齢者向けに開発された栄養状態の簡便なスクリーニング法である。食事量の減少，体重の減少，移動能力，精神的ストレス・急性疾患の経験，神経・精神的問題の有無，体格指数の6項目について14点満点で施設職員が評価を行った。12点以上を正常，8点以上11点以下を低栄養のおそれあり，7点以下を低栄養と判定する。

4．日常生活動作

Barthel Index（以下，BIと記す）を用いて，対象者の基本的な日常生活動作を施設職員が評価した。BIは，食事，車椅子からベッドへの移動，整容，トイレ動作，入浴，歩行，階段昇降，着替え，排便コントロール，排尿コントロールの10項目に対し，自立，部分介助，全介助の段階に分けて評価する。100点満点が全自立，60点が部分自立，40点が大部分介助，0点は全介助となる[12]。

5．四肢筋肉量の測定

虚弱のリスクとして筋肉量を評価する目的で，四肢筋肉量について，体組成計InBody S10®（Biospace社）を用いて多周波部位別生体電気インピーダンス法（BIA：Bioelectrical Impedance Analysis）法によって四肢別の骨格筋量を測定した。測定は，歯科医師および歯科衛生士が行った。サルコペニアの評価として広く用いられている方法を用いて，四肢筋肉量を身長の二乗で除したSMI（Skeletal Muscle Mass Index）を算出した[13]。

6．口腔診査

口腔診査は，事前に十分な研修を行った上で，歯科医師および歯科衛生士が実施した。

1）歯数の状態

残根歯等の咬合に関与しない歯は含まず，歯根の存在する歯の数を現在歯数，現在歯数と補綴歯

数（インプラント，ポンティック，義歯等で欠損補綴されている歯）の総和を機能歯数としてカウントした。

2）咀嚼機能評価

咀嚼機能評価として咬合力測定フィルムであるデンタルプレスケール® 50H タイプ R および専用評価機器オクルーザー®（GC 社製）を用いた咬合力の評価と，咬筋触診によって咬筋緊張度を，「強い」，「弱い」，「なし」の 3 段階で評価した[14, 15]。

3）オーラルディアドコキネシス（以下，ODK と記す）

舌の運動速度やリズムにより口腔機能の巧緻性を評価する目的で，「タ」音を 5 秒間繰り返し，なるべく早く発音させ，1 秒間あたりの回数に換算し評価した。

4）嚥下機能評価

(1) 反復唾液嚥下テスト（Repetitive Saliva Swallowing Test；以下，RSST と記す）

対象者の喉頭挙上を触診し，30 秒間の空嚥下の回数と，1 回目の嚥下惹起時間を評価した[16, 17]。

(2) 改訂水飲みテスト（Modified Water Swallowing Test；以下，MWST と記す）

表 1 MWST の評価基準

0：テスト施行不可 頚部聴診の実施
1：嚥下なし，むせる and/or 呼吸切迫
2：嚥下あり，呼吸切迫（不顕性誤嚥疑い）
3：嚥下あり，むせる and/or 湿性嗄声
4：嚥下あり，呼吸良好，むせなし
5：4 に加え，追加嚥下運動が 30 秒以内に 2 回可能

3ml の冷水を対象者の口腔底に注ぎ嚥下を指示し，その様子を観察して 5 段階で評価した（表 1）[18]。

(3) 頚部聴診

嚥下の状態を評価する目的で，嚥下時の嚥下音および呼吸音を頚部から聴診した。頚部の側方で，輪状軟骨の外側に聴診器を当て，嚥下音とその後の呼吸音を聴診した。嚥下時の咽頭貯留，呼吸時の湿性音や嗽音の有無により，誤嚥のリスクを評価した[19]。

