と瘻孔閉鎖，スプリントの着用で咬合の偏位の改善を図った．術後の経過は良好で，咬合も改善し，退院後には旅行が可能となるなど良好なQOLを得た．患者は主病変の悪化で術後1年7カ月後に死亡したが，腫瘍内科医との連携が奏功した例であった．

本症例で，仮に欠損している7|にインプラントがあり，インプラント周囲炎を併発していれば，同様の経過をたどったであろうことは想像に難くない．膵臓がんの症例は多くはないが，乳・前立腺の各がんは骨転移を来しやすく，骨転移に対する治療で長期予後が見込めるため，BP製剤などのBMAが投与される可能性が高いことは認識しておいたほうがよい．

V インプラント治療が「がん」で無駄にならないように

以上に示したように，せっかくのインプラント治療が無駄にならないようにするために，われわれ歯科医師ができることの一つとして，がんと前がん病変である白板症や紅板症を早期にみつけることが挙げられる．口腔はわれわれ歯科医師がもっとも観察している部位である．「インプラントをしたためにがんになった」などと言われないためにも，歯の欠損に至った部位とその周囲の粘膜状態の観察，舌や頬粘膜の状態を観察することは，インプラント治療を成功させることと同じくらい重要ではないだろうか？

また，高齢者へのインプラント治療では患者ががんになることを想定したリスクマネジメントも必要である．喫煙や飲酒は頭頸部がんや食道がん，肺がんのリスクファクターであり，C型肝炎ウイルス感染者も肝がんのハイリスク群である．インプラント適用の選択は十分に注意したい．特に乳がんや前立腺がんの既往に注意することは，インプラント周囲炎によるBMA関連顎骨壊死を回避することにつながる．

さらに，インプラント治療を受けた患者ががんになり，がん化学療法が施行されれば，粘膜炎や骨髄抑制によるインプラントの感染リスクが高くなる．放射線治療が計画された際には，インプラントが照射野に入っているかどうかを確認しなければならない．そして，照射中・照射後は厳重な口腔管理が必要になってくる．

高齢者にインプラントを施術する際には，「がん」に対する配慮も必要であることを強調したい．

参考文献

1）吉野邦俊：頭頸部癌の疫学（特集 頭頸部癌の治療方針－わたしたちはこうしている－．1 頭頸部癌は増えているか）．耳鼻咽喉科・頭頸部外科，76（6）：345-350，2004.
2）高岡一樹，岸本裕充：骨修飾薬（BMA）による顎骨壊死．歯界展望別冊／Q&A 歯科の薬がわかる本，22-28，医歯薬出版，東京，2014.

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第3章

インプラント治療後に大きな病気に罹患したら？

—— 原　　著 ——

胃瘻療養中の脳血管障害患者に対する心身機能と摂食状況の調査

Physical, Mental Status and Eating Status of Convalescing Patients after Stroke with Gastrostomy

原　豪志，戸原　玄，近藤　和泉，才藤　栄一
東口　高志，早坂　信哉，植田耕一郎，菊谷　武
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Koji Hara, Haruka Tohara, Izumi Kondo, Eiichi Saito
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老年歯科医学　別刷
第29巻　第2号　57頁～65頁

―― 原　　著 ――

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抄録：経皮内視鏡的胃瘻造設術は，経口摂取が困難な患者に対して有用な栄養摂取方法である。しかしその適応基準はあるが，胃瘻造設後の経口開始基準や抜去基準はない。われわれは，胃瘻療養中の脳血管障害患者の心身機能と摂食状況を，複数の医療機関にて調査したので報告する。133名(男性72人，女性61人)を対象とし，その平均年齢は77.1±11.3歳であった。患者の基本情報，Japan Coma Scale（JCS），認知症の程度，Activities of daily living（ADL），口腔衛生状態，構音・発声の状態，気管切開の有無，嚥下内視鏡検査(Videoendoscopic evaluation of swallowing，以下VE)前の摂食状況スケール（Eating Status Scale，以下ESS），VEを用いた誤嚥の有無，VEを用いた結果推奨されるESS（VE後のESS），の項目を調査した。

居住形態は在宅と特別養護老人ホームで61.3%を占め，認知症の程度，ADLは不良な対象者が多かったが，半数以上は口腔衛生状態が良好であった。また，言語障害を有する対象者が多かった。対象者の82.7%は食物形態や姿勢調整で誤嚥を防止することができた。また，VE前・後のESSの分布は有意に差を認めた(p<0.01)。胃瘻療養患者に対して退院後の摂食・嚥下のフォローアップを含めた環境整備，嚥下機能評価の重要性が示唆された。

キーワード：胃瘻，PEG，脳血管障害，高齢者，訪問診療

緒　　言

脳血管障害は，摂食・嚥下障害の原疾患として最大の割合を占める。その摂食・嚥下障害の頻度は，急性期に約30～60%と高い割合であるが，その多くは数日から1カ月程度で改善し，慢性期まで持続する例は，約10%程度とされる[1,2)]。さらに才藤ら[3)]

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は「急性期には30～40%の嚥下障害があり，慢性期まで残るのは，10%以下である」とまとめている。しかし，嚥下障害が改善せず，経口摂取が再開できない場合は，消化管機能が保たれているのであれば，経腸栄養法の適応となる[4]。

胃瘻は，経口摂取が困難な患者に対する経腸栄養療法の有用な方法として位置づけられており，在宅でも取り扱いやすいという利点から，広く普及している。厚生労働省調査研究によると新規胃瘻造設件数は年間20万件，胃瘻カテーテル交換も60万件に達し，今後も胃瘻患者の増加が予測されることを報告している[5]。

日本消化器内視鏡学会のガイドライン[6]によると，PEGの適応として，①経腸栄養のアクセスとしての胃瘻造設(脳血管障害・認知症などのため自発的に摂食できない症例や神経筋疾患などのため嚥下不能または困難症例，咽喉頭・食道・胃噴門部狭窄症例など)，②誤嚥性肺炎を繰り返す例(摂食できてもしばしば誤嚥する例や経鼻胃管に伴う誤嚥)，③減圧目的(幽門狭窄や上部小腸閉塞)などが挙げられるが，胃瘻造設後の経口摂取の開始基準や抜去基準はない。

胃瘻造設後の入院患者に対して，嚥下機能評価や胃瘻の離脱を試みたという報告[7~12]もあり，胃瘻造設を行った患者の経口摂取再開の可能性を示唆する点において有益であるが，それらは単一の病院での調査であった。

われわれは，胃瘻造設患者に対しての転院・退院時の申し送り事項についての調査[13]を行い，胃瘻造設後の転院，退院先は，療養型病院，在宅が65%を占めており，転院，退院先での摂食・嚥下の専門的な介入は，半数近くが不可能であり，転院，退院先で専門的な介入が可能であれば，7割以上が部分的に摂食可能であると判断されたと報告している。在宅で療養している胃瘻患者の嚥下機能評価を行い，経口摂取を試みたという報告[14,15]も散見され，病院だけでなく，在宅や施設で療養している胃瘻患者の実態を，把握することは有益であると考える。本論文では複数の医療機関によって，在宅，介護施設で療養している胃瘻患者の心身機能，摂食状況を調査し，嚥下内視鏡検査を行ったので，その結果を報告する。

対象と方法

1．対　象

2011年9月から2013年の10月までの期間で，210名の在宅療養中の胃瘻患者に対して，56の複数機関(大学，医療研究センター，病院，開業医，訪問看護ステーション)に所属する医師・歯科医師・看護師が同一の用紙を用いて調査を行った。神経筋疾患を有する対象者は除外し，脳血管障害を主疾患とする133人を対象者とした。

2．調査項目

1）対象者の基本情報

年齢，性別，BMI，居住形態(在宅，特別養護老人ホーム，介護保健施設，有料老人ホーム，その他の介護施設)，胃瘻造設から本調査を行うまでの期間，胃瘻造設の理由(複数回答可：摂食・嚥下障害，認知症，低栄養，その他)，をアンケート用紙より抽出した。

2）意識障害の程度，認知症の程度と調査時の日常生活活動(Activities of daily living，以下ADL)

意識障害の程度はJapan Coma Scale (以下，JCS)を用いて評価した。認知症の程度は，認知症高齢者の日常生活自立度(表1)を用い，ADLは，障害老人の日常生活自立度(表2)，mRS[16](表3)を用いて評価した。

3）口腔衛生状態，構音，発声の状態，気管切開の有無

口腔衛生状態は，「良好」，「やや不良」，「不良」と分類した。構音の状態は，「良好」，「不良」，「不可」と分類した。発声の状態は，「良好」，「嗄声あり」，「不可」と分類した。また意思疎通が不可能もしくは，失語，気管切開のために構音や発声が施行でない場合は「不可」とした。

気管切開の有無は，「あり」と「なし」に分類され，スピーチカニューレやレティナカニューレを使用している対象者は「あり」とした。

4）嚥下内視鏡検査(Videoendoscopic evaluation of swallowing：VE)前の摂食状況スケール(Eating Status Scale，以下ESS)，誤嚥の有無，VE後の摂食状況スケール

摂食状況は，ESS[17](表4)を用いて次のように評

表1　認知症高齢者の日常生活自立度（老健第135号　厚生省老人保健福祉局長通知より）

ランク	判定基準	見られる症状・行動の例
Ⅰ	何らかの認知症を有するが，日常生活は家庭内及び社会的にほぼ自立している。	
Ⅱ	日常生活に支障を来すような症状・行動や意思疎通の困難さが多少見られても，誰かが注意していれば自立できる。	
Ⅱa	家庭外で上記Ⅱの状態が見られる。	たびたび道に迷うとか，買い物や事務，金銭管理などそれまでできたことにミスが目立つ等
Ⅱb	家庭内でも上記Ⅱの状態が見られる。	服薬管理ができない，電話の対応や訪問者との対応などひとりで留守番ができない等
Ⅲ	日常生活に支障を来すような症状・行動や意思疎通の困難さがときどき見られ，介護を必要とする。	
Ⅲa	日中を中心として上記Ⅲの状態が見られる。	着替え，食事，排便・排尿が上手にできない・時間がかかる，やたらに物を口に入れる，物を拾い集める，徘徊，失禁，大声・奇声を上げる，火の不始末，不潔行為，性的異常行為等
Ⅲb	夜間を中心として上記Ⅲの状態が見られる。	ランクⅢaに同じ
Ⅳ	日常生活に支障を来すような症状・行動や意思疎通の困難さが頻繁に見られ，常に介護を必要とする。	ランクⅢに同じ
M	著しい精神症状や問題行動あるいは重篤な身体疾患が見られ，専門医療を必要とする。	せん妄，妄想，興奮，自傷・他害等の精神症状や精神症状に起因する問題行動が継続する状態等

表2　障害高齢者の日常生活自立度（老健第102－2号 厚生省大臣官房老人保健福祉部長通知）

生活自立	ランクJ	何らかの障害等を有するが，日常生活はほぼ自立しており独力で外出する 1. 交通機関等を利用して外出する 2. 隣近所なら外出する
準寝たきり	ランクA	屋内での生活は概ね自立しているが，介助なしには外出しない 1. 介助により外出し，日中はほとんどベッドから離れて生活をする 2. 外出の頻度が少なく，日中も寝たり起きたりの生活をしている
寝たきり	ランクB	屋内での生活は何らかの介助を要し，日中もベッド上での生活が主体であるが，座位を保つ 1. 車いすに移乗し，食事，排泄はベッドから離れて行う 2. 介助により車いすに移乗する
寝たきり	ランクC	1日中ベッド上で過ごし，排泄，食事，着替えにおいて介助を要する 1. 自力で寝返りをうつ 2. 自力で寝返りもうたない

価した。「1．経管のみ；経口摂取を行っていない」，「2；経管＞経口；一部経口摂取を行っているが，栄養摂取は主に経管栄養」，「3；経管＜経口；一部経管栄養を行っているが，栄養摂取は主に経口摂取」，「4；経口調整；食形態の調整や代償法が必要」，「5；経口調整不要；食形態や代償法を必要としない」。より具体的には，いわゆるお楽しみレベルの経口摂取にて，まれに一口程度の経口摂取を行う場合は経管のみとし，1日に数口程度持続的に経口摂取を行っている場合は，経管＞経口とした。食事として1日に1回経口摂取を行う場合にはこれに含めた。また，食事として2回以上経口摂取を行っている場合を経管＜経口とした。例えば3食経口摂取をしていても水分を胃瘻から補給するような場合には，経管＜経口に含めた。

VEは医師・歯科医師が行い，食物形態や姿勢調

表3　日本版 modified Rankin Scale(mRS)判定基準書

modified Rankin Scale	
0	まったく症候がない
1	症候はあっても明らかな障害はない 日常の勤めや活動は行える
2	軽度の障害 発症以前の活動がすべて行えるわけではないが自分の身の回りのことは介助なしに行える
3	中等度の障害 何らかの介助を必要とするが，歩行は介助なしに行える
4	中等度から重度の障害 歩行や身体的要求には介助が必要である
5	重度の障害 寝たきり，失禁状態，常に介護と見守りを必要とする
6	死亡

表4　摂食状況スケール

5	経口調整不要*
4	経口調整要*
3	経口>経管
2	経口<経管
1	経管のみ

*経口調整：食物形態や体位などの摂食時の工夫を指す

節により誤嚥を防止できた場合，誤嚥を防ぐ手法ありと定義し，誤嚥を防止できなかった場合，誤嚥を防ぐ手法なしと定義した。また，食物形態は，対象者の嚥下障害の重症度に応じて，ゼリー，トロミ水，ミキサー食などを選択した。最後に，VE の結果をもとに推奨される栄養摂取方法を，VE 後の ESS とした。

3．統　計

統計処理は，VE 前の ESS と VE 後の ESS のいずれも記載があり，嚥下内視鏡検査を施行した106名について，VE 前・後の ESS の差異を，Wilcoxon's signed rank test を用いて検討した。本調査は日本大学歯学部倫理委員会の承認（承認番号，倫許2011-4）を受けて行った。

結　　果

対象者の基本情報を表5に記す。対象者133人(男性72人，女性61人)の平均年齢は77.1±11.3歳であった。BMI は97名(無記載は36名)の対象者のうち平均18.7±2.5であった。胃瘻造設の理由として，摂食・嚥下障害は133名中の120人(90.2%)，認知症は133名中の13名(9.8%)，低栄養は133名中の9名(6.8%)，グループホームや介護付き有料老人ホームなどを含むその他の介護施設は133名中の8名(6%)であり，摂食・嚥下障害により胃瘻を造設した対象者が多数であった。

続いて，対象者の意識障害の程度，認知症の程度，ADL，口腔衛生状態，構音・発声の状態，気管切開の有無を表6に記す。JCS(無記載は2名)はⅠが最多で38.9%，清明は16.8%存在したが，JCS のⅡ，Ⅲは合わせて44.3%であった。認知症高齢者の日常生活自立度(無記載は5名)でⅣ，M であった対象者は53.9%であり，日常生活に支障をきたす症状や行動，意思疎通の困難さのために，常に介護を要する対象者が半数であった。障害老人の日常生活自立度(無記載は1名)で，B，C であった対象者が85.7%，mRS(無記載は5名)で4，5であった対象者が90.6%であり，ADL の不良な対象者が多かった。その一方，口腔衛生状態は，半数以上が良好に保たれていた(無記載は1名)。また構音(無記載は3名)は，良好であるものが28.5%であったのに対し，発声(無記載はなし)が良好であるものは，42.9%であった。気管切開の有無(無記載は2名)は，なしが多数であったが，ありが8.4%存在した。

対象者の ESS と誤嚥を防ぐ手法の有無について，表7に記す。VE 前の ESS(無記載は9名)は，経管のみであった対象者が88名(71%)で最多だったが，VE 後の ESS（無記載は16名)は，経管>経口であった対象者68名(58.1%)と最多であった。誤嚥を防ぐ手法の有無について(無記載は23名)，全体

表5　対象者の基本情報

	人数	割合(%)
年齢(歳)	77.1±11.3, N=133	
性別	133	
男性	72	54.1
女性	61	45.9
BMI	18.7±2.7, N=97	
居住形態	129	
在宅	62	48.1
特別養護老人ホーム	17	13.2
介護保健施設	14	10.9
有料老人ホーム	11	8.5
その他	25	19.4
胃瘻造設から調査までの期間(月)	19.7±18 (range 1〜76)	
胃瘻造設の理由(複数回答可)	133	
摂食・嚥下障害	120	90.2
認知症	13	9.8
低栄養	9	6.8
その他	8	6.0
原疾患	133	
脳梗塞	72	54.1
脳出血	36	27.1
くも膜下出血	16	12.0
不明(脳血管障害とのみ記載)	9	6.8

の82.7%の対象者は食物形態や姿勢調節により誤嚥を防止することが可能であった。

VE前のESSとVE後のESSの差異を表8に記す。VE前・後のESSの分布は有意に差を認めた($p<0.01$)。VE前のESSと比較して，VE後のESSが増加した対象者は51名(48.1%)，不変であった対象者は51名(48.1%)，減少した対象者は4名(3.8%)であり，増加した51名のうち，49名はVE前のESSが，経管のみであった。

考　察

1．対象者の基本情報と調査項目について(表5, 6)

本調査において，意識障害の程度，認知症の程度，ADLが不良な対象者が多かった。脳卒中治療ガイドライン[18]によれば，維持期の患者において筋力，体力，歩行能力などを維持向上させるために，訪問または外来リハビリテーションが推奨されている。また，重度の運動麻痺や半側空間無視などで自然回復が期待できない場合でも，長期のリハビリテーションでADLが改善することもあり[19]，ADLが不良な高齢者に対しては訪問リハビリテーション

表6　対象者の意識障害の程度，認知症の程度，日常生活動作，口腔咽頭機能，気管切開の有無について

	人数	割合(%)
JCS	131	
清明	22	16.8
I	51	38.9
II	39	29.8
III	19	14.5
認知症高齢者の日常生活自立度	128	
なし	23	18.0
I	6	4.7
II	10	7.8
III	20	15.6
IV	53	41.4
M	16	12.5
障害老人の日常生活自立度	132	
なし	2	1.5
J	3	2.3
A	14	10.6
B	60	45.5
C	53	40.2
mRS	128	
0	1	0.8
1	0	0
2	3	2.3
3	8	6.3
4	69	53.9
5	47	36.7
口腔衛生状態	132	
良好	72	54.5
やや不良	43	32.6
不良	17	12.9
構音	130	
良好	37	28.5
不良	44	33.8
不可	49	37.7
発声	133	
良好	57	42.9
嗄声あり	30	22.6
不可	46	34.6
気管切開の有無	131	
あり	11	8.4
なし	120	91.6

mRS : Modified Rankin Scale

J. Neurol. Neurosurg. Psychiatry., **52**：236～241, 1989.
2）Daniels, SK., Brailey, K., Priestly, DH., Herrington, LR., Weisberg, LA., Foundas, AL.：Aspiration in patients with acute stroke, Arch. Phys. Med. Rehabil., **79**：14～19, 1998.
3）才藤栄一，千野直一：脳血管障害による嚥下障害のリハビリテーション，総合リハ，**19**：611～615, 1991.
4）A.S.P.E.N. Board of Directors：Guidelines for the use of parenteral and enteral nutrition in adults and pediatric patients, JPEN., **9**：608～617, 1985.
5）鈴木　裕：認知症患者の胃ろうガイドラインの作成—原疾患，重症度別の適応・不適応，見直し，中止に関する調査研究，厚生労働省調査研究事業，2012.
6）上野文昭　ほか：経皮内視鏡的胃瘻造設術ガイドライン.「消化器内視鏡ガイドライン　第3版」（日本消化器内視鏡学会監修），医学書院，2006.
7）Yokohama, S., Aoshima, M., Koyama, S., Hayashi, K., Shindo, J. and Maruyama, J.：Possibility of oral feeding after induction of percutaneous endoscopic gastrostomy, J. Gastroenterol. Hepatol., **25**：1227～1231, 2010.
8）佐藤　武，佐藤和典：当院における経皮内視鏡的胃瘻造設術施行患者の予後因子の検討，日老医会誌，**50**：96～103，2013.
9）Krieger, RP., Brady, S., Stewart, RJ., Terry, A. and Brady, JJ.：Predictors of returning to oral feedings after feeding tube placement for patients poststroke during inpatient rehabilitation, Top Stroke Rehabil., **17**：197～203, 2010.
10）Paramsothy, S., Papadopoulos, G., Mollison, LC. and Leong, RW.：Resumption of oral intake following percutaneous endoscopic gastrostomy, J. Gastroenterol. Hepatol., **24**：1098～1101, 2009.
11）Yi, Y., Yang, EJ., Kim, J., Kim, WJ., Min, Y. and Paik, NJ.：Predictive factors for removal of percutaneousendoscopic gastrostomy tube in post-stroke dysphagia, J. Rehabil. Med., **44**：922～925, 2012.
12）Ickenstein, GW., Kelly, PJ., Furie, KL., Ambrosi, D., Rallis, N., Goldstein, R., Horick, N. and Stein, J.：Predictors of feeding gastrostomy tube removal in stroke patients with dysphagia, J. Stroke Cerebrovasc. Dis., **12**：169～174, 2003.
13）近藤和泉：平成24年度長寿科学総合研究事業報告書，76～77，2012.
14）松香芳三，笈田育尚，熊田　愛，縄稚久美子，西山憲行，菊谷　武，窪木拓男：家族の介護により経口摂取が可能となり，胃瘻から脱却した症例，老年歯学，**24**：91～96，2009.
15）齋藤貴之，戸原　玄，半田直美，飯田貴俊，井上統温，和田聡子，内山　宙，小林健一郎，中川兼佑，植田耕一郎，櫻井　薫：摂食機能療法ならびに多職種のチーム連携によりQOLが改善された1例，老年歯学，**26**：18～24，2011.
16）Quinn, TJ., Dawson, J., Walters, MR. and Lees, KR.：Functional outcome measures in contemporary stroke trials, Int. J. Stroke., **4**：200～205, 2009.
17）才藤栄一：平成11年度長寿科学総合研究事業報告書，1～17，2000.
18）脳卒中治療ガイドライン，日本脳卒中学会，2009.
19）Dam, M., Tonin, P., Casson, S., Ermani, M., Pizzolato, G. and Iaia, V.：The effects of long-term rehabilitation therapy on poststroke hemiplegic patients, Stroke, **24**：1186～1191, 1993.
20）坪井章雄，新井光男，松若寿男：訪問リハビリテーションにおける座位保持訓練の効果—寝たきりの在宅高齢障害者を対象として—，作業療法，**20**：36～44，2001.
21）坪井章雄，新井光男，松若寿男：在宅高齢障害者に対する訪問リハビリテーションの効果—大腿骨頸部骨折後の「寝たきり」の生活レベルから，受傷前の生活レベルに改善した一症例を通して—，作業療法，**19**：120～126，2000.
22）坪井章雄，新井光男：訪問リハビリテーションにおける高齢障害者の在宅介護継続因子の検討—在宅介護継続例と破綻例の介護者の心理的側面より—，作業療法，**18**：402～409，1999.
23）藤島一郎，佐藤有理：嚥下専門外来，MB Med. Reha.，**100**：13～19，2008.
24）Yoneyama, T., Yoshida, M., Matsui, T. and Sasaki, H.：Oral care and pneumonia, Oral Care Working Group, Lancet, **354**(9177)：515, 1999.
25）Yoneyama, T., Yoshida, M., Ohrui, T., Mukaiyama, H., Okamoto, H., Hoshiba, K., Ihara, S., Yanagisawa, S., Ariumi, S., Morita, T., Mizuno, Y., Ohsawa, T., Akagawa, Y., Hashimoto, K. and Sasaki, H.：Oral Care Working Group, J. Am. Geriatr. Soc., **50**：430～433, 2002.
26）才藤栄一：摂食・嚥下リハビリテーション，第1版，p215～222，医歯薬出版，東京，2007.
27）厚生労働省：第3-28・29表．平成18年身体障害児・者実態調査結果，2008.
28）半田理恵子：在宅言語障害患者をめぐる現状と課題，訪問看護と介護，**10**：336～370，2005.
29）Wu, C.H., Hsiao, T.Y., Chen, J.C., Chang, Y.C. and Lee, S. Y.：Evaluation of swallowing safety with fiberoptic endoscope：comparison with videofluoroscopic technique, Laryngoscope., **107**：396～401, 1997.
30）Langmore, SE., Schatz, K. and Olson, N.：Endoscopic and videofluoroscopic evaluations of swallowing and aspiration. Ann. Otol. Rhinol. Laryngol., **100**：678～681, 1991.
31）服部史子，戸原　玄，中根綾子，大内ゆかり，後藤志乃，三串伸哉，若杉葉子，高島真穂，小城明子，都島千明，植松　宏：在宅および施設入居摂食・嚥下障害者の栄養摂取方法と嚥下機能の乖離，日摂食・嚥下リハ会誌，**12**：101～108，2008.
32）稲本陽子，小口和代，保田祥代，才藤栄一：脳血管障害による摂食・嚥下障害患者の退院後のフォローアップ，日摂食・嚥下リハ会誌，**8**：135～142，2004.

33) 若杉葉子，戸原　玄，日野多加美，三瓶龍一，鰕原賀子，岡田猛司，島野嵩也，植松　宏：摂食・嚥下障害患者の退院後の摂食状況　退院後フォローの重要性について，日摂食・嚥下リハ会誌，16：198〜202，2012.

Physical, Mental Status and Eating Status of Convalescing Patients after Stroke with Gastrostomy

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Percutaneous endoscopic gastrostomy need easy operation, and gastrostomy is useful enteral nutrition for dysphagic patients. Although the guidelines for the application of PEG are established, there are no guidelines for the resumption of oral ingestion for patients with PEG or removal PEG. Our aim was to investigate the body function and eating status of convalescing patients after stroke with gastrostomy by multiple centers. 133 patients (men 72, women 61) were enrolled (mean age were 77.1 ± 11.3). We investigated the patients' basic data, Japan Coma Scale ; JCS, cognitive function, Activities of daily living ; ADL, oral hygiene, the presence of dysarthria and dysphonia, the presence of tracheostomy, the Eating Status Scale ; ESS at the investigation (the ESS pre-Videoendoscopic evaluation of swallowing ; VE), the presence of aspiration by VE and the desirable ESS by the result of VE (the ESS post-VE). 61.3 % of the patients lived in their home or nursing home. The cognition and ADL of most patients were poor, but more than half of them showed favorable oral hygiene. There were many patients with dysarthria and dysphonia. 82.7% of 110 patients were evaluated as non-aspiration by VE. There was a significant difference between the ESS pre-VE and the ESS post-VE ($p<0.01$). The present study showed the importance of swallowing evaluation for convalescing patients with gastrostomy after discharge from hospital.

Key words : gastrostomy, PEG, cerebral vascular disease, elderly, visiting treatment

Geriatr Gerontol Int 2014; **14 (Suppl. 1):** *93–101*

ORIGINAL ARTICLE

Development of a simple screening test for sarcopenia in older adults

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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

Accepted for publication 17 October 2013.

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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 Sarcopenia (n = 139)	No sarcopenia (n = 838)	P	Women 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

Table 4 Score charts for estimated probability of sarcopenia

Variables	Value													
Men														
Age			<66	66	68	70	72	74	76	78	80	82	84	86≦
Score			0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11
Grip strength		<20	20	23	26	29	32	35	38	41	44	47	50≦	
Score		+99	+90	+81	+72	+63	+54	+45	+36	+27	+18	+9	0	
Calf circumference	<26	26	28	30	32	34	36	38	40	42≦				
Score	+81	+72	+63	+54	+45	+36	+27	+18	+9	0				
Estimated individual probability of sarcopenia														
Sum score	70	80	90	95	100	105	110	115	120	125	130	135	140	145
Probability (%)	1	2	5	8	13	19	28	39	51	64	74	83	89	93
Women														
Age			<66	66	68	70	72	74	76	78	80	82	84	86≦
Score			0	+2	+4	+6	+8	+10	+12	+14	+16	+18	+20	+22
Grip strength		<14	14	16	18	20	22	24	26	28	30	32	34≦	
Score		+110	+100	+90	+80	+70	+60	+50	+40	+30	+20	+10	0	
Calf leg circumference			<26	26	28	30	32	34	36	38	40	42≦		
Score			+63	+56	+49	+42	+35	+28	+21	+14	+7	0		
Estimated individual probability of sarcopenia														
Sum score	80	90	95	100	105	110	115	120	125	130	135	140	145	150
Probability (%)	1	3	5	8	12	19	28	39	51	63	74	82	88	93

Values for each variable are given with such intervals that the scores show small steps, and scores for intermediate values can be estimated by linear interpolation. The exact formula to calculate the scores are as follows: score in men, 0.62 × (age – 64) – 3.09 × (grip strength – 50) – 4.64 × (calf circumference – 42); score in women, 0.80 × (age – 64) – 5.09 × (grip strength – 34) – 3.28 × (calf circumference – 42). The corresponding probabilities of sarcopenia are calculated with the following formulae: probability in men, $1 / [1 + e^{-(\text{sum score} / 10 - 11.9)}]$; probability in women, $1 / [1 + e^{-(\text{sum score} / 10 - 12.5)}]$.

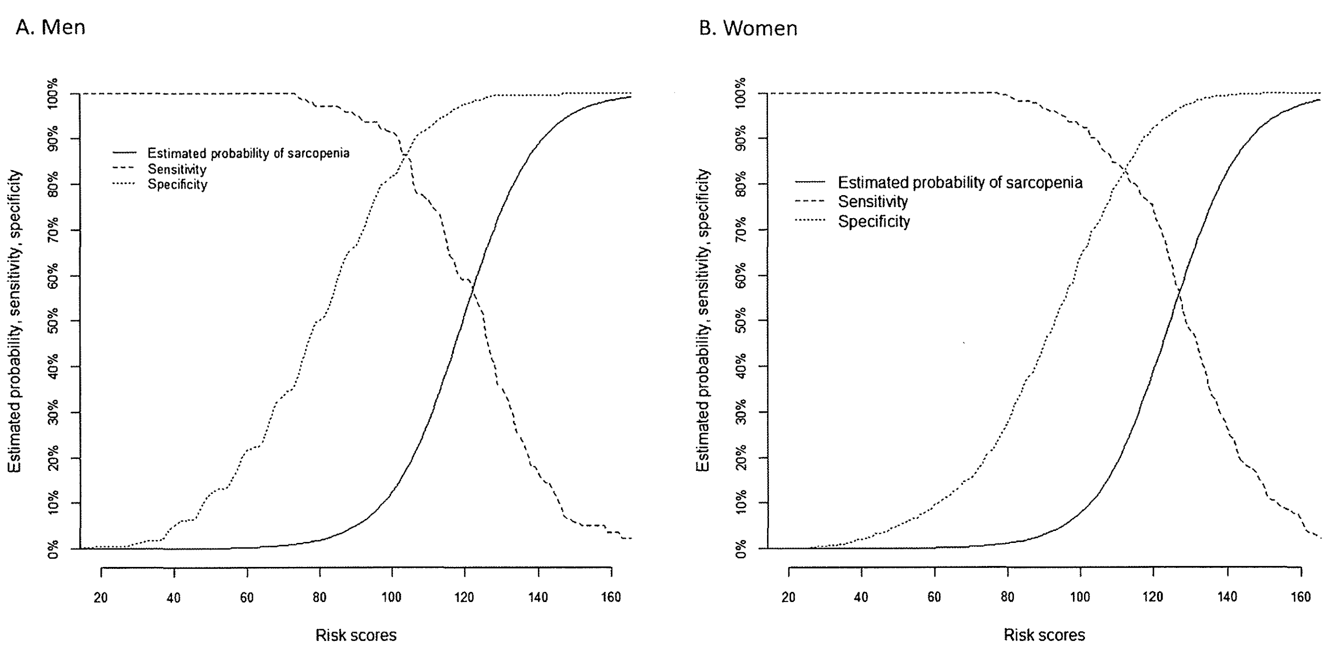

Figure 1 Estimated probabilities, sensitivity and specificity corresponding to sum scores. The sum scores and corresponding estimated probabilities are read from Table 3.

be applicable to populations of other race/ethnicity or in other countries. Similarly, caution should be exercised in projecting beyond the range of our data. For example, the obese were underrepresented in our data, and the performance of our models was not assessed for the obese. However, the present findings suggest that three variables, namely age, grip strength and calf circumference, should be considered for inclusion in the development of sarcopenia screening in other populations. Third, although the internal validity was good (i.e. the models would perform well in a similar population), assessment of external validity is still warranted to determine whether the results can be extended to other Japanese populations. Finally, we could not exclude the possibility of the healthy volunteer effect (i.e. volunteers for clinical studies tend to be healthier than the general population). Although participants were randomly selected from the resident register, participation was voluntary and the response rate was approximately 17%. However, the sensitivity analysis showed that the models' ability to estimate the probability of sarcopenia remained excellent when participants with more severely impaired muscle function were categorized as having sarcopenia.

In conclusion, we showed that the presence of sarcopenia in older adults could be detected with high accuracy using three easily obtainable variables. Importantly, we derived the models from a functionally independent, community-dwelling population. Functionally independent older adults with sarcopenia are good candidates for interventions to prevent further physical limitations, given their potential for regaining muscle mass and restoration of muscle function. The score charts we developed can be used as an effective screening tool and help identify functionally independent older adults with sarcopenia.

Acknowledgments

This work was supported by a Health and Labor Sciences Research Grant (H24-Choju-Ippan-002) from the Ministry of Health, Labor, and Welfare of Japan. The authors thank the staff members and participants of the Kashiwa study and the following individuals for helping with the acquisition of data: Dr Yoshiya Oishi PhD DDS, Oishi Dental Clinic. Yuki Ohara, Tokyo Metropolitan Geriatric Institute of Gerontology; Dr Noriaki Takahashi and Dr Hiroyasu Furuya, The Nippon Dental University; Seigo Mitsutake, Tokyo Metropolitan Institute of Gerontology; Mr Masashi Suzuki, Institute of Gerontology, The University of Tokyo; and staff members of The Institute of Healthcare Innovation Project, The University of Tokyo.

Disclosure statement

The authors declare no conflict of interest.

References

1 Cruz-Jentoft AJ, Baeyens JP, Bauer JM *et al.* Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010; **39**: 412–423.
2 Yamada M, Arai H, Yoshimura K *et al.* Nutritional supplementation during resistance training improved skeletal muscle mass in community-dwelling frail older adalts. *J Frailty Aging* 2012; **1**: 64–70.
3 Waters DL, Baumgartner RN, Garry PJ, Vellas B. Advantages of dietary, exercise-related, and therapeutic interventions to prevent and treat sarcopenia in adult patients: an update. *Clin Interv Aging* 2010; **5**: 259–270.
4 Visvanathan R, Chapman I. Preventing sarcopaenia in older people. *Maturitas* 2010; **66**: 383–388.
5 Peterson MD, Sen A, Gordon PM. Influence of resistance exercise on lean body mass in aging adults: a meta-analysis. *Med Sci Sports Exerc* 2011; **43**: 249–258.
6 Rosenberg IH. Sarcopenia: origins and clinical relevance. *J Nutr* 1997; **127**: 990S–991S.
7 Mijnarends DM, Meijers JM, Halfens RJ *et al.* Validity and reliability of tools to measure muscle mass, strength, and physical performance in community-dwelling older people: a systematic review. *J Am Med Dir Assoc* 2013; **14**: 170–178.
8 Shafer KJ, Siders WA, Johnson LK, Lukaski HC. Validity of segmental multiple-frequency bioelectrical impedance analysis to estimate body composition of adults across a range of body mass indexes. *Nutrition* 2009; **25**: 25–32.
9 Tanimoto Y, Watanabe M, Sun W *et al.* Association between muscle mass and disability in performing instrumental activities of daily living (IADL) in community-dwelling elderly in Japan. *Arch Gerontol Geriatr* 2012; **54**: e230–e233.
10 Nagasaki H, Itoh H, Hashizume K, Furuna T, Maruyama H, Kinugasa T. Walking patterns and finger rhythm of older adults. *Percept Mot Skills* 1996; **82**: 435–447.
11 Ainsworth BE, Bassett DR, Jr, Strath SJ *et al.* Comparison of three methods for measuring the time spent in physical activity. *Med Sci Sports Exerc* 2000; **32**: S457–S464.
12 Frank EH, Jr. *Regression Modeling Strategies : With Applications to Linear Models, Logistic Regression, and Survival Analysis*, 1st edn. New York, NY: Springer, 2001.
13 Hastie T, Tibshirani R, Friedman J. *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd edn. New York, NY: Springer, 2009.
14 Steyerberg EW, Harrell FE, Borsboom GJJM, Eijkemans MJC, Vergouwe Y, Habbema JDF. Internal validation of predictive models: efficiency of some procedures for logistic regression analysis. *J Clin Epidemiol* 2001; **54**: 774–781.
15 Steyerberg EW. *Clinical Prediction Models*, 1st edn. New York, NY: Springer, 2009.
16 Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology* 1982; **143**: 29–36.
17 Faraggi D, Reiser B. Estimation of the area under the ROC curve. *Stat Med* 2002; **21**: 3093–3106.
18 Homer D, Lemeshow S. *Applied Logistic Regression*. New York: John Wiley & Sons, 2000.

19 Rolland Y, Lauwers-Cances V, Cournot M *et al.* Sarcopenia, calf circumference, and physical function of elderly women: a cross-sectional study. *J Am Geriatr Soc* 2003; **51**: 1120–1124.
20 Chen BB, Shih TT, Hsu CY *et al.* Thigh muscle volume predicted by anthropometric measurements and correlated with physical function in the older adults. *J Nutr Health Aging* 2011; **15**: 433–438.
21 Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. *J Gerontol A Biol Sci Med Sci* 2002; **57**: M772–M777.
22 McIntosh EI, Smale KB, Vallis LA. Predicting fat-free mass index and sarcopenia: a pilot study in community-dwelling older adults. *Age (Dordrecht, Netherlands)* 2013; **35**: 2423–2434.
23 Kenny AM, Dawson L, Kleppinger A, Iannuzzi-Sucich M, Judge JO. Prevalence of sarcopenia and predictors of skeletal muscle mass in nonobese women who are long-term users of estrogen-replacement therapy. *J Gerontol A Biol Sci Med Sci* 2003; **58**: M436–M440.
24 Muscaritoli M, Anker SD, Argiles J *et al.* Consensus definition of sarcopenia, cachexia and pre-cachexia: joint document elaborated by Special Interest Groups (SIG) "cachexia-anorexia in chronic wasting diseases" and "nutrition in geriatrics". *Clin Nutr* 2010; **29**: 154–159.
25 Abellan van Kan G, Rolland Y, Andrieu S *et al.* Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *J Nutr Health Aging* 2009; **13**: 881–889.
26 Henriksson M, Hirschfeld H. Physically active older adults display alterations in gait initiation. *Gait Posture* 2005; **21**: 289–296.
27 Polcyn AF, Lipsitz LA, Kerrigan DC, Collins JJ. Age-related changes in the initiation of gait: degradation of central mechanisms for momentum generation. *Arch Phys Med Rehabil* 1998; **79**: 1582–1589.
28 Tanimoto Y, Watanabe M, Sun W *et al.* Association of sarcopenia with functional decline in community-dwelling elderly subjects in Japan. *Geriatr Gerontol Int* 2013; **13**: 958–63.

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1 Receiver operating characteristic curves of models estimating the probability of sarcopenia.
Figure S2 Receiver operating characteristic curves of models estimating the probability of sarcopenia based on different cut-off values for grip strength and usual gait speed.
Table S1 Application of Score Chart in two hypothetical patients.

One-leg standing time with eyes open: comparison between the mouth-opened and mouth-closed conditions

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Objective: Many studies report a significant relationship between the one-leg standing time with the eyes open and the occlusal relationship. To determine the association between proprioception (the periodontal membrane vs muscle spindle) to the one-leg standing time, the authors compared the one-leg standing time with eyes open between mouth-opened and mouth-closed conditions.
Methods: The study participants were 107 healthy, elderly patients. The authors measured the one-leg standing time with eyes open between mouth-opened and mouth-closed conditions.
Results: The one-leg standing time was significantly shorter with the mouth opened (21.1±19.1 seconds) than with the mouth closed (25.1±21.4 seconds). Patients whose one-leg standing time was equal or shorter with the mouth opened than with the mouth closed were not different from the other patients with regard to age, handgrip strength, BMI, and the number of remaining teeth.
Discussion: The vertical mandibular position may affect body balance.

Keywords: Handgrip strength, One leg standing time with eyes open, Remaining teeth

Introduction

In today's aging society, a variety of initiatives have been proposed to address a major focus in primary care: falls and fractures prevention. The World Health Organization (WHO) declared the 2000–2010 decade as the Bone and Joint Decade.[1] In response, Japan has taken active steps towards preventing primary nursing care and nursing care risks due to locomotive difficulty. This is fueled by new concepts of the locomotive syndrome. A method of assessing the risk of falling is the one-leg standing time with the eyes open.[2] Several reports suggest that this standing time is significantly related to the number of remaining teeth and the occlusal relationship.[3–6] However, the causal relationship between these factors is not yet fully understood, and it is assumed that the connection lies between the proprioception of muscle spindles (e.g. the periodontal membrane or the masseter muscle).[7] Some researchers have examined the relationship between body posture and the mandibular position by using a stabilometer in young subjects, and they concluded that the foot center of pressure is not influenced by asymmetric malocclusion or by different dental positions.[8–10] This may indicate a need to focus on the effects of extreme mandibular positions in the elderly population to reveal this relationship.

If the proprioception of the periodontal membrane and muscle spindle affect the one-leg standing time with eyes open, a difference between one-leg standing times with the mouth opened and mouth closed would be expected. Therefore, to determine whether such a difference existed, the authors measured and compared the one-leg standing times with the eyes open and the mouth opened and mouth closed in community-dwelling elderly people.

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DOI 10.1179/2151090314Y.0000000007

Table 1 Comparison between the sexes in age, grip strength, body mass index, number of remaining teeth, and normal one-leg standing time with eyes open (mouth closed)

	Sexes		
Physical Indices	Male	Female	*P*
Age (years)	75.9±5.1	75.4±5.1	0.650^{NS}
Hand grip strength (kg)	33.0±6.5	19.5±4.5	0.000*
BMI (kg/m^2)	24.4±2.5	24.6±3.2	0.903^{NS}
Number of remaining teeth	22.4±8.0	19.0±9.6	0.932^{NS}
Normal one-leg standing time (seconds)	25.3±22.3	25.0±21.2	0.071^{NS}

Note: BMI=body mass index; NS=no significant difference.
*P<0.05, based on the Mann–Whitney U test.

Methods

Healthy elderly residents (32 men and 75 women) aged 65–89 years (average age, 75.6±5.1 years) from the Yahatahigashi Ward of Kitakyushu City, Japan were selected for the study. All participants came to the research area (i.e. a community center) voluntarily. Brief medical interviews were performed. Patients with bone and joint disease, neuromuscular diseases, or temporomandibular disorders were excluded as subjects. The study was approved by the Saiseikai Yahata General Hospital Ethics Committee and was conducted with assistance from the Saiseikai Yahata General Hospital in Kokura, Japan.

The authors measured physical indices such as height, weight, and grip strength in the dominant hand and the one-leg standing times with the eyes open. Body mass index (BMI) was calculated by weight/height^2. For the one-leg standing time with eyes open, the authors measured the length of time with the mouth closed (i.e. 'normal') and with the mouth wide open—each for a maximum of 60 seconds. The authors randomized the order of measurements (i.e. open versus close) and waited a minimum of 1 minute between measurements. A dentist confirmed the number of remaining teeth through an intraoral examination: wisdom teeth were included in the measurement, but roots were excluded.

The statistical software PASWver.18 (IBM, Tokyo, Japan) was used for the analysis. These physical indices were compared by nonparametric analysis because one-leg standing times were counted up to 60 seconds. Spearman's rank correlation coefficient was assessed between the normal one-leg standing times and the age, grip strength, BMI and number of remaining teeth. Using the Wilcoxon signed-rank test, one-leg standing times with the mouth closed were compared to one-leg standing times with the mouth opened. Furthermore, subjects were divided into two subgroups: (1) patients whose one-leg standing times were equal or shorter with the mouth opened than with the mouth closed and (2) patients whose one-leg standing times were prolonged with the mouth opened. Physical indices of these subgroups were compared using the Mann–Whitney *U* test. The significance level was set at 0.05.

Results

The mean number of remaining teeth was 20.1±9.2. Everyone who had lost molar teeth contacts on both sides was wearing removable dentures. There was no difference between the sexes for all physical indices examined, except for grip strength (Table 1). Therefore, all variables were compared between both sexes. A significant correlation was observed between normal one-leg standing time with eyes open and age, handgrip strength, BMI, and the number of remaining teeth (Table 2).

The average one-leg standing times with the mouth closed and with the mouth opened were 24.84±21.33 and 21.55±19.24 seconds, respectively. The time was significantly shorter with the mouth opened than with the mouth closed. The shortened group patients, whose standing time was equal or shortened with the mouth opened than with the mouth closed, consisted of 19 males and 46 females. The prolonged group patients, whose time with the mouth opened was prolonged, consisted of 13 males and 29 females. There were no significant differences between the two

Table 2 Comparison between the normal one-leg standing time with eyes open (mouth closed) and the age, grip strength, BMI, and number of remaining teeth

		Age	Grip strength	Body mass index	Number of remaining teeth
Normal one-leg standing time	Correlation coefficient	−0.376	0.193	−0.194	0.316
	P	0.000*	0.047*	0.045*	0.001*

Note: *P<0.05, based on Spearman's rank correlation coefficient.