Table 3 Comparison of characteristics of the hyposalivation and normal groups.

	Hyposalivation			*Normal*			
Variable	*Mean ± SD*	*n*	*%*	*Mean ± SD*	*n*	*%*	*p-Value*
Age (year)	73.7 ± 5.4			73.5 ± 5.0			0.633[a]
Gender							
Male		22	21.4		333	42.1	<0.001[b]
Female		81	78.6		458	57.9	
Presense of systemic disease (% present)							
Hypertension		51	49.5		358	45.3	0.238[b]
Heart disease		11	10.7		132	16.7	0.073[b]
Stroke		6	5.8		43	5.4	0.505[b]
Diabetes mellitus		13	12.6		93	11.8	0.450[b]
Osteoporosis		17	16.5		115	14.6	0.345[b]
Presense of medication (% present)							
Antihypertensive		49	47.6		336	42.8	0.208[b]
Anti-inflammatory drugs/analgesics		14	13.6		72	9.1	0.105[b]
Steroids		3	2.9		21	2.7	0.530[b]
Drug for the treatment of osteporosis		13	12.6		90	11.5	0.422[b]
Axiolytics		13	12.6		114	14.4	0.375[b]
Hypnotics		11	10.7		54	6.8	0.115[b]
Agents affecting digestive organs		38	36.9		201	25.5	0.011[b]
Smoking habit (% yes)		6	5.8		86	10.9	0.071[b]
SDS (points)	35.2 ± 10.0			34.3 ± 8.9			0.482[c]
TMIG-IC total points	12.4 ± 1.6			12.4 ± 1.3			0.574[c]

SDS, Zung Self-rated Depression Scale; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence; SD, standard deviation.
[a]Student *t*-test.
[b]χ^2 test.
[c]Mann–Whitney U test.

xerostomia. Therefore, health care providers have to consider the importance of psychological factors that influence the xerostomic status of the patient when making an oral health care plan. Friedlander and Norman[40] emphasised the importance of preventive dental education for older people with late-life depression. For older population with xerostomia and hyposalivation, both an educational approach (including tooth brushing instruction and/or smoking cessation) and professional intervention such as oral prophylaxis would be necessary[40,41].

In this study, we found that participants with xerostomia tended to have a lower score of TMIG-IC, representing a higher level functional capacity than participants without xerostomia. Autonomy of living is an adequate indicator of health status in older populations[32]; therefore, functional capacity is essential to enhance their independence.

Since we hypothesized that xerostomia and hyposalivation would have an influence on functional capacity among older people, we assessed the association by TMIG-IC which has been used widely in Japan. The results of the present study indicated

Table 4 Multiple logistic regression analysis of factors associated with xerostomia.

Independent variables	*OR*	*95% CI*	*p-Value*
Age (year)	1.01	0.98–1.04	0.496
Gender (male = 0, female = 1)	1.18	0.85–1.64	0.330
Osteoporosis (for presence)	1.34	0.87–2.05	0.189
Anti-inflammatory drugs/analgesics (for presence)	1.06	0.64–1.77	0.821
Anxiolytics (for presence)	1.00	0.56–1.80	0.997
Hypnotics (for presence)	1.71	1.13–2.61	0.012
Agents affecting digestive organs (for presence)	1.28	0.91–1.81	0.159
Smoking habit (% yes)	1.69	1.03–2.77	0.039
SDS (points)	1.05	1.04–1.07	<0.001
TMIG-IC total points (points)	0.87	0.76–0.99	0.035

Forced entry analysis. OR, odds ratio; 95% CI, 95% confidence intervals; SDS, Zung Self-rated Depression Scale; TMIG-IC, Tokyo Metropolitan Institute of Gerontology index of competence.
The variable 'osteoporosis drugs' was deleted as a dependent variable, avoid multicollinearity.

Table 5 Multiple logistic regression analysis of factors associated with hyposalivation.

Independent variables	*OR*	*95% CI*	*p-Value*
Age (year)	1.01	0.96–1.05	0.806
Gender (male = 0, female = 1)	2.59	1.55–4.31	<0.001
Heart disease (for presence)	1.22	0.64–2.35	0.542
Antihypertensive	0.62	0.31–1.21	0.161
Anti-inflammatory drugs/ analgesics (for presence)	1.26	0.82–1.96	0.291
Hypnotics (for presence)	0.66	0.35–1.26	0.206
Agents affecting digestive organs (for presence)	1.78	1.11–2.86	0.017
Smoking habit (% yes)	0.73	0.30–1.77	0.488

Forced entry analysis. OR, odds ratio; 95% CI, 95% confidence intervals.

that higher functional capacity was an independent associated factor of xerostomia, even though a significant association was not observed with hyposalivation. The association between higher functional capacity and xerostomia as well as oral health related quality of life[3,5,14] is a new finding.

The prevalence of hyposalivation was significantly associated with female gender. This tendency is similar to that reported in previous studies[1,9,42–44]. However, owing to the cross-sectional study, the cause-and-effect relationship is still unclear. Menopausal changes may affect salivary flow among females[45,46]. All female participants in the present study could have been postmenopausal, but the questionnaire did not retrieve menopausal data. Further investigation is necessary to clarify these gender differences.

Our study has several strengths. First, this was a population based study that investigated the prevalence of both xerostomia and hyposalivation with a relatively large sample size. Second, we comprehensively analysed various factors including general condition, medications, depressive conditions and a higher level functional capacity. Although it is well known that medications and psychological factors are associated with xerostomia, ORs for these factors have not been defined, especially in the older Japanese population; this represents a novel aspect of the present study. Health care providers should attempt to consider these multidimensional factors when assessing for older people with xerostomia and hyposalivation.

There were also three limitations in this study because of population-based study large sample size. First, we evaluated hyposalivation by measuring only the amount of resting saliva. Some previous studies, evaluated hyposalivation by measuring both resting saliva and stimulated saliva, other studies evaluated one or the other[1–4,7,8,14]. Hence, there is no general consensus regarding the definition of the term hyposalivation. For a more detailed assessment of hyposalivation in clinical practice settings, both measurements would be preferable. Second, we evaluated hyposalivation using the cotton roll method. Placing the cotton roll into the mouth may have stimulated flow to some extent. Therefore, it may be difficult to compare the prevalence of hyposalivation with other previous studies. Finally, the investigation of systemic disease and regular medications were not sufficient. Since it was impossible to conduct detailed medical interviews, we were only able to investigate some diseases and medications based on previous reports. Polypharmacy is considered to have become an important problem gerontology[47,48]; however in this study, we only investigated the relationship between individual medication and xerostomia or hyposalivation. Therefore, further investigation would be required.

In conclusion, our study found that that the prevalence of xerostomia and hyposalivation were approximately 1 in 3 and 1 in 10 respectively. The factors xerostomia was associated with psychological factors and higher level functional competence, while hyposalivation was associated with medications and gender, as well as systemic and/or metabolic differences. Our study underlines the importance of evaluating xerostomia and hyposalivation comprehensively by investigating their associations with factors such as medication use, psychological factors and functional capacity.

Disclosure statement

None of the authors has a conflict of interest to declare.

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Correspondence to:
Yuki Ohara, Section of Behavioral Dentistry, Graduate School, Tokyo Medical and Dental University, 1-5-45, Yushima, Bunkyoku, Tokyo 113-8549, Japan.
Tel.: 81 3 5803 5894
Fax: 81 3 3803 5889
E-mail: yukiohara_dh@yahoo.co.jp

〈原　著〉

アルツハイマー病と血管性認知症高齢者の食行動の比較に関する調査報告：第一報—食行動変化について—

枝広あや子[1)]　平野　浩彦[1)]　山田　律子[2)]　千葉　由美[3)]　渡邊　裕[4)]

要　約　**目的**：認知症高齢者では，食事の自立が低下することにより，食事量の減少，低栄養，脱水および免疫機能の低下，さらなる認知機能の低下や，誤嚥性肺炎および死亡率の上昇が起こることが知られている．しかし認知症高齢者の食行動障害の病態および重症度別把握は不十分であり，介護現場では食事の自立支援に苦慮している現状がある．そこで本研究は，認知症高齢者の多数を占めるアルツハイマー病（以下 AD）と血管性認知症（以下 VaD）を対象に，認知症の重症度別に食事に関する行動障害を比較分析することで，AD と VaD における食行動の特徴を明らかにすることを目的とした．**方法**：対象者は，施設入所の認知症高齢者計 233 名（AD150 名，VaD83 名）とした．対象者に対し食行動調査と認知機能検査，神経学的検査，生活機能調査，栄養学的調査（MNA-SF）を行い，AD，VaD の 2 群について食行動について詳細な検討を行った．**結果**：食事に関連した行動障害は重度認知症の者ほど増加する傾向がみられた．一方，「リンシング・ガーグリング困難」「嚥下障害の徴候」の認知症重症度別の出現頻度は，AD と VaD で違いがあった．軽度認知症では VaD は AD に比較して食事に関連した行動障害の出現頻度が高かった．AD では食事開始困難や注意維持困難，巧緻性の低下等の認知機能障害の影響が大きい項目の出現が重度認知症において顕著にみられた．一方 VaD の食事に関連した行動障害と嚥下障害は，認知症の重症度との関連は認められず，軽度認知症でも神経脱落症状に起因した嚥下障害が認められた．**結論**：AD と VaD はどちらも認知症でありながら，食事に関連した行動障害の出現頻度が大きく異なっていた．認知症背景疾患や重症度による相違点を考慮した効果的な支援の確立が望まれる．

Key words：認知症，認知症重症度，食行動，先行期，嚥下障害

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緒　言

近年，認知症高齢者における種々の行動障害を BPSD (Behavioral and Psychological Symptoms of Dementia) と共通認識し，アセスメントやケア方法の研究が散見される[1)]．認知症高齢者においては排泄や入浴，歩行の機能低下に比較して，自立摂食は認知症が重度になっても保たれていることが多い[1)]．一方，「食事を開始しない」「食事を中断する」「食具が使用できず手づかみで食べる」など，食事に関連した認知症の神経心理学的症状に由来した行動障害（以下，食行動変化）が生じ，介助摂食となり介護負担の増加につながっている実情もある[2)]．食行動変化は認知症の中核症状の進行を反映し，またその一部は環境によって変化しうる周辺症状であると言われている[3)]．

認知症がさらに進行すると食欲低下が起こり摂食量の低下が起こると知られているが，それに先行して認知症の進行に由来する食行動変化により食事の自立低下と嚥下機能障害などが生じる[4)]．こうした食行動変化は，摂取量の低下により低栄養，脱水，全身状態の低下および免疫機能や認知機能の低下を引き起こし，結果的に誤嚥性肺炎の発症率や，死亡率が高まると報告されている[4)]．

認知症の背景疾患の中でも多数を占めている原因疾患がアルツハイマー病（以下 AD）と血管性認知症（以下 VaD）であるが，現在では臨床像や危険因子に共通性が多く認められるとの解析が進んだことから，両疾患は明確に鑑別することが困難な症例も少なくなく，実際の臨床現場では依然として AD と VaD の関係は混沌としている[5)]．また認知機能障害に起因する食行動変化と脳血

1）A. Edahiro, H. Hirano：東京都健康長寿医療センター研究所
2）R. Yamada：北海道医療大学看護福祉学部
3）Y. Chiba：横浜市立大学医学部看護学科
4）Y. Watanabe：国立長寿医療研究センター口腔疾患研究部口腔感染制御研究室
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管障害後遺症の神経脱落症状に起因する食行動変化を区別することはケア従事者には困難であり，実際は認知症の確定診断が曖昧なまま臨床的に出現する食行動変化に対応している現状である．

これまで嚥下障害の治療は脳血管障害に対するものが中心であり，認知症に対する治療は検討がすすんでいなかった．嚥下造影検査による嚥下機能評価については，ADはVaDよりも咽頭期嚥下障害が少ないが，咽頭期嚥下障害出現前に口腔期障害や大脳皮質変化があるという報告がされている[6][7]．しかし，実際に食事場面で表れる，認知症に関連した食行動変化については，先行研究において認知症患者を一つの集団として調査したものは散見されるが，認知症背景疾患別の食行動変化についての調査や，特に認知症重症度別の特徴に関する詳細な調査は数少ない[3]．特に認知症患者の食事自立に関する支援については，個々の患者の臨床症状に対する非薬物療法が中心であるが，適切な支援方法の検討課題も明確ではない現状がある．経口摂取の維持のために，可能な限り食事の自立を支援することが重要であり，早期の適切な介入の必要性が指摘されている[3]．自立摂食を妨げる要因について典型的なADとVaDを対象として疾患および重症度による特徴の実態把握を行うことで，認知症高齢者の食事支援方法確立の一助となる可能性がある．そこで本研究は，認知症高齢者の多数を占めるADとVaDを対象に，認知症の重症度別に食行動変化を比較分析することで，ADとVaDにおける食行動の特徴を明らかにし，自立支援の方法の確立に向けた基礎情報を得ることを目的とした．

方　法

1．対象と診断

対象者と方法：慢性期認知症病棟2病棟の認知症高齢者，特別養護老人ホーム6施設に入居している認知症高齢者，グループホーム8施設に入居している認知症高齢者の計324名（平均年齢84.7±9.5歳，男性54名平均年齢78.5±10.3歳，女性270名平均年齢85.9±8.9歳）を調査し，今回はそのうち神経内科医によってADまたはVaDの診断がつけられている者(233名：AD150名，VaD83名）で，施設で栄養・嚥下を担当する専門職（言語聴覚士および管理栄養士を含む施設職員）によって適切に摂食機能評価されており，その時点で最適な食事形態でかつ必要栄養量の食事を経口摂取している者を検討の対象とした．神経内科医によるADおよびVaDの診断はDSM-IV-TR®によって行われていた[8]．またADの診断はNINCDS-ADRDAによって行われ，Hachinski's ischemic scoreで4点以下の群とし診断的分類が行われていた[9][10]．VaDの診断はNINDS-AIRENによって行われHachinski's ischemic scoreで7点以上の群とされていた[11]．調査にあたり混合型認知症と考えられた群は除外した．認知症の重症度は，Clinical Dementia Rating（以下CDR）によって分類した[12]．

本研究は，ヘルシンキ宣言の条項に従ったプロトコールとし，東京都健康長寿医療センター研究部門倫理委員会（受付番号38号（2009年12月18日））の承認を受けて実施した．調査対象者およびその家族介護者ないし後見人には，調査趣旨に関する十分な説明を行うとともに，参加は自由意志によるものであり，参加を拒否しても，また途中で撤回しても不利益にはならないこと，取得したデータは匿名化された上で使用することを伝え，個別に同意を得て調査を実施した．

2．調査

調査では，認知機能検査，神経学的検査，食行動調査，生活機能評価，栄養評価および基礎情報の調査が行われた．認知機能検査，神経学的検査は，認知症を専門とする医師および歯科医師（日本老年歯科医学会認定医）によって対面調査で行われた．調査は2010年1月～2010年3月に行われた．

1）対面調査：認知機能検査と神経学的検査

i）認知症重症度の判定はCDR（認知症なし（0），疑わしい（0.5），軽度（1），中等度（2），重度（3））の5段階評価で判定された．CDR0，0.5と判断されたものは今回の検討の対象者に含めず，検討では軽度(CDR1)，中等度（CDR2），重度（CDR3）の3群を対象とした．

ii）Mini-Mental State Examination（以下MMSE）(score 0～30）を用いて，認知機能の検査が行われた[13]．

iii）神経学的検査：全身的な麻痺・拘縮の有無について調査した．

2）生活機能評価，栄養評価および基礎情報

対象者の年齢，性別，基礎疾患，身長，体重，Body Mass Index（以下BMI），血清アルブミン（以下Alb），the Short-Form Mini Nutritional Assessment（以下MNA-SF），Barthel Index（以下BI），Vitality Index（以下VI），については，担当の看護・介護職員に対する質問紙調査とした[14]～[19]．顎顔面運動機能の検査としては，顔面口腔の失行や運動障害に関連し顎顔面口腔および呼吸機能の協調運動が必要とされる，いわゆる“ぶくぶくうがい(リンシング)”，“がらがらうがい(ガーグリング)”に着目し，日常生活におけるリンシング・ガーグリング困難の有無について，“毎回できる”，“毎回はできない”として評価することとした．

表1　認知症背景疾患別，認知症重症度別の対象者数および男女比

	CDR1		CDR2		CDR3		総数	
	n	(男性/女性)	n	(男性/女性)	n	(男性/女性)	n	(男性/女性)
総数	56	(13/43)	80	(12/68)	97	(12/85)	233	(37/196)
AD	41	(5/36)	59	(4/55)	50	(4/46)	150	(13/137)
VaD	15	(8/7)	21	(8/13)	47	(8/39)	83	(24/59)

3）食行動調査

看護・介護職員に対する質問紙調査によって，対象者の日常の食事行動を観察して評価される食行動変化の項目を調査した．ケア対象者の評価は，a Self-Feeding assessment tool for the elderly with Dementia (SFD)[3]を参考に，以下の基準で評価することとした．食行動変化には，認知症によって起こる変化と神経脱落症状に起因する変化が含まれるが，臨床的には区別困難であり本調査では観察による評価のみとした．

i）嚥下障害の徴候：食事中のむせ，湿性嗄声および咽頭貯留音がある．狭義の嚥下障害と広義の嚥下障害を区別せず，臨床的な徴候をもって判断する．

ii）食事開始困難：食事が提供されて5分間自ら食事を開始することがない．他のものに注意が向いている，食事に興味を示さないなど．

iii）食具使用困難：箸やスプーンを逆さに持ったり，手づかみで食べるなど，食具を正しく使えない．食具の使用方法がわからない，また麻痺・拘縮等の運動障害により適切に動かせないものを含む．

iv）巧緻性の低下：紙パックにストローを挿す，容器のふたを開けるなどの容器の取り扱いが正しくできない．容器の取り扱いがわからない．また麻痺・拘縮等の運動障害により取扱い出来ないものを含む．

v）適量のすくい取りが困難：食具または手ですくった食べ物が過多・過少である．すくい取りの計画が不備なもの，麻痺・拘縮等の運動障害により適切な量をすくい取り出来ないものを含む．

vi）提供された食事全量の認知が困難：個人の膳に乗った全ての皿を認識していない様子，日頃から全く手をつけず食べ残す皿がある，等．

vii）食事中の注意維持困難：食事に対して注意を向け続けることができない．周囲の物音，動く人などに対して気が散ってしまう等．

viii）食事中の覚醒維持困難：食事中に覚醒を保っていられず傾眠してしまう．

統計解析はSPSS ver.17 (SPSS, Chicago, IL, USA)を使用した．ADとVaDの比較についてはStudent's T-test，認知症重症度別の比較についてはone-way ANOVA with the Bonferroni post-hoc testを使用した．食行動変化の頻度に関する検定にはχ^2検定を用いた．5%有意水準を有意差ありと判定した．

結　果

対象者の認知症重症度別の人数，性別の内訳を背景疾患（ADとVaD）別に示す（表1）．今回対象とした認知症高齢者はAD150名（男性13名，女性137名）平均年齢87.0±7.9歳であり，VaD83名（男性24名，女性59名）平均年齢85.4±9.7歳で，ADで有意に女性が多かった．

年齢，MMSE，生活機能評価，栄養評価の結果を，背景疾患別，認知症重症度別に検討した（表2）．年齢は認知症が重度の者ほど高齢であったが，CDR1群で有意にVaDがADより若年であった．MMSE，BI，VIは両群とも認知症が重度のものほど有意に低値であった．重症度別に両群を比較すると，BIではそれぞれの重症度において有意にADが高値であった（CDR1：$p<0.001$，CDR2：$p=0.003$，CDR3：$p=0.002$）．MNA-SF，BMI，Albについて重症度別に比較するとADとVaDに有意差はなかったが，MNA-SFで両群とも認知症が重度のものほど有意に低値であった．

食事に関与する神経学的検査，顎顔面運動機能および食行動変化の項目を背景疾患別，重症度別に比較したものを示す（表3）．「麻痺・拘縮」では各群において有意にVaDで麻痺・拘縮をもつ者が多かった（図1）．「リンシング，ガーグリング困難」について，重症度別では，CDR1，3において有意にVaDに困難な者が多かった（$p=0.004$，$p=0.024$）が，CDR2では有意差を認めなかった（図2）．「嚥下障害の徴候」について重症度別では，CDR1，3において有意にVaDで嚥下障害の徴候を示す者が多かった（$p=0.001$，$p=0.006$）（図3）．「食事開始困難」「巧緻性の低下」については，重症度別の比較ではADとVaDの間に有意な差はなかった（図4，図5）．「食具使用困難」について，重症度別の比較ではCDR1ではADとVaDに有意差は無かったが，CDR2，3で有意に

表2　認知症背景疾患および認知症重症度別の基礎情報

		認知症重症度別のADとVaDの比較（t-test）									背景疾患別重症度による比較		
		CDR1			CDR2			CDR3			ANOVA	Bonferroni post-hoc test	
		n	平均年齢±SD	P value	n	平均年齢±SD	P value	n	平均年齢±SD	P value	P value		P value
年齢（歳）	AD	38	86.9±6.9	] 0.009	55	86.8±8.3	] 0.165	48	87.4±8.3	] 0.771	0.934		
	VaD	14	80.1±10.9		19	83.6±9.5		46	87.9±8.7		0.018	CDR1 ＜ CDR3	0.023
MMSE	AD	41	18.6±5.6	] 0.269	57	11.3±5.5	] 0.859	47	3.0±4.6	] 0.619	＜0.001	CDR1 ＞ CDR2	＜0.001
												CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
	VaD	15	16.7±5.8		21	11.0±6.9		41	3.6±5.2		＜0.001	CDR1 ＞ CDR2	0.017
												CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
BI	AD	41	65.1±21.4	]＜0.001	59	47.3±24.6	] 0.003	50	15.9±17.1	] 0.002	＜0.001	CDR1 ＞ CDR2	＜0.001
												CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
	VaD	15	35.3±27.7		21	28.3±25.0		47	7.0±9.6		＜0.001	CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
VI	AD	41	7.9±1.9	] 0.083	59	6.3±2.4	] 0.283	50	3.2±1.9	] 0.082	＜0.001	CDR1 ＞ CDR2	0.001
												CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
	VaD	15	6.9±2.1		21	5.7±2.7		47	2.5±1.9		＜0.001	CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
MNA-SF	AD	40	9.7±2.0	] 0.273	59	8.9±2.3	] 0.059	49	6.4±2.2	] 0.585	＜0.001	CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	＜0.001
	VaD	15	8.9±2.6		21	7.7±2.7		46	6.2±2.0		＜0.001	CDR1 ＞ CDR3	＜0.001
												CDR2 ＞ CDR3	0.035
BMI	AD	38	20.6±3.8	] 0.570	55	21.1±4.4	] 0.129	47	19.4±4.4	] 0.831	0.131		
	VaD	13	21.3±4.8		19	19.4±2.5		45	19.2±2.7		0.099		
Alb	AD	22	3.8± .3	] 0.313	43	3.8± .4	] 0.288	38	3.6± .4	] 0.257	0.028	CDR2 ＞ CDR3	0.046
	VaD	14	3.7± .3		18	3.6± .4		44	3.5± .3		0.055		

MMSE：Mini Mental State Examination（score0～30），BI：Barthel Index（score0～100），VI：Vitality Index（score0～10），MNA-SF：the Short-Form Mini Nutritional Assessment（score0～14），BMI：Body Mass Index，Alb：血清アルブミン．

左：対象者数と各スコアの平均値．認知症重症度別のADとVaDの比較（Student's T-test）．

右：認知症背景疾患ごとの重症度別比較（one way ANOVA with Bonferroni post-hoc test）．

表3　食事に関与する神経学的検査，顎顔面運動機能および食行動変化の項目についての認知症背景疾患別，認知症重症度別の比較

			認知症重症度別の AD と VaD の比較（χ^2 test）								背景疾患別重症度による比較（χ^2）
			CDR1			CDR2			CDR3		
			Applicable Pts.		comparison (χ^2)	Applicable Pts.		comparison (χ^2)	Applicable Pts.		comparison (χ^2)
			(n)		P value	(n)		P value	(n)		P value	P value
神経学的検査	麻痺・拘縮	AD	41	14.6%	] 0.002	58	1.7%	] <0.001	48	39.6%	] <0.001	<0.001
		VaD	15	60.0%		21	57.1%		46	84.8%		0.027
顎顔面運動機能	リンシング・ガーグリング困難	AD	41	2.4%	] 0.004	59	8.5%	] 0.595	49	49.0%	] 0.024	<0.001
		VaD	15	33.3%		21	9.5%		45	71.1%		<0.001
食行動変化	嚥下障害の徴候	AD	39	12.8%	] 0.001	59	23.7%	] 0.163	49	51.0%	] 0.006	<0.001
		VaD	15	60.0%		21	38.1%		45	77.8%		0.007
	食事開始困難	AD	39	2.6%	] 0.482	59	27.1%	] 0.506	49	75.5%	] 0.519	<0.001
		VaD	15	6.7%		21	23.8%		44	77.3%		<0.001
	食具使用困難	AD	39	5.1%	] 0.306	59	18.6%	] 0.031	49	69.4%	] 0.009	<0.001
		VaD	15	13.3%		21	42.9%		44	90.9%		<0.001
	巧緻性の低下	AD	13	33.3%	] 0.107	38	64.4%	] 0.537	46	93.9%	] 0.541	0.001
		VaD	8	57.1%		14	66.7%		43	95.6%		<0.001
	適量のすくい取りが困難	AD	39	2.6%	] 0.018	59	27.1%	] 0.250	49	71.4%	] 0.006	<0.001
		VaD	15	26.7%		21	38.1%		44	93.2%		<0.001
	提供された食事全量の認知が困難	AD	39	7.7%	] 0.205	59	27.1%	] 0.554	49	71.4%	] 0.576	<0.001
		VaD	15	20.0%		21	28.6%		45	71.1%		<0.001
	食事中の注意維持困難	AD	39	7.7%	] 0.030	59	37.3%	] 0.574	49	83.7%	] 0.473	<0.001
		VaD	15	33.3%		21	38.1%		44	86.4%		<0.001
	食事中の覚醒維持困難	AD	39	.0%	] 0.001	59	22.0%	] 0.521	49	63.3%	] 0.449	<0.001
		VaD	15	33.3%		21	19.0%		45	66.7%		0.001

左：各徴候・困難がみられた者の人数および認知症重症度別の AD と VaD の比較（χ^2 test）．
右：認知症背景疾患ごとの認知症重症度による比較（χ^2 test）．

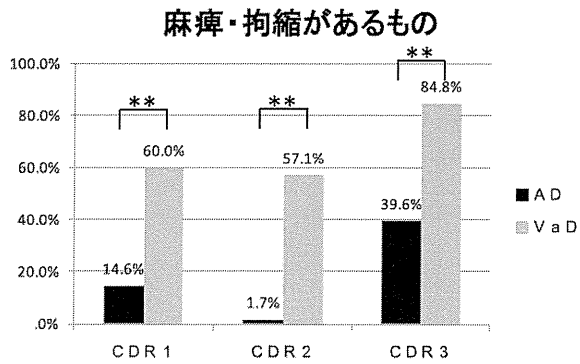

図1　認知症重症度別，麻痺・拘縮のあるもののADとVaDの比較　**：P<0.01

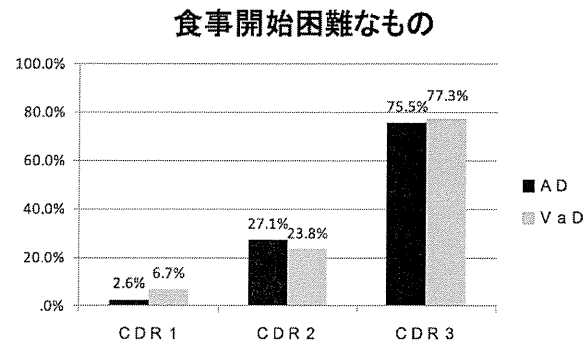

図4　認知症重症度別，食事開始困難なもののADとVaDの比較

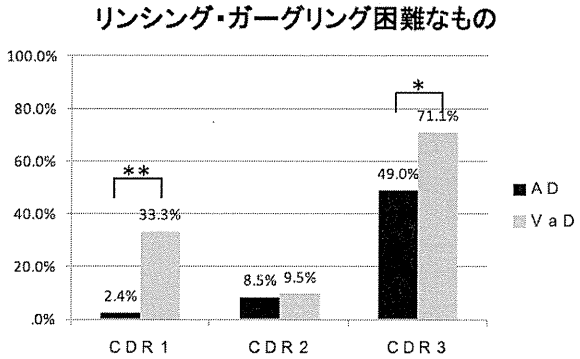

図2　認知症重症度別，リンシング・ガーグリング困難なもののADとVaDの比較　*：P<0.05，**：P<0.01

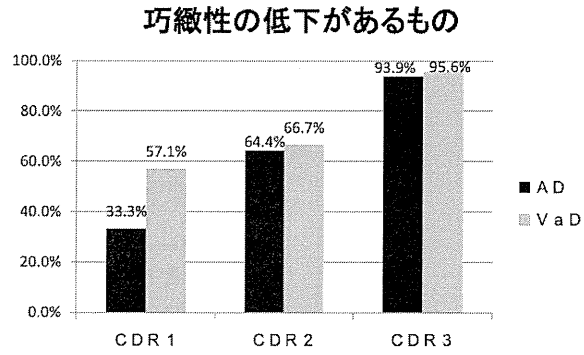

図5　認知症重症度別，巧緻性の低下があるもののADとVaDの比較

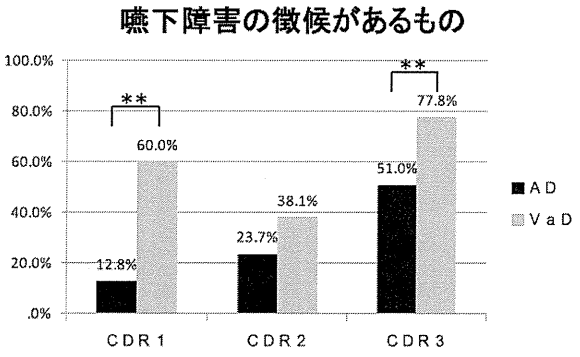

図3　認知症重症度別，嚥下障害の徴候があるもののADとVaDの比較　**：P<0.01

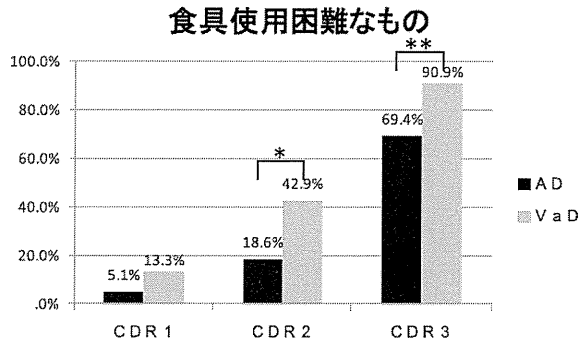

図6　認知症重症度別，食具使用困難なもののADとVaDの比較　*：P<0.05，**：P<0.01

VaDに困難な者が多かった（p=0.031，p=0.009）（図6）．「適量のすくい取りが困難」について，重症度別ではCDR 1，3で有意にVaDに困難な者が多くみられた（p=0.018，p=0.006）（図7）．「提供された食事全量の認知が困難」について，重症度別ではADとVaDの間に有意な差は見られなかった（図8）．「食事中の注意維持困難」について，重症度別ではCDR1で有意にVaDには注意維持の障害が多かった（p=0.030）が，CDR2，3では有意な差は見られなかった（図9）．「食事中の覚醒維持困難」については，重症度別ではCDR1で有意にVaDは覚醒の維持が困難であった（p=0.001）が，CDR2，3では有意な差は認められなかった（図10）．これらはVaDの

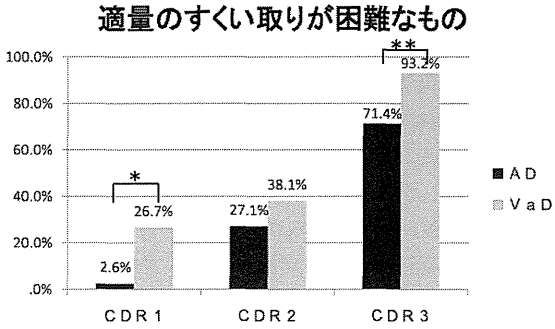

図7　認知症重症度別，適量のすくい取りが困難なもののADとVaDの比較　*：P<0.05，**：P<0.01

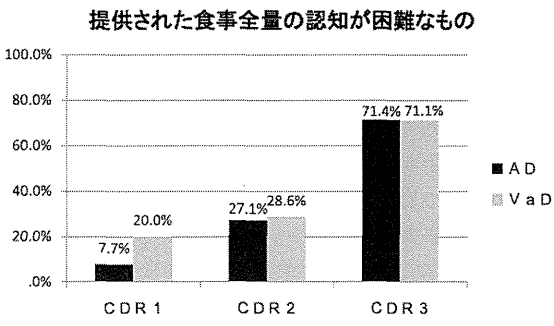

図8　認知症重症度別，提供された食事全量の認知が困難なもののADとVaDの比較

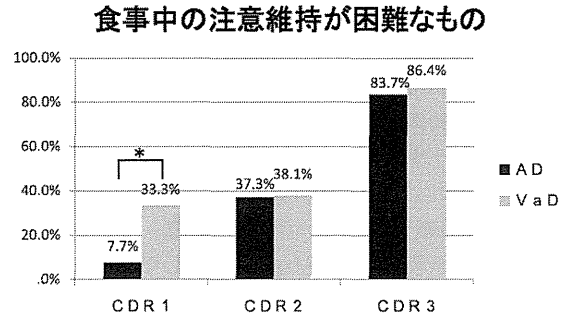

図9　認知症重症度別，食事中の注意維持が困難なもののADとVaDの比較　*：P<0.05

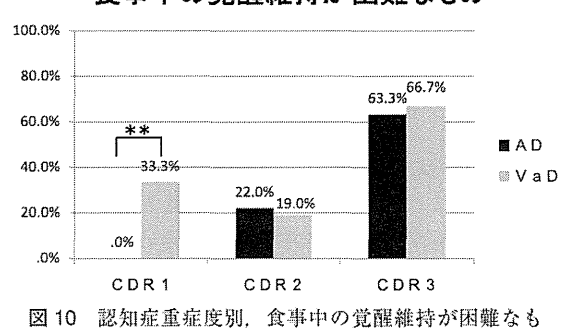

図10　認知症重症度別，食事中の覚醒維持が困難なもののADとVaDの比較　**：P<0.01

「麻痺・拘縮」以外すべて認知症が重度の者ほど困難な者が有意に多くなる結果であった．

考　察

食行動変化については，一般的に食行動変化が多いと言われる前頭側頭認知症や早期の嚥下障害が起こりやすいと言われるレビー小体型認知症に関しては，これまでADとの比較による報告がなされているが，依然として認知症背景疾患別，および特に認知症重症度別の特徴に関する詳細な調査は数少ない[20][21]．認知症患者では，「個体が固形物や液体を摂取するために計画する考え，動作，行動」に，意識レベルの変化，意欲低下，注意力障害，発動性，失見当識，判断力障害，実行機能障害，視空間認知障害，上肢の運動機能障害と失行，顔面・口腔の随意運動障害と失行など様々な要因が影響し，様々な食行動変化が生じると推測される[22]．ケア現場では曖昧になっている認知症背景疾患それぞれの特徴的な認知機能障害や神経脱落症状に起因する食行動変化を可視化し，比較分析することで，ケア現場の対応への一助となる可能性がある．本研究はADとVaDを対象として認知症重症度別の食行動変化の程度を比較分析し，ADとVaDにおける食行動の特徴を明らかにすることで自立支援の方法の確立に向けた基礎情報を得ることを目的とした．

ADとVaDの相違点は，ADは脳の変性性疾患であり，VaDは脳血管障害後遺症であって神経脱落症状を有すというところにある．この点を基に，本結果について考察する．

それぞれの重症度において有意にVaDがADよりBIにおいて低値を示していたことは，脳血管障害の後遺症である身体機能障害を反映していると考えられた．重症度別の検討（ANOVA）では，両群ともに認知症が重度の者ほど有意に低下する結果であった．MNA-SFは臨床上の栄養状態を強く反映し，予知性を反映した指標としてリスク群を選び分けるのに有効であり，高齢者の栄養評価に使用されている[14]．今回の調査で重度認知症の者ほどMNA-SFの低下がみられたが，MNA-SFの小項目「神経・精神的問題の有無」以上の差はほとんど見られず，BMIやAlbでも背景疾患および重症度の有意差が見られなかったことは，対象集団の良好な栄養状態を反映しているものと考えられる．

ADは経過とともに脳の萎縮が進行し，中核症状が全体的に悪化していく疾患である．「巧緻性の低下」に関してはCDR1群でも30%以上の者に低下を認め，麻痺・拘縮など運動機能低下がなくても認知症軽度の時期から巧緻性が低下することが推察された．また認知症が重度の者ほど，特に中等度から重度にかけてBI，VIおよび「食事開始困難」「食事中の注意維持困難」などの食行動変化，「嚥下障害の徴候」が有意に増加していたことは，重度認知症において顕著になる失見当識，失認，実行機能障害，意欲低下との関連が考えられた．一方「嚥下障害の徴候」「リンシング・ガーグリング困難」「食具使用困難」については，CDR3群でも行動障害がない者が30%以上という結果であった．これらからADの食事自立低下には，認知機能低下の影響がある一方，重度な記憶障害をきたしている時期でも手続き記憶や運動学習は保持されるという報告と合致していると考えられる[23]．

一方VaDは，脳血管障害の局在に応じた質・程度の機能障害によって見かけ上の生活機能低下と，認知機能低下が一致せず機能障害の個人差が大きい[24]．認知症重症度が同程度のADとVaDを比較すると，視空間認知障害や運動の協調性・速度の障害，行動計画の障害は，有意にVaDが重度に障害されているという報告がある[25]．加えて系列動作の失行や実行機能障害もVaDの摂食動作に関与するとも報告されている[26]．本結果で，CDR1群において調査対象となった食行動変化すべてにおいて，VaDがADよりも頻度が高いという結果であった．VaDでは軽度認知症の段階から，脳血管障害に起因する神経脱落症状や仮性球麻痺による嚥下障害により食行動に問題が出ることが明らかになったことは，一連の報告を裏付ける結果と考えられる．VaDの食事自立低下には，軽度認知症の段階から脳血管障害後遺症による認知機能の障害に神経脱落症状が相乗しており，それに加えて認知症の重度化とともに加齢と廃用性萎縮が追加されることでさらに自立が低下するものと考えられる．

一方ADとVaDの注意障害は同程度発現するという報告同様，本結果でもCDR2，3群での「食事中の注意維持困難」は両群とも同程度であった[27]．また両群で「食事中の注意維持困難」「食事開始困難」がCDR3で顕著に増加していることは，重度認知症において一連の食事動作の開始に注意の維持が重要な役割を担っていることが推察される．

上述したADとVaDの相違点は，多くの場合比較的典型的な認知機能低下を示す変性性認知症であるADと，認知症の進行経過も非典型的で個人差が大きい脳血管障害後遺症であるVaDの違いに関連すると推察する．VaDの機能障害は発症前には予測困難である．しかし，VaDでは身体機能障害があっても認知機能障害が軽度である症例は，傷害された機能自体の回復は困難でも残存機能に対してのリハビリテーションや環境の調整は有効なことが多いことが知られている[28]．これは食行動や嚥下機能障害に対しても同様であり，本結果におけるVaD認知症軽度での食行動障害や嚥下障害等に対して，それぞれの機能障害と残存する運動機能と認知機能を十分に評価・把握し，活用するための個別のマネジメントが有効であると考える．

一方ADでは，認知症重度で食具の適正な使用や嚥下機能障害の徴候がない者も存在するという結果であった．食事開始困難や食事中の注意維持困難など“食事開始・再開の手がかりの喪失”を引き起こす認知障害があっても運動機能や嚥下機能に著しい問題がない場合は，開始の手がかりの支援や，食事開始を障害する環境因子の刺激の質と量を調整する支援をすることで部分的にでも自立摂食行動を維持することができると報告されている[2]．ADは進行性疾患であり，中核症状の進行を抑制することは困難であるが，認知機能，生活機能や嚥下機能それぞれが認知症のステージにより状態の変化があることを正確に把握することで，認知症の進行に伴って出現する食行動変化を予測し事前に対策をたてることが可能である[29]．たとえば嚥下障害が顕著になる前の軽度認知症の段階から嚥下機能を維持するためのプログラムの導入を行うなど，予知性を持ったケア方法の立案を行い，食事支援の負担も軽減できる可能性がある．

本調査でこうした客観的な結果が出たことは，認知症高齢者の支援に携わるすべての臨床医，看護・介護職員，ケア提供者に対して有益な基礎資料になるものと思われる．

本研究においては，認知症の重症度分類に関し本来ADを基軸としているCDRでADとVaDの重症度分類を行った．本研究はケア現場における食事支援を念頭にした研究であり，臨床的な生活のニーズを把握するという点で，VaDにCDRを適用し検討を行った[30]．また施設入所高齢者を主な対象としたためVaDのサブタイプ別の分類を行っておらず，VaDにCDRを適用することの妥当性を含め今後の詳細な検討の必要性がある．また本研究は観察評価と質問調査が中心の実態調査であったことから，実際に有効な支援の方法の検証は行っていない．今後，今回の結果を参考に経過を追った介入研究を行い，効果的な食事の自立の支援方法の確立にむけて検

討を進めたい．

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尚，本論文に関して，開示すべき利益相反状態は存在しない．

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Comparative study of eating behavior in elderly patients with Alzheimer's disease and vascular dementia: A first report. —Comparison of disturbed eating behavior—

Ayako Edahiro[1], Hirohiko Hirano[1], Ritsuko Yamada[2], Yumi Chiba[3] and Yutaka Watanabe[4]

Abstract

Aim: In elderly patients with dementia, it is known that a loss of independence in eating can cause malnutrition, dehydration, a decrease in food consumption and the immune function and further worsening of the cognitive function, with an increased risk of pneumonia and a shortened life expectancy. The purpose of this study was to investigate the occurrence of a disturbed eating behavior in elderly patients with Alzheimer's disease (AD) and vascular dementia (VaD), who together comprise the majority of elderly patients with dementia.

Methods: A total of 233 patients (150 AD patients and 83 VaD patients) who were residents of institutions or group homes were enrolled. The patients underwent an assessment of eating behavior, a cognitive assessment, a neurological examination and measurement of the vital signs. Additionally, statistical analyses were performed to compare eating behavior between the patients with AD and those with VaD at varying severity of dementia.

Results: A disturbed eating behavior was observed significantly more frequently as the severity of dementia increased. The prevalence of difficulty in rinsing/gargling and dysphagia increased with the severity of dementia. There were differences in the frequency of disturbed eating behavior between the AD and VaD patients. Among the patients with mild dementia, the VaD patients exhibited a higher incidence of a disturbed eating behavior than the AD patients. On the other hand, some behaviors prominent in the patients with severe dementia were related to various types of cognitive impairment in the AD patients, namely difficulty in beginning a meal, difficulty in maintaining attention while eating and difficulty in performing the specific motor skills necessary to open food packages. Marked individual differences were observed in the mild VaD patients, with a high frequency of disturbed eating behavior and dysphagia related to symptoms of neurological deficits. No correlations were found with the severity of dementia.

Conclusions: Both AD and VaD are types of dementia; however, the frequency of a disturbed eating behavior differs greatly between these populations. It is necessary to focus on differences in these parameters and also the causes of dementia in order to develop effective care techniques for patients with dementia.

Key words: *Dementia, Severity of dementia, Feeding behavior, Anticipatory stage of swallowing, Dysphagia*
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1) Research Team for Promoting Independence of the Elderly, Tokyo Metropolitan Institute of Gerontology
2) School of Nursing & Social Services, Health Sciences University of Hokkaido
3) College of Nursing, School of Medicine, Yokohama City University
4) Department of Oral Diseases Research, National Center for Geriatrics and Gerontology

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ORIGINAL ARTICLE

Development of a simple screening test for sarcopenia in older adults

Shinya Ishii,[1] Tomoki Tanaka,[2] Koji Shibasaki,[1] Yasuyoshi Ouchi,[3] Takeshi Kikutani,[4] Takashi Higashiguchi,[5] Shuichi P Obuchi,[6] Kazuko Ishikawa-Takata,[7] Hirohiko Hirano,[6] Hisashi Kawai,[6] Tetsuo Tsuji[2] and Katsuya Iijima[2]

[1]Department of Geriatric Medicine, Graduate School of Medicine, [2]Institute of Gerontology, The University of Tokyo. [3]Federation of National Public Service Personnel Mutual Aid Associations Toranomon Hospital, [4]Division of Clinical Oral Rehabilitation, The Nippon Dental University Graduate School of Life Dentistry at Tokyo, [6]Tokyo Metropolitan Institute of Gerontology, [7]Division of Health Promotion and Exercise, National Institute of Health and Nutrition, Tokyo, and [5]Department of Surgery & Palliative Medicine, Fujita Health University School of Medicine, Toyoake City, Japan

Aim: To develop a simple screening test to identify older adults at high risk for sarcopenia.

Methods: We studied 1971 functionally independent, community-dwelling adults aged 65 years or older randomly selected from the resident register of Kashiwa city, Chiba, Japan. Data collection was carried out between September and November 2012. Sarcopenia was defined based on low muscle mass measured by bioimpedance analysis and either low muscle strength characterized by handgrip or low physical performance characterized by slow gait speed.

Results: The prevalence of sarcopenia was 14.2% in men and 22.1% in women. After the variable selection procedure, the final model to estimate the probability of sarcopenia included three variables: age, grip strength and calf circumference. The area under the receiver operating characteristic curve, a measure of discrimination, of the final model was 0.939 with 95% confidence interval (CI) of 0.918–0.958 for men, and 0.909 with 95% CI of 0.887–0.931 for women. We created a score chart for each sex based on the final model. When the sum of sensitivity and specificity was maximized, sensitivity, specificity, and positive and negative predictive values for sarcopenia were 84.9%, 88.2%, 54.4%, and 97.2% for men, 75.5%, 92.0%, 72.8%, and 93.0% for women, respectively.

Conclusions: The presence of sarcopenia could be detected using three easily obtainable variables with high accuracy. The screening test we developed could help identify functionally independent older adults with sarcopenia who are good candidates for intervention. **Geriatr Gerontol Int 2014; 14 (Suppl. 1): 93–101.**

Keywords: disability, rehabilitation, sarcopenia, screening, sensitivity and specificity.

Introduction

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal mass and strength with aging.[1] A recent realization that sarcopenia is associated with a risk of adverse events, such as physical disability, poor quality of life and death, has provided significant impetus to sarcopenia research.[1] Effective interventions have been vigorously sought and some interventions, such as resistance training in combination with nutritional supplements, appear promising.[2–4] It is also becoming apparent that interventions might be more effective early rather than late in the course when patients develop physical disability or functional dependence.[4,5] The early stage in the course of sarcopenia (i.e. without loss of physical or functional independence) might therefore represent a valuable opportunity to carry out interventions to decelerate the progress of sarcopenia and prevent physical disability.

However, patients with sarcopenia are generally unaware of their sarcopenic state until the gradual decline in muscle function becomes severe enough to be pathological, resulting in physical and functional dependence.[4,6] As patients are unlikely to seek medical

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Correspondence: Dr Katsuya Iijima MD, Institute of Gerontology, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan. Email: iijima@iog.u-tokyo.ac.jp

attention for their sarcopenic state, population screening to detect sarcopenia before the occurrence of physical disability could improve the chance of intervention.

Currently, the recommended criteria for the diagnosis of sarcopenia require the documentation of low muscle mass and either low muscle strength or low physical performance.[1] Muscle mass is commonly assessed by dual energy X-ray absorptiometry (DXA) or bioimpedance analysis (BIA), muscle strength with handgrip strength, and physical performance with Short Physical Performance Battery or usual gait speed.[1,7] Unfortunately, the feasibility of applying the recommended diagnostic algorithm in the setting of population screening is limited by the need for special equipment and training. Hence, a screening test for sarcopenia simple enough to be carried out on a large scale is required.

Using baseline data from the Kashiwa study on functionally independent, community-dwelling older adults, we designed an analysis to develop a simple screening test for sarcopenia and examine its ability to estimate the probability of sarcopenia.

Methods

Participants

The Kashiwa study is a prospective cohort study designed to characterize the biological, psychosocial and functional changes associated with aging in community-dwelling older adults. In 2012, a total of 12 000 community-dwelling, functionally independent (i.e. not requiring nursing care provided by long-term care insurance) adults aged 65 years or older were randomly drawn from the resident register of Kashiwa city, a commuter town for Tokyo in Chiba prefecture, Japan, and asked by mail to participate in the study. A total of 2044 older adults (1013 men, 1031 women) agreed to participate in the study and comprised the inception cohort. The sample reflected the distribution of age in Kashiwa city for each sex.

Baseline examinations were carried out between September and November 2012 at welfare centers and community centers close to the participants' residential area, to obviate their need to drive. A team consisting of physicians, nurses, physical therapists, dentists and nutritionists carried out data collection. To standardize data collection protocol, they were given the data collection manual, attended two sessions for training in the data collection methods and carried out a rehearsal of data collection. A total of 73 participants who did not undergo BIA, usual gait speed or handgrip strength measurements were excluded, leaving an analytic sample of 1971 older adults (977 men, 994 women).

The study was approved by the ethics committee of the Graduate School of Medicine, The University of Tokyo. All participants provided written informed consent.

Sarcopenia classification and measurement of each component of sarcopenia

We followed the recommendation of the European Working Group on Sarcopenia in Older People (EWGSOP) for the definition of sarcopenia.[1] The proposed diagnostic criteria required the presence of low muscle mass plus the presence of either low muscle strength or low physical performance.

Muscle mass measurement

Muscle mass was measured by BIA using an Inbody 430 machine (Biospace, Seoul, Korea).[8] Appendicular skeletal muscle mass (ASM) was derived as the sum of the muscle mass of the four limbs. ASM was then normalized by height in meters squared to yield skeletal muscle mass index (SMI) (kg/m^2).[1] SMI values lower than two standard deviations below the mean values of young male and female reference groups were classified as low muscle mass (SMI <7.0 kg/m^2 in men, <5.8 kg/m^2 in women).[9]

Muscle strength measurement

Muscle strength was assessed by handgrip strength, which was measured using a digital grip strength dynamometer (Takei Scientific Instruments, Niigata, Japan). The measurement was carried out twice using their dominant hand, and the higher of two trials (in kilograms) was used for the present analysis. Handgrip strength values in the lowest quintile were classified as low muscle strength (cut-off values: 30 kg for men, 20 kg for women).

Physical performance measurement

Physical performance was assessed by usual gait speed. Participants were instructed to walk over an 11-m straight course at their usual speed. Usual gait speed was derived from 5 m divided by the time in seconds spent in the middle 5 m (from the 3-m line to the 8-m line). Good reproducibility of this measurement was reported previously.[10] Usual gait speed values in the lowest quintile were classified as low physical performance (cut-off values: 1.26 m/s for each sex).

Other measurements

Demographic information and medical history of doctor-diagnosed chronic conditions were obtained

using a standardized questionnaire. Physical activity was assessed using Global Physical Activity Questionnaire and Metabolic Equivalent minutes per week was computed.[11] Serum albumin was measured at the time of the visit. Anthropometric measurements were obtained with the participants wearing light clothing and no shoes. Height and weight were measured with a fixed stadiometer, and a digital scale and used to compute body mass index (BMI). Upper arm, thigh and calf circumferences were measured to the nearest 0.1 cm directly over the skin using a measuring tape with the participant sitting. Upper arm circumference was measured at the mid-point between the olecranon process and the acromion of the non-dominant arm with the participant's arm bent 90° at the elbow. Calf circumference measurement was made at the maximum circumference of the lower non-dominant leg with the participant's leg bent 90° degrees at the knee. Thigh circumference was measured 15 cm above the upper margin of the patella of the dominant leg.

Statistical analysis

All analyses were stratified by sex. Differences in participant characteristics between those with and without sarcopenia were examined using Student's *t*-test or Wilcoxon rank–sum test. To develop a statistical model to estimate the probability of sarcopenia, candidate variables were selected by experts based on cost, ease of measurement and availability of equipment to measure them. The candidate variables included age, sex, BMI, grip strength, and thigh, calf and upper arm circumferences. Pearson's correlation between each component of sarcopenia and the candidate variables was first computed. We then examined the functional form of the relationships between the variables, and the logit of sarcopenia probability using restricted cubic spline plots and the Wald test for linearity.[12] We considered dichotomization, square and logarithmic transformations if the Wald test for linearity was statistically significant, rejecting the assumption of linearity.[12] A multivariate logistic regression model including all the candidate variables ("full model") was constructed. Variable selection with Bayesian Information Criteria was carried out to make the model parsimonious, and a multivariate logistic regression model including the variables selected ("restricted model") was made.[13] A bootstrapping procedure was used to obtain estimates of internal validity of the model[14] and to derive the final models by correcting the regression coefficients for overoptimism.[15] The final model was presented as a score chart to facilitate clinical application.[15] The score chart was created based on rounded values of the shrunken regression coefficients.

The ability of each model to correctly rank order participants by sarcopenia probability (discrimination ability) was assessed by the area under the receiver operator characteristic (ROC) curve.[16,17] The model fit was verified using the Hosmer–Lemeshow goodness-of-fit test.[18]

There were no missing values of any variable in the entire analytic sample.

All analyses were carried out using SAS version 9.3 (SAS Institute, Cary, NC, USA) and R statistical software version 2.15.2 (R Foundation, Vienna, Austria). Two-sided $P < 0.05$ was considered statistically significant.

Results

There were 32.2% of men and 48.9% of women classified as having low muscle mass, and 14.2% of men and 22.1% of women were classified as having sarcopenia. The participant characteristics by the sarcopenia status in each sex are shown in Table 1. Those with sarcopenia were older and had smaller body size compared with those without sarcopenia in each sex (all $P < 0.001$). Those with sarcopenia were physically less active in each sex. Chronic medical conditions were in general more prevalent in those with sarcopenia, and a statistically significant difference was observed for hypertension in women, stroke in men and osteoporosis in both sexes. Serum albumin was significantly lower in those with sarcopenia in each sex.

Table 2 shows the correlation between each component of sarcopenia and the candidate variables. SMI was correlated with all the variables, with the highest correlation coefficient observed with calf circumference in each sex. Usual gait speed was most highly correlated with age, followed by grip strength and calf circumference in the order of the magnitude of correlation, and this finding was consistent in both sexes.

Visual inspection of the restricted cubic spline plots and the Wald test for linearity suggested that the variables were linearly associated with the logit of sarcopenia probability, except for grip strength in both sexes and upper arm circumference in women (data not shown). However, neither dichotomization nor transformation improved the model fit, and we decided to use linear terms of these variables in the development of statistical models.

Table 3 shows the unadjusted and adjusted associations between sarcopenia and the variables. In bivariate analysis, all the variables were significantly associated with sarcopenia. In multiple logistic regression with all the variables (full model), age was positively, and grip strength and calf circumference were inversely associated with sarcopenia, whereas BMI, thigh circumference and upper arm circumference were not significantly associated. Variable selection resulted in the selection of age, grip strength and calf circumference, and the three selected variables were significantly associated with

Table 1 Characteristics of study participants

	Men			Women		
	Sarcopenia (n = 139)	No sarcopenia (n = 838)	P	Sarcopenia (n = 220)	No sarcopenia (n = 774)	P
Age (years)	78.4 ± 5.5	72.2 ± 5.0	<0.001	76.2 ± 5.8	71.8 ± 4.9	<0.001
Height (cm)	160.0 ± 5.6	164.9 ± 5.5	<0.001	148.2 ± 5.6	152.3 ± 5.1	<0.001
Weight (kg)	54.1 ± 7.2	64.3 ± 8.0	<0.001	46.4 ± 5.7	52.9 ± 7.6	<0.001
BMI (kg/m^2)	21.1 ± 2.5	23.6 ± 2.6	<0.001	21.1 ± 2.6	22.8 ± 3.2	<0.001
Grip strength (kg)	27.5 ± 4.3	36.0 ± 5.3	<0.001	18.4 ± 3.2	23.6 ± 3.3	<0.001
Thigh circumference (cm)	38.8 ± 3.5	42.4 ± 3.3	<0.001	38.9 ± 3.4	41.7 ± 4.0	<0.001
Calf circumference (cm)	32.8 ± 2.3	36.3 ± 2.5	<0.001	32.1 ± 2.1	34.5 ± 2.7	<0.001
Upper arm circumference (cm)	25.7 ± 2.5	28.4 ± 2.4	<0.001	25.7 ± 2.3	27.3 ± 2.9	<0.001
SMI (kg/m^2)	6.34 ± 0.48	7.44 ± 0.58	<0.001	5.25 ± 0.41	6.02 ± 0.60	<0.001
Usual gait speed (m/s)	1.28 ± 0.24	1.51 ± 0.24	<0.001	1.26 ± 0.26	1.51 ± 0.23	<0.001
Physical activity (MET-minutes/week)	1813 (720, 3504)	2540 (1200, 4746)	0.008	1341 (33, 3209)	2587 (1092, 4824)	<0.001
Chronic conditions (%)						
Hypertension	51.1	46.5	0.32	45.9	38.1	0.04
Diabetes mellitus	18.0	14.9	0.36	8.2	8.9	0.73
Stroke	12.2	6.4	0.01	5.9	4.4	0.35
Osteoporosis	4.3	1.4	0.02	32.7	16.6	<0.001
Use of medications (%)						
Statins	18.7	17.4	0.71	29.1	30.6	0.66
Antihypertensives	53.2	45.1	0.08	42.7	36.2	0.08
Albumin (g/dL)	4.37 ± 0.26	4.43 ± 0.23	0.005	4.39 0.23	4.43 ± 0.22	0.04

Values are shown as mean ± standard deviation except for physical activity which was not normally distributed and therefore the mean value and inter-quartile range were shown. BMI, body mass index; MET, Metabolic Equivalent; SMI, skeletal muscle mass index.

Table 2 Pearson correlations between components of sarcopenia and six candidate variables

	Age	BMI	Grip strength	Thigh circumference	Calf circumference	Upper arm circumference
Men						
SMI	−0.33***	0.70***	0.49***	0.70***	0.78***	0.69***
Grip strength	−0.46***	0.21***	1	0.27***	0.35***	0.35***
Usual gait speed	−0.35***	0.007	0.29***	0.06	0.13***	0.10**
Women						
SMI	−0.24***	0.69***	0.50***	0.67***	0.75***	0.65***
Grip strength	−0.36***	0.16***	1	0.22***	0.33***	0.21***
Usual gait speed	−0.42***	−0.08**	0.36***	0.01	0.12***	−0.02

*, **, ***Significance at 0.1%, 1%, 5% level, respectively. BMI, body mass index; SMI, skeletal muscle mass index.

sarcopenia in multiple logistic regression (restricted model). These findings were consistent in both sexes. The area under the ROC curve of the full model was 0.940 (95% confidence interval [CI] 0.920–0.959) for men and 0.910 (95% CI 0.888–0.932) for women, showing excellent discriminative ability. The area under the ROC curve of the restricted model (0.939 with 95% CI 0.918–0.958 for men and 0.909 with 95% CI 0.887–0.931 for women) was not significantly different from that of the full model in both sexes ($P = 0.71$ for men, 0.43 for women). Assessment of internal validity showed that discriminative ability of the restricted model is expected to be good in similar populations (area 0.937 for men, 0.907 for women).

The final model was presented as a score chart in each sex (Table 4). The use of the score chart with two hypothetical patients is shown in Table S1. The discriminative ability of the score chart was comparable with those of the full and restricted models in each sex (area 0.935 for men, 0.908 for women; Fig. S1).

Figure 1 shows the estimated probabilities corresponding to the sum scores as calculated with the score chart in Table 4, and the sensitivity and specificity using the sum scores as cut-off values. The sum score that maximized the sum of sensitivity and specificity was 105 for men and 120 for women. The corresponding sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios were 84.9%, 88.2%, 54.4% and 97.2%, and 7.19 and 0.17 for men, and 75.5%, 92.0%, 72.8% and 93.0%, and 9.44 and 0.27 for women, respectively.

Sensitivity analysis

Because there are no established reference cut-off values for grip strength and usual gait speed in Japanese older adults, we used the lowest quintiles of the observed distributions to classify low muscle strength and low physical performance. As sensitivity analysis, we used the lowest deciles of grip strength and usual gait speed to capture participants with more severely impaired muscle function (i.e. strength or performance), and defined them as having sarcopenia, with the same cut-off values for muscle mass as in the main analysis. We then examined the model performance with all six variables and with the same set of three variables as selected in the main analysis (age, grip strength and calf circumference). The cut-off value of grip strength was 27 kg for men and 17 kg for women, and that of usual gait speed was 1.16 m/s for men and 1.13 m/s for women. The prevalence of sarcopenia was 9.6% in men and 12.7% in women. Both models performed well (area of the full model: 0.932 for men, 0.919 for women; area for the restricted model; 0.931 for men, 0.918 for women; Figure S2).

Discussion

To estimate the probability of sarcopenia in functionally independent, community-dwelling Japanese older adults, we created multivariate models based on the three selected variables (age, grip strength and calf circumferences), and found excellent discrimination ability of the models: the area under the curve was 0.939 for men and 0.909 for women. We constructed a score chart in each sex so that the approximate probability of sarcopenia could be easily obtained from the values of the three variables, and confirmed that the score charts also had excellent discrimination.

Although our multivariate models had excellent discrimination capacity, the model's sensitivity and specificity at candidate diagnostic thresholds must be assessed to judge the model's clinical usefulness.[18] Higher sensitivity can be achieved at the expense of lower specificity and vice versa. For example, if higher sensitivity was desired; for example, 90%, then the cut-off score would be 101 for men and 104 for women, and the specificity would be lower at 82.2% for men and 70.4% for women. Higher specificity, 90%, could be achieved with the higher cut-off score of 107 for men

Table 3 Unadjusted and adjusted associations between sarcopenia and the variables

Variables	Men						Women					
	Bivariate		Multivariate (full model)		Multivariate (restricted model)		Bivariate		Multivariate (full model)		Multivariate (restricted model)	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.21 (1.17–1.26)	<0.001	1.07 (1.02, 1.12)	0.008	1.07 (1.02, 1.12)	0.008	1.16 (1.13, 1.20)	<0.001	1.10 (1.05, 1.14)	<0.001	1.09 (1.04, 1.13)	<0.001
BMI	0.68 (0.63–0.74)	<0.001	0.96 (0.78, 1.18)	0.69			0.82 (0.78, 0.87)	<0.001	0.86 (0.74, 1.00)	0.05		
Grip strength	0.71 (0.67, 0.75)	<0.001	0.73 (0.68, 0.78)	<0.001	0.73 (0.68, 0.79)	<.001	0.57 (0.53, 0.62)	<0.001	0.58 (0.53, 0.64)	<0.001	0.59 (0.55, 0.65)	<0.001
Thigh circumference	0.73 (0.69, 0.78)	<0.001	1.05 (0.91, 1.21)	0.53			0.82 (0.78, 0.86)	<0.001	0.94 (0.85, 1.04)	0.24		
Calf circumference	0.57 (0.52, 0.63)	<0.001	0.62 (0.53, 0.73)	<0.001	0.62 (0.56, 0.69)	<.001	0.68 (0.64, 0.74)	<0.001	0.80 (0.69, 0.91)	<0.001	0.71 (0.65, 0.78)	<0.001
Upper arm circumference	0.63 (0.57, 0.68)	<0.001	0.97 (0.82, 1.15)	0.71			0.80 (0.75, 0.85)	<0.001	1.15 (0.98, 1.35)	0.10		

BMI, body mass index; CI, confidence interval; OR, odds ratio.

and 118 for women, resulting in lower sensitivity of 77.7% for men and 76.8% for women (Fig. 1). The trade-off between sensitivity and specificity depends on the cost of incorrect classification of those with sarcopenia relative to the cost of incorrect classification of those without sarcopenia. The cost of incorrect answers would vary according to the clinical or research scenario and personal preferences.[16,17]

Several observations suggested that the selection of three variables (age, grip strength and calf circumference) was not based on chance. First, sarcopenia was classified based on muscle mass, muscle strength and physical performance, all of which were significantly correlated with the three variables. Calf circumference was used to represent muscle mass, considering the highest correlation between SMI and calf circumference among the variables considered. A strong correlation between calf circumference and muscle mass was previously shown in Caucasian older women who were on average more obese than women in the present.[19] Grip strength was used as an indicator of muscle strength. Usual gait speed, a measure of physical performance, was significantly correlated with each of the three variables. Second, sarcopenia was associated with each of the three variables in both bivariate and multivariate analyses in each sex, and *P*-values for these findings were comfortably below 0.01. Third, the models with the three variables had excellent discrimination for sarcopenia based on more stringent cut-off levels for grip strength and usual gait speed.

There have been several prior attempts at estimating the quantity of muscle mass using a variety of variables with varying degrees of accuracy.[20–23] Although these studies were inspired by the desire to facilitate the diagnosis of sarcopenia, recently developed definitions of sarcopenia entail the presence of low muscle function, as well as muscle mass.[1,24] The present study developed statistical models with high accuracy for sarcopenia, which was defined based on muscle mass and muscle function.

This study had several limitations. First, the measurement method of usual gait speed was different from those used by the majority of previous studies.[25] The measurement method used in the present study required the participant to walk 3 m before the measurement started. An attribute of this method is that it is less affected by the gait initiation phase where age-related changes independent of gait speed occur.[26,27] This method has been widely used in Japan,[9,28] and has been shown to be reliable,[10] but because it starts measuring after the gait initiation phase, it tends to yield higher values than those obtained with other measurement methods, such as usual gait speed over a 4- or 6-m course,[25] making direct comparison difficult. Second, the current analysis was carried out on data from Japanese older adults, and our findings therefore might not