(4) 咳テスト

不顕性誤嚥の有無をスクリーニングする目的で，クエン酸を生理食塩水に溶かした液をネブライザーで吸引し，1 分間で咳をするかどうかを評

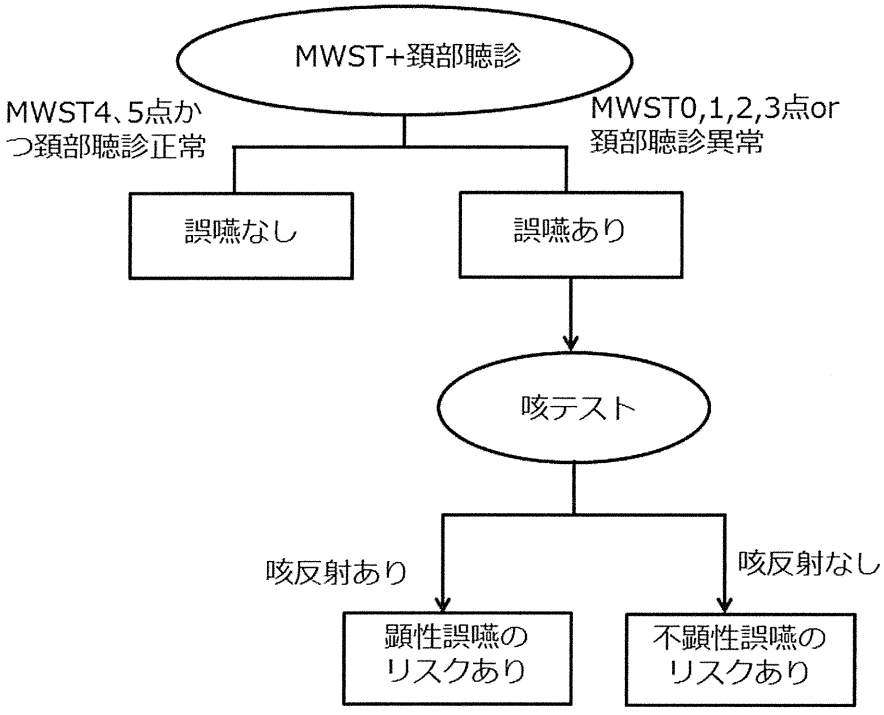

図 1 誤嚥リスク評価のフローチャート

価した[20]。

MWST，頚部聴診および咳テストによる評価に基づき，「誤嚥なし」，「顕性誤嚥のリスクあり」，「不顕性誤嚥のリスクあり」の3群に分類した（図1）[19]。

5）口腔衛生状態

口腔衛生状態の評価として，食物残渣，歯垢，舌苔について評価した。食物残渣およびプラーク付着状態については，「ほとんどない」，「中等度」，「著しい」の3段階，舌苔付着については，「ない」，「薄い」，「著しい」の3段階で，いずれも口腔機能向上マニュアルに示された基準写真に基づき評価を行った[14]。

6）リンシング・ガーグリング

口腔機能を評価する目的で，リンシング（ぶくぶくうがい）およびガーグリング（がらがらうがい）の可否について，「できる」，「不十分」，「できない」，「不明」の4段階で評価した。評価基準は，リンシングについては，頬を何度も膨らまし，同時に早く動かすことができる場合を「できる」，頬の膨らましが小さく舌の動きが遅い，2回しか頬を膨らますことができない場合を「不十分」，唇を閉じることができない，頬を膨らますことができない，舌を動かすことができない場合を「できない」，評価できない場合を「不明」と判定した。また，ガーグリングについては，頸部を後屈させ，舌口蓋閉鎖をしつつ呼気を少しずつ吐くことで可能な場合を「できる」，口に含んだ水を少し飲み込んでしまう場合を「不十分」，むせる場合を「できない」，評価できない場合を「不明」とした[19]。

Ⅲ．統計分析

調査対象者のうち指示理解が出来なかった者，および拒否等により実施できなかった者は調査項目ごとにリストから除外して分析を行った。認知症の重症度別の差異を検討する目的で，連続変数

表2　対象者の特性

	n	Mean ± SD	%
年齢（歳）	150	84.2 ± 7.2	
性別			
男性	25		16.7
女性	125		83.3
介護保険認定状況			
要介護1	24		16.0
要介護2	41		27.3
要介護3	48		32.0
要介護4	20		13.3
要介護5	15		10.0
不明	2		1.3
認知症の類型			
アルツハイマー型認知症	123		82.0
血管性認知症	18		12.0
レビー小体型認知症	5		3.3
その他	4		2.7
CDR			
健康（0）	0		0.0
疑い（0.5）	17		11.3
軽度（1）	63		42.0
中等度（2）	53		35.3
高度（3）	17		11.3
栄養状態			
BMI	150	22.4 ± 11.8	
SMI	150	5.4 ± 1.2	
MNA® （点）	150	10.0 ± 2.2	
BI（点）	150	67.0 ± 29.1	

表3　対象者の口腔内状況

	n	Mean ± SD	%
歯数の状態			
現在歯数（本）	141	7.8 ± 9.1	
機能歯数（本）	139	23.6 ± 8.1	
咀嚼機能			
咬合力　(N)	133	124.6 ± 155.5	
咬筋緊張度			
強い	93		62.0
弱い	39		26.0
なし	14		9.3
実施不可	4		2.7
ODK　タ音　（回　/　秒）	128	4.7 ± 1.4	
嚥下機能			
RSST　回数	116	3.0 ± 1.1	
RSST　1回目惹起時間（秒）	116	3.0 ± 3.4	
誤嚥リスク			
なし	123		82.0
顕性誤嚥	19		12.7
不顕性誤嚥	8		5.3
口腔衛生状態			
プラーク付着状態			
ほとんどない	102		68.0
中等度	43		28.7
著しい	4		2.7
実施不可	1		0.7
食物残渣			
ほとんどない	121		80.7
中等度	26		17.3
著しい	2		1.3
実施不可	1		0.7
舌苔付着			
ない	56		37.3
薄い	82		54.7
著しい	11		7.3
実施不可	1		0.7
リンシング			
できる	129		86.0
不十分	8		5.3
できない	9		6.0
不明	2		1.3
実施不可	2		1.3
ガーグリング			
できる	113		75.3
不十分	8		5.3
できない	19		12.7
不明	8		5.3
実施不可	2		1.3

については Bonferroni の多重比較を，カテゴリ変数についてはカイ二乗検定を用いて有意差検定を行った。統計分析には，SPSS® Ver.20.0（日本IBM）を用い，有意水準 5% 未満を有意差ありとした。

Ⅳ．倫理的配慮

本研究は，独立行政法人国立長寿医療研究センターの倫理・利益相反委員会の承認を得て実施し

た（受付番号　No.648）。調査対象者本人および家族等の代諾者に対して，研究目的，方法，期待される成果について口頭と書面にて説明を行い，同意を得た上で調査を行った。なお，本研究により得られたデータは匿名化し個人を特定できない状態で分析を行った。

【結　果】

Ⅰ．対象者の特性

調査対象者の特性を表2および表3に示す。日常生活動作を示す指標であるBIの平均値は，67.0 ± 29.1点，平均介護度は2.7であった。対象者は全て経口摂取可能であり，栄養に関する指標の平均値は，MNA®のスコアは，10.0 ± 2.2，BMIは22.4 ± 11.8，SMIは5.4 ± 1.2であった。現在歯数は平均7.8 ± 9.1本，機能歯数は平均23.6 ± 8.1本であった。CDRは，軽度が42.0％（63名）で最も多く，次いで中等度が35.3%（53名）であった。認知症の類型では，アルツハイマー型認知症が最も多く82.0％（123名）を占めていた。

Ⅱ．CDRによる群間比較

CDRによる群間比較の結果を表4および表5に示す。CDRによる分類で，連続変数について4群間に有意差がみとめられたのは，SMI（疑い＞高度），MNA®スコア（疑い＞高度，軽度＞高度），BI（疑い＞中等度，疑い＞高度，軽度＞高度，中等度＞高度），RSSTの回数（疑い＞軽度），ODK（軽度＞高度）であった（$p<0.05$）。

一方，カテゴリ変数については，CDRと有意差がみとめられたのは，咬筋緊張度，誤嚥リスクの発現，プラーク付着，食物残渣，リンシングおよびガーグリングの可否であった（$p<0.05$）。

【考　察】

本研究の対象者の平均介護度は2.7，BIの平均スコアも60点以上であり，認知機能の低下等によってある程度生活上の介助が必要ながらも，比較的自立して生活している者が多いという特徴を有していたと考えられる。しかしながら，本研究の対象者全員が経口摂取可能であったにもかかわらず，MNA®のスコアは「低栄養のおそれあり」の範囲内であった。認知症と栄養状態との関連については，以前から検討されてはいるもの[21]，食行動の問題[2]，口腔機能の問題[3, 22]のほか，味の嗜好の変化や食習慣など種々の要因が関与しており，低栄養への対応には個別性を考慮した対応が求められる。また，BMIについてはCDRとの間に有意な関連性は認められなかったが，SMIについては，高度では疑いと比較して有意に低い値を示していた。骨格筋肉量の減少は，身体の活動性やQOLにも直結する問題であることから，より早期からの積極的な栄養管理が必要であると考えられる[23]。

口腔機能について，CDRと関連性が認められたのは，触診による咬筋緊張度，RSSTの30秒間の回数，ODK，リンシングおよびガーグリングの可否であった。また，対象者の18.0%に誤嚥のリスクが認められ，認知症の症状が重度なほど，不顕性誤嚥のリスクのある対象者の割合が多い傾向を示していた。不顕性誤嚥が生じている症例では，痛みの伝達物質であるサブスタンスPの濃度が低く，誤嚥物が声門を越えて気管内に入った場合の咳嗽反射が生じにくいとされている[24]。サブスタンスPはドーパミンに誘導され，迷走・舌咽頭神経を介して逆行性に咽頭に放出されたため，ドーパミンの産生低下がサブスタンスPの分泌低下ひいては不顕性誤嚥をまねくとされている。ドーパミンは加齢現象だけでなく，強いパーキンソン症状や重度の認知症高齢者で低下する傾向を示すとされており[25]，ドーパミンの産生低下が，本研究の結果における不顕性誤嚥のリスク者数の差異の背景にあるものと考えられる。摂食・嚥下機能の低下によって，低栄養による身体機能の低下をきたすばかりでなく，誤嚥による生命の危機に直結し，かつ「食べる楽しみの喪失」は，患者のQOLを低下させる要因ともなることから，認知症高齢者の摂食嚥下障害については，認知機能と嚥下機能の両面からの評価とアプローチが必要である[26]。今回の調査結果では，CDRが高度の者は，リンシングとガーグリング能力が低下している割合が高い傾向を示していた。Satoらによるアルツハイマー型認知症高齢者を対象とした調査では，日常のリンシング能力の欠如が，

表4　CDR ごとの群間比較

	n	CDR0.5 (11.3%) Mean±SD	n	CDR1 (42.0%) Mean±SD	n	CDR2 (35.3%) Mean±SD	n	CDR3 (11.3%) Mean±SD	p-value	Bonferroni の多重比較
BMI	17	21.5±3.2	63	24.0±17.8	53	21.8±3.5	17	19.5±3.1	N.S.	
SMI	17	5.9±1.6	63	5.4±1.3	53	5.4±1.0	17	4.6±1.1	$p<0.05$	CDR0.5 > CDR3
MNA® (点)	17	11.3±1.6	63	10.3±1.9	53	9.7±2.3	17	7.8±2.0	$p<0.05$	CDR0.5 > CDR3, CDR1 > CDR3
BI (点)	17	92.5±6.1	63	78.2±17.1	53	63.3±24.1	17	10.3±15.9	$p<0.05$	CDR0.5 > CDR2, CDR0.5 > CDR3, CDR1 > CDR3, CDR 2 > CDR3
現在歯数 (本)	16	10.2±11.1	59	7.8±8.9	52	6.6±8.6	14	9.4±9.2	N.S.	
機能歯数 (本)	16	26.3±4.6	59	24.2±7.2	52	22.9±9.4	12	19.6±9.1	N.S.	
咬合力 (N)	17	191.6±203.2	61	133.3±166.5	48	103.8±123.5	7	46.9±39.0	N.S.	
RSST　1回目惹起時間(秒)	16	2.3±1.8	59	2.9±3.7	41	3.5±3.4	0	0.0	N.S.	
RSST　回数 (回)	16	3.6±0.9	59	2.9±1.0	41	3.0±1.2	0	0.0	$p<0.05$	CDR0.5 > CDR1
ODK (回/秒)	17	4.6±1.7	61	4.9±1.2	47	4.7±1.4	3	2.8±0.4	$p<0.05$	CDR1 > CDR3

CDR: Clinical Dementia Rating, BMI: Body Mass Index, SMI: Skeletal Muscle Mass Index, MNA®: Mini Nutritional Assessment-Short Form, BI: Barthel Index, RSST: Repetitive Saliva Swallowing Test, ODK: Oral Diadochokinesis, N.S.: Not Significant, SD: Standard Deviation
※ CDR3 は，指示理解が困難であったため，RSST を実施できず。

表5　CDRごとの群間比較

	CDR0.5（11.3%）		CDR1（42.0%）		CDR2（35.3%）		CDR3（11.3%）		p-value
	n	%	n	%	n	%	n	%	
咬筋緊張度									
強い	15	93.8	45	71.4	29	54.7	4	28.6	
弱い	1	6.3	13	20.6	18	34.0	7	50.0	p<0.05
なし	0	0.0	5	7.9	6	11.3	3	21.4	
誤嚥リスク									
なし	15	88.2	59	93.7	41	77.4	8	47.1	
顕性誤嚥	2	11.8	3	4.8	9	17.0	5	29.4	p<0.05
不顕性誤嚥	0	0.0	1	1.6	3	5.7	4	23.5	
プラーク付着									
ほとんどない	15	88.2	46	74.2	34	64.2	7	41.2	
中等度	2	11.8	14	22.6	19	35.8	8	47.1	p<0.05
著しい	0	0.0	2	3.2	0	0.0	2	11.8	
食物残渣									
ほとんどない	16	94.1	54	87.1	43	81.1	8	47.1	
中等度	1	5.9	6	9.7	10	18.9	9	52.9	p<0.05
著しい	0	0.0	2	3.2	0	0.0	0	0.0	
舌苔付着									
ない	9	52.9	26	41.9	15	28.3	6	35.3	
薄い	8	47.1	30	48.4	34	64.2	10	58.8	N.S
著しい	0	0.0	6	9.7	4	7.5	1	5.9	
リンシング									
できる	17	100.0	61	98.4	46	88.5	5	29.4	
不十分	0	0.0	1	1.6	3	5.8	4	23.5	p<0.05
できない	0	0.0	0	0.0	3	5.8	6	35.3	
不明	0	0.0	0	0.0	0	0.0	2	11.8	
ガーグリング									
できる	17	100.0	59	95.2	34	65.4	3	17.6	
不十分	0	0.0	0	0.0	7	13.5	1	5.9	p<0.05
できない	0	0.0	0	0.0	8	15.4	11	64.7	
不明	0	0.0	3	4.8	3	5.8	2	11.8	

N.S.:Not Significant

嚥下障害のリスクファクターとなり得ると報告しており[19]，リンシングやガーグリングは，特別な検査機器や専門職種による評価が不要であるという点において，日常生活の中から摂食嚥下障害のリスクを早期にスクリーニングするツールとして，簡便かつ侵襲性が低く有用であると考えられる。

本研究は，これまであまり検討されてこなかった認知症の重症度の分類であるCDRを用いて，ある程度の介助が必要ながらも比較的自立して生活をしている認知症グループホーム入居高齢者における口腔機能と栄養状態低下の差異を把握した。認知症の原因疾患の診断には専門医の診断が不可欠であるが，CDRは，保健・看護・介護スタッフでも評価しやすいという利点があることから，今回は，対象者の日常生活をよく知る介護職員が評価を行ったCDRを切り口として，口腔機能と栄養状態の差異を検討した。CDRの評価によって，認知症の程度が高度であると判定された対象者は，口腔状態や栄養状態が不良である傾向が示していたことから，口腔ケアや低栄養に対する介入においても，認知症の原因疾患への理解や口腔内状況の評価のみならず，認知症の重度化によって生じる生活の不具合を考慮し，対象者のニーズに応じたケアの提供する必要があると考えられた。