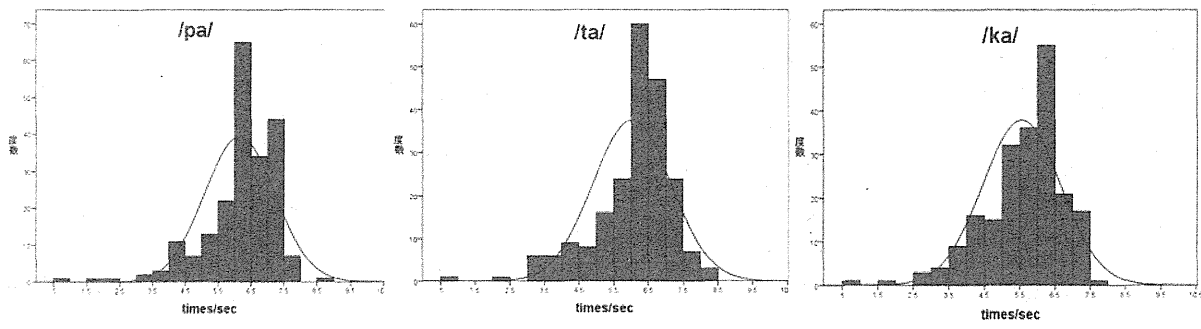

図　対象者212名におけるOD別の分布

表2　ODの性別・年代群別平均値と中央値

	55～64歳			65～74歳			75歳以上		
	全体 n=42	男性 n=19	女性 n=23	全体 n=88	男性 n=29	女性 n=59	全体 n=82	男性 n=38	女性 n=44
/pa/	6.5±0.8 6.6	6.6±0.8 6.8	6.5±0.7 6.6	6.2±1.2 6.4	6.1±1.2 6.2	6.3±1.0 6.4	5.8±1.0[ad] 6.2	5.9±1.3 6.3	5.8±1.1[bc] 6.1
/ta/	6.5±0.9 6.7	6.6±1.0 6.8	6.5±0.9 6.6	6.1±1.0[b] 6.2	6.1±1.2 6.0	6.1±1.0 6.2	5.7±1.2[d] 6.0	6.0±1.2 6.4	5.4±1.2[ad †] 5.9
/ka/	6.1±0.8 6.2	5.9±0.9 5.8	6.2±0.8 6.4	5.7±1.0 5.8	5.5±0.9 5.6	5.7±1.0 6.0	5.2±1.3[d] 5.6	5.3±1.3 5.6	5.1±1.2[ad] 5.4

上より平均回数±標準偏差，中央値を示す．
[a]$p<0.05$ vs 65～74歳　[b]$p<0.05$ vs 55～64歳　[c]$p<0.01$ vs 65～74歳　[d]$p<0.01$ vs 55～64歳
[†]$p<0.05$ vs. 75歳以上男性．

表3　ODの性別・年代群別95%信頼区間，平均－2標準偏差値

	55～64歳			65～74歳			75歳以上		
	全体 n=42	男性 n=19	女性 n=23	全体 n=88	男性 n=29	女性 n=59	全体 n=82	男性 n=38	女性 n=44
/pa/	6.31～6.77 4.9	6.23～6.99 5.0	6.17～6.81 5.1	6.02～6.47 3.8	5.65～6.56 3.8	6.07～6.57 4.3	5.59～6.11 3.8	5.53～6.38 3.3	5.43～6.10 3.6
/ta/	6.26～6.83 4.7	6.01～7.02 4.6	6.14～6.92 4.7	5.86～6.30 4.1	5.64～6.53 3.7	5.82～6.33 4.1	5.41～5.95 3.3	5.69～6.38 3.6	5.06～5.80 3.0
/ka/	5.80～6.32 4.5	5.46～6.35 4.1	5.87～6.53 4.6	5.45～5.86 3.7	5.19～5.90 3.7	5.45～5.97 3.7	4.90～5.45 2.6	4.88～5.74 2.7	4.69～5.43 2.7

それぞれ上段より95%信頼区間：下限～上限，平均－2 SD値を示す．

年代群間に有意差は認めなかった．なお，義歯装用の有無と，各OD値には，有意な関連性は認めなかった．

表3に「平均値－2SD値」による各OD値の下限基準値を示す．55～64歳群では4.9回(/pa/)，4.7回(/ta/)，4.5回(/ka/)であったが，65～74歳群では3.8回(/pa/)，4.1回(/ta/)，3.7回(/ka/)と減少した．75歳以上群では，/pa/は3.8回と変わらなかったが，/ta/と/ka/はそれぞれ3.3回，2.9回とさらに低下した．性別ごとの検討では，女性の/ta/において経年的低下が顕著に観察された．

考　察

本研究において，OD値を用いた構音機能の評価を横断的に検討したところ，75歳以上の者における各OD値は，他の年齢群と比較して有意に低値であった．これらの結果より，後期高齢者においては，構音機能の低下が顕著となるため，口腔機能向上に関する介護予防的アプローチを行う必要性について，構音機能の数量的評価

からも明確になった．特に，/ta/のOD値の低下は55～64歳代から認められたことより，機能低下を鋭敏に反映する指標になる可能性が示唆された．また，OD値による構音機能評価の性差については，女性は経年的な減少傾向が有意に認められたのに対し，男性では経年的な減少幅は少なく，年齢との間には有意な関連性が認められず，明確な性差が明らかになった．

基準値の設定については，今回のOD値の分布が正規性を保持していたことから，平均値と2SDを用いて行った．また，構音機能評価の場合，血液などの生化学検査項目とは異なり，上限基準値の設定はあまり意義を有していないため[15]，本研究では下限基準値のみを求めた．

虚弱高齢者を対象とした我々のOD値とADLとの関連性に関する研究[5)16)]においては，ODの低下は起居動作，身の回り動作，コミュニケーション等の包括的ADLの低下と有意な関連性を有することを報告しているが，健康高齢者においても早期よりOD値の低下をきたす者は，潜在的にADL低下のリスクを保有している可能性がある．

また，下限基準値の分析結果からも，/ta/は加齢による変化をより受けるものであり，特に75歳以上の女性は大きく低下することが示唆された．/ta/の構音では，舌尖部が前歯歯茎部の裏面と接して閉鎖を作り一旦呼気流を遮断した後，瞬間的に閉鎖を解放し呼気が急激に流れることで，「た」の音が作られる[17]．従って，舌尖部と前歯歯茎部との速い閉鎖と解放の運動がくり返される/ta/のODでは，舌尖部の規則的かつ正確な運動が必要となる．本研究の結果は，これら舌尖部が担う速い運動が，前期高齢期から低下することを示唆しており，ODにおける/ta/の評価は，口腔機能の良否を鋭敏に評価できるものと考えられる．また，このような舌尖部の円滑な動きは，摂食・嚥下においては，舌の前部と硬口蓋間でゼリー等の半固形物の食物を押しつぶす等の動作と深く関係しており[18]，前期高齢期からのODの/ta/の回数の減少は，準備期・口腔期における摂食・嚥下機能の低下リスクのひとつにもなると考えられる．今後は，縦断研究を行うことにより，ODと摂食・嚥下機能との関連性について，更に調べる必要性がある．また，サ行やラ行等，舌尖を用いる他の構音[19]によるODについても，今後は各年代における比較や，摂食・嚥下機能との関連性の検討を行う必要性があると考える．

本研究の結果より，健康な中高年者においても，加齢による構音機能の低下は高齢前期より認められるため，口腔機能向上のための介護予防プログラムを実施する際は，性差を考慮しつつ，50代後半からのいわゆる「プレ高齢期」の年代より取り組むことが重要であると考えられる．今まで，65歳未満を対象とした口腔機能の状態を年代別に調査した報告は数少なかったこともあり[20)21)]，50歳代後半期からの体系的取り組みを行う必要がある．そのためにも，今後は縦断研究により，50歳代後半からの対象者の構音機能の経年的変化を追跡して調べる必要があると考えられる．

本研究は，200名以上の地域在住の健康な中高齢者のODを測定した研究であり，50歳代後半からの構音機能評価指標としてのOD値における妥当な基準値を示していると考えられる．国内外の先行研究での健常者におけるODの平均値[11)22)23)]は，少数の対象によるものであり，かつ年齢群や男女別による検討はなされておらず，集団を対象とした構音機能評価において，本研究で示した下限基準値は活用できるものと考えられる．今回，得られた基準値の提示は，いままで主観的評価によることが多かった口腔機能評価を定量的に実施するためにも有用である．今後は，OD値の低下と関連する要因についてもさらに詳細に分析し，口腔機能評価指標として「低下」を示す明らかなカットオフ値を提示する必要がある．また構音は，呼吸・発声とも連動している．神経学的所見の存在は，構音機能および呼吸・発声機能に影響を及ぼすことが考えられる[7]が，脳血管障害等の神経学的疾患の既往の有無は，本研究においては調査していない．また，呼吸や発声機能が影響を受けやすい喫煙習慣[24]や運動習慣[25]などが，交絡要因としてODに影響を及ぼしていることが考えられるため，今後は前述の神経学的所見や交絡要因についても考慮しつつ，より正確なODの正常基準値またはカットオフ値について検討を行う必要がある．

ODを用いた構音評価は，生体侵襲を伴うことがなく，かつ大規模な測定機器等が不要であるため，フィールド調査や健康診査にて口腔機能を定量的に把握するのに有効な方法であると考えられる．また，従来のODの評価がペン打ち法[26]やマイクが捉えた音声をアナログ分析するもの[27)28)]であったのに比較して，本研究で実施したPCMレコーダーへの録音と音声分析装置を用いた分析は，近年急速に普及したデジタル音声技術を活用するものであり，ICTによる新たな口腔機能評価法になりうる可能性がある．今後は，ODに加えて音響分析を取り入れた口腔機能評価の導入や，本研究の対象地域以外の高齢者についても測定や調査を行い，更なる検討を加える必要性があると考えられる．

結　論

地域住民を対象に，オーラルディアドコキネシスを年代別・性別に分析し，基準値案を提示した．特に，/ta/のOD値は他の音節に比較して，前期高齢者の時期から低下が認められた．また，ODによる構音機能評価値の加齢による低下傾向には，性差が見られた．

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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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Oral diadochokinesis among Japanese aged over 55 years: analysis of standard values

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Abstract

Aim: We investigated oral diadochokinesis (OD) among 212 Japanese aged over 55 years to assess the standard values of articulation ability.

Methods: Each subject repeatedly produced the OD syllables /pa/, /ta/, and /ka/. Subjects were divided into three age-groups (55-64 years, 65-74 years, and over 75 years) and by gender to compare the number of OD syllables per second. We also calculated the lower limit of values that determined the standard range for OD syllables.

Results: The number of all OD syllables in the over-75 age-group was significantly lower than in the 55-64 group. The number of OD /pa/ syllables in the over-75 group was significantly lower than in the 65-74 group. The number of OD /ta/ syllables in the 65-74 group was significantly lower than in the 55-64 group. The lower limit of the standard values for OD /pa/, /ta/, and /ka/ was, respectively, as follows: 4.9, 4.7, and 4.5 times in the 55-64 group; 3.8, 4.1, and 3.7 times in the 65-74 group; and 3.8, 3.3, and 2.6 times in the over-75 group. Among women, the number of OD /pa /, /ta/, and /ka/ syllables was significantly lower in the over-75 group than in other age-groups.

Conclusions: We demonstrated that the lower limit of standard OD values is a means of assessing articulation in elderly subjects. We found that OD /ta/ tends to decrease from age 65 years. The decline in articulation ability clearly begins earlier in women than in men.

Key words: *Oral diadochokinesis, Assessment of articulation ability, Local inhabitants, Elderly, Standard values*
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Factors associated with self-assessed masticatory ability among community-dwelling elderly Japanese

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Self-assessed masticatory ability has been shown to be significantly related to general health among elderly persons. ***Objective:*** To identify oral factors associated with the self-assessed masticatory ability. ***Basic research design:*** Cross-sectional study. ***Participants:*** A total of 736 community-dwelling elderly persons. ***Main outcome measures:*** Data on background factors and the self-assessed masticatory ability were collected by questionnaire. An intraoral examination examined the pattern of posterior occluding pairs of natural teeth (POPs), the WHO Community Periodontal Index of Treatment Needs (CPI) and denture-related factors such as use of dentures, pain when using dentures and stability and retention of dentures. Chi-squared tests examined the relationships between the self-assessed masticatory ability and the background factors and oral conditions. Ordinal regression models were constructed with the self-assessed masticatory ability as the dependent variable and oral conditions as the principal independent variables, to adjust for the potential confounding variables. ***Results:*** Self-assessed impairment of masticatory ability was associated with lost POPs ($p<0.001$) and CPI ($p=0.012$). In the participants with lost POPs, self-assessed impairment of masticatory ability was associated with not using dentures and pain when using dentures ($p<0.001$). In the totally edentulous subjects, impairment of masticatory ability was not associated with stability and retention of dentures ($p=0.070$). ***Conclusions:*** Factors affecting self-assessed masticatory ability include the pattern of POPs, periodontal status, denture use and pain when using dentures.

Key words: *mastication, dentition status, community periodontal index of treatment needs, periodontal status, dentures, Japan*

Introduction

In many developed countries, the elderly population continues to increase and maintaining their general health is a concern. Therefore, it is necessary to identify factors influencing their health conditions.

Among the elderly, calorie-adjusted nutrient intake decreases with progressively impaired dentition and masticatory function is positively correlated with intake of dietary fibre, most vitamins and minerals (Krall *et al.*, 1998). Self-assessed masticatory ability is related to general health conditions, including muscle strength, balance function and 9-year mortality among elderly persons (Moriya *et al.*, 2009; Nakanishi *et al.*, 2005). Further it has been shown that functional occlusion might prevent falls in elderly persons with dementia (Yoshida *et al.*, 2005), suggesting better mastication ability may be associated with improved general health. Masticatory ability is considered an important indicator of general health among the elderly.

It has been shown that self-assessed impairment of masticatory ability was related to poor dental status (Nakanishi *et al.*, 1999; Österberg *et al.*, 1996). The existence occluding pairs of natural teeth has been shown to be a key factor in preserving masticatory function (Yamashita *et al.*, 2000). However, it is still necessary to elucidate oral factors other than dental status associated with the self-assessed masticatory ability.

The aim of the present study was to identify oral factors associated with the self-assessed masticatory ability in detail, focused on the pattern of posterior occluding pairs of natural teeth (POPs), periodontal status and denture-related factors among community-dwelling elderly persons.

Materials and Methods

Dental health examinations were carried out on 882 independently residing persons aged 65 or over and were sponsored by public offices in 2 rural communities (Tomamae and Iwanai) in Hokkaido, the northernmost prefecture of Japan. Full details of the study design, recruitment and procedures were shown previously (Moriya *et al.*, 2009). After exclusion of 38 persons aged 85 or over, 843 persons aged 65-84 remained. Those aged 85 or over were excluded from the survey, because we judged that the whole interview and examination could not be performed due to age-related declines in physical strength and their participation was limited to the intraoral examination.

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Ethical approval was secured from the ethical committee of the Hokkaido University Graduate School of Dental Medicine and written informed consent was obtained from each participant. Questionnaires on background factors and the self-assessed masticatory ability were sent via mail prior to the survey and the responses confirmed by the examiners on the day of the examination.

The questions about background factors included age, gender, current employment (working or not working), type of household (alone or with other family members), educational background (<10 years or ≥10 years of school education), social interaction (participating or not) including participation in groups gathering for social service, sports and hobbies, further about chronic systemic diseases (presence or absence of one or more chronic complaints such as hypertension, cardiac complaints, diabetes, cerebrovascular complaints, respiratory tract complaints, renal complaints, articular rheumatism, hepatic diseases and history of malignant tumour). The self-assessed masticatory ability was assessed by the question "Can you chew all kinds of food?" and the four alternative responses: "Yes, all kinds of food" (Good); "Yes, fairly hard food" (Fair), and "Only soft food" or "Only pureed food" (Poor) (Moriya *et al.*, 2009).

Data collected by intraoral examination included the pattern of POPs, periodontal status and denture related factors. Intraoral examinations were performed by four dentists of the Graduate School of Dental Medicine, Hokkaido University and calibration was conducted to get close agreement in the assessments of dental status, periodontal status and the quality of dentures prior to the survey. The pattern of POPs was classified according to the presence or absence of POPs in the bilateral premolar and molar regions: 1, tooth contact in all of the bilateral premolar and molar regions; 2, tooth contact at least in one region except 1; or, 3, an absence of tooth contact (lost POPs). Periodontal status was evaluated by using the WHO Community Periodontal Index of Treatment Needs (CPI) and it was examined for all participants with at least one recordable sextant. Each participant was classified according to the maximum CPI code: code 0-2; code 3; or, code 4. Denture-related factors were evaluated based on use of dentures when eating and pain when using dentures for the participants with lost POPs and denture base fit for those using full upper and lower dentures. According to Kapur (1967) denture base fit of the totally edentulous was scored separately for its stability and retention, respectively, on 3- (0-2) and 4- (0-3) point-scales then summed for upper and lower dentures to range from 0 to 10. A sum >8 was characterised as clinically good dentures, 6-8 as fair dentures and <6 as poor dentures (Kapur, 1967). The assessment of denture base fit was not applied to the participants using partial dentures, because any standardised assessment tool for partial dentures suitable for an epidemiological survey was not available to our limited knowledge.

The chi-squared test was used to examine the relationships between the self-assessed masticatory ability and the background factors and oral conditions. Further, ordinal regression models were constructed with the self-assessed masticatory ability as the dependent variable; the background factors and oral conditions as the independent variables. These models present the estimated coefficient of ordinal regression (β) which reflects how changes in the independent variables affect the dependent variables and its 95% confidence interval (95% CI) for the self-assessed masticatory ability. The concordance of measurements between the examiners was evaluated according to the Kappa statistic. Only p-values <0.05 were considered significant. Analyses were performed using SPSS PASW® Statistics Base v18.0.

Results

After excluding participants with missing data from the 843 participants, there were 736 participants in the study (411 females, mean age 73.0 (sd 5.3) years, 325 males, 73.1 (sd 5.0) years). The relationships between the self-assessed masticatory ability and the background factors are shown in Table 1. The distributions of the participants by the self-assessed masticatory ability were related to age, gender, type of household, employment status, degree of social interaction and hypertension. Renal diseases and articular rheumatism were not included in the analysis because too few participants (6 and 5 respectively) had these diseases. The relationships between the self-assessed masticatory ability and oral conditions are shown in Table 2. The CPI could be assessed for 540 persons and use of dentures when eating was assessed for 428 persons who had no POPs. Of the 428 participants, 270 were partially edentulous and 158 were totally edentulous. After exclusion of 32 participants who did not use any dentures when eating from the 428 participants having no POPs, 396 participants using dentures could be included in the assessment of pain when using dentures. Of the 158 totally edentulous participants, 8 participants using no dentures were excluded and finally 150 could be evaluated for stability and retention of dentures. The distributions of the participants by the self-assessed masticatory ability were significantly related to the pattern of POPs (p<0.001), CPI (p=0.025), use of dentures (p<0.001), pain when using dentures (p<0.001) and stability and retention of dentures (p=0.049) (Table 2). Kappa values of each item were more than 0.80 for inter assessor agreement.

The results of ordinary regression analysis for the self-assessed impairment of masticatory ability are shown in Tables 3 and 4. Educational background and systemic diseases other than hypertension were not included in these models because no significant relationship was established in the univariate analysis. Five ordinal regression models were constructed for all participants (model 1), for those of CPI (model 2), for those who had no POPs (model 3), for those who had no POPs but used dentures when eating (model 4) and for the totally edentulous participants using both upper and lower dentures when eating (model 5). In model 1, self-assessed impairment of masticatory ability was associated with living alone status (p=0.020), non-working status (p=0.040), low social activity status (p=0.012) and lost POPs (p<0.001). In model 2, an association was established with code 4 of CPI (p=0.012). In model 3, self-assessed impairment of masticatory ability was associated with not using dentures when eating (p<0.001). In model 4, an association was established with pain when using dentures (p<0.001). In model 5 for the totally edentulous participants us-

Table 1. Relationships between the self-assessed masticatory ability and background factors

Background factors		*n*	*Self-assessed masticatory ability (%)*			*p-value*
			Good	*Fair*	*Poor*	
Age	65-74 years	447	68.9	25.3	5.8	
	75-84 years	289	58.5	35.6	5.9	**0.009**
Gender	Female	411	59.9	32.1	8.0	
	Male	325	71.1	25.8	3.1	**0.001**
Household	Living with others	561	68.3	27.1	4.6	
	Living alone	175	53.7	36.6	9.7	**0.001**
Employment	Working	561	62.0	31.0	7.0	
	Not working	175	73.7	24.0	2.3	**0.007**
Social interaction	Yes	324	70.1	26.5	3.4	
	No	412	60.7	31.6	7.7	**0.007**
Educational background	≥10 years	207	67.2	28.0	4.8	
	<10 years	529	63.9	29.9	6.2	0.631
Hypertension	Absence	382	68.8	26.7	4.5	
	Presence	354	60.5	32.2	7.3	0.038
Diabetes	Absence	650	63.7	30.0	6.3	
	Presence	86	73.3	24.4	2.3	0.139
Cardiac disease	Absence	618	66.0	28.3	5.7	
	Presence	118	58.5	34.7	6.8	0.290
Cerebrovascular disease	Absence	699	64.9	29.5	5.6	
	Presence	37	62.2	27.0	10.8	0.415
Liver disease	Absence	713	65.4	28.7	5.9	
	Presence	23	47.8	47.8	4.4	0.142
Respiratory tract disease	Absence	714	64.6	29.4	6.0	
	Presence	22	72.7	27.3	0.0	0.454
Malignant tumour	Absence	716	64.7	29.4	5.9	
	Presence	20	70.0	25.0	5.0	0.886

Table 2. Relationships between the self-assessed masticatory ability and oral conditions

Oral conditions		*n*	*Self-assessed masticatory ability (%)*			*p-value*
			Good	*Fair*	*Poor*	
The pattern of POPs	All regions	139	90.6	8.6	0.8	
n=736	At least one region	169	82.2	15.4	2.4	
	Absence	428	49.5	41.6	8.9	**<0.001**
CPI	Code 0-2	116	79.3	17.3	3.4	
n=540	Code 3	239	72.4	24.3	3.3	
	Code 4	185	62.2	32.4	5.4	**0.025**
Dentures use	Yes	396	51.3	42.2	6.5	
n=428	No	32	28.1	34.4	37.5	**<0.001**
Pain when using dentures	No	278	59.7	37.1	3.2	
n=396	Yes	118	30.5	55.1	14.4	**<0.001**
Stability/retention of dentures	Good/Fair	76	64.5	28.9	6.6	
n=150	Poor	74	44.6	45.9	9.5	**0.049**

POPs: Posterior occluding pairs of natural teeth, CPI: The maximum WHO Community Periodontal Index of Treatment Needs of each participant. Use of dentures was evaluated for the participants having no POPs. Pain when using dentures was evaluated for the participants having no POPs but using dentures (partial dentures: 246 persons, full upper and lower dentures: 150 persons). Stability and retention of dentures were evaluated for the totally edentulous participants wearing both upper and lower dentures.
All regions: tooth contact in all of the bilateral premolar and molar regions
At least one regions: tooth contact at least in one region, except the participants of all regions
Absence: an absence of tooth contact in premolar and molar regions (lost POPs)

Table 3. Results of the ordinal regression analysis for the self-assessed impairment of masticatory ability (1)

Independent variables		*Self-assessed masticatory ability (dependent variable)* *			
		Model 1 (n=736)		*Model 2 (n=540)*	
		β (95%CI)	*p-value*	*β (95%CI)*	*p-value*
Age	65-74 years	0.00		0.00	
	75-84 years	-0.15 (-0.49,0.20)	0.409	-0.12 (-0.56,0.32)	0.592
Gender	Female	-0.20 (-0.54,0.14)	0.245	-0.06 (-0.49,0.37)	0.799
	Male	0.00		0.00	
Household	With others	0.00		0.00	
	Alone	-0.60 (-0.98,-0.22)	**0.020**	-0.37 (-0.83,0.89)	0.113
Employment	Working	0.00		0.00	
	Not working	-0.44 (-0.86,-0.02)	**0.040**	-0.25 (-0.78,0.27)	0.344
Social interaction	Yes	0.00		0.00	
	No	-0.43 (-0.76,-0.09)	**0.012**	-0.60 (-1.02,-0.18)	0.012
Hypertension	Absence	0.00		0.00	
	Presence	-0.31 (-0.64,-0.02)	0.068	-0.32 (-0.73,0.09)	0.125
Pattern of POPs	All regions	0.00		0.00	
	At least one region	-0.56 (-1.27,0.14)	0.116	-0.52 (-1.23,0.19)	0.154
	Absence	-2.24 (-2.85,-1.62)	**<0.001**	-2.16 (-2.81,-1.52)	**<0.001**
CPI	Code 0-2			0.00	
	Code 3			-0.20 (-0.78,3.80)	0.499
	Code 4			-0.76 (-1.35,-0.16)	**0.012**

Model 1 was constructed for all participants and Model 2 was constructed for the participants of CPI.
β: coefficient of ordinal logistic regression, CI: confidence interval
* Dummy variables of the self-assessed masticatory ability were created as: Good=2, Fair=1 and Poor=0.

Table 4. Results of the ordinal regression analysis for the self-assessed impairment of masticatory ability (2)

Independent variables		*Self-assessed masticatory ability (dependent variable)* *			
		Model 3 (n=428)		*Model 4 (n=396)*	
		β (95%CI)	*p-value*	*β (95%CI)*	*p-value*
Age	65-74 years	0.00		0.00	
	75-84 years	-0.15 (-0.54,0.24)	0.409	-0.21 (-0.63,0.21)	0.335
Gender	Female	-0.41 (-0.81,-0.11)	**0.044**	-0.31 (-0.74,0.12)	0.156
	Male	0.00		0.00	
Household	With others	0.00		0.00	
	Alone	-0.61 (-1.06,-0.17)	**0.007**	-0.59 (-1.07,0.10)	**0.017**
Employment	Working	0.00		0.00	
	Not working	-0.64 (-1.13,-0.14)	**0.012**	-0.72 (-1.24,-0.19)	**0.008**
Social interaction	Yes	0.00		0.00	
	No	-0.36 (-0.75,-0.03)	0.067	-0.19 (-0.61,0.22)	0.353
Hypertension	Absence	0.00		0.00	
	Presence	-0.17 (-0.56,0.22)	0.387	-0.25 (-0.66,0.16)	0.238
Denture use when eating	Yes	0.00			
	No	-1.55 (-2.28,-0.82)	**<0.001**		
Pain when using dentures	No			0.00	
	Yes			-1.28 (-1.73,-0.84)	**<0.001**

Model 3 was constructed for the participants having no POPs and Model 4 was constructed for the participants having no POPs but using dentures (partial dentures: 246 persons, full upper and lower dentures: 150 persons).
β: coefficient of ordinal logistic regression, CI: confidence interval
*: Dummy variables of the self-assessed masticatory ability were created as follows: Good=2, Fair=1 and Poor =0.

ing dentures (n=150), there were also associations with pain when using dentures (β=-1.33, 95% CI -2.06,-0.60, $p<0.001$), but not with stability and retention of dentures (β=-0.64, 95% CI -1.33, 0.51, $p=0.070$) (data not shown).

Discussion

We have shown previously that the self-assessed masticatory ability was significantly related to physical performance among community-dwelling elderly persons (Moriya *et al.*, 2009). The findings here identified factors associated with the self-assessed masticatory ability. Our study has several limitations that should be recognised. The study population was considered to be representative of a rural elderly population in Japan but not a nationally representative sample and the study was cross-sectional in design (Moriya *et al.*, 2009). Nevertheless, the findings here added data for the detailed relationships between the self-assessed masticatory ability and oral conditions such as dental status, periodontal status and denture-related factors, to prior studies in this area (Nakanishi *et al.*, 2005; Österberg *et al.*, 1996).

The self-assessed masticatory ability was associated with the type of household, employment and social interaction in model 1 and these findings are consistent with those of earlier studies (Nakanishi *et al.*, 2005; Österberg *et al.*, 1996). It is not possible to show any causation of these relationships here, but a theoretical mechanism of the relationships can be explained by a number of hypotheses. First, living with others, working and reporting high social activity may have a positive effect on oral hygiene and consequently contribute to the preservation of the self-assessed masticatory ability. Elsewhere, life style related factors have been significantly related to oral hygiene in a rural population in Japan (Harada *et al.*, 2005).

Second, a perception of masticatory ability may be influenced by psychosocial status, i.e., positive affect, defined as emotional contentment and happiness that has been associated with social activity (Kurland *et al.*, 2006). Finally, it has been shown that masticatory ability was associated with physical performance and higher level functioning capacity (Moriya *et al.*, 2009; Takata *et al*, 2008) and consequently the self-assessed masticatory ability may contribute to participating in work and the high social activity status.

A number of studies have found no clinical significant differences between subjects with shortened dental arches (SDA) of 3 to 5 occlusal units and complete dental arches regarding variables such as masticatory ability, signs and symptoms of temporomandibular disorders and oral comfort (Witter *et al.*, 1994a, 1994b). Partially lost POPs (at least one region) was not related to the self-assessed impairment of masticatory ability in the present study. These findings suggest that occluding pairs of natural teeth may play an important role in oral functions, especially masticatory ability.

Lost POPs was significantly and closely related to the self-assessed impairment of masticatory ability here. These findings are in agreement with earlier studies, which have suggested that fewer functional tooth units and extremely shortened dental arches are associated with the perceived impairment of chewing ability (Sarita *et al.*, 2003). The pattern of POPs has been significantly associated also with an objective masticatory performance based on particle size measures of a test food (Yamashita *et al.*, 2000). Therefore, POPs may influence subjective and objective assessments of masticatory ability. These relationships may be accounted for through the stability of jaw relation, degree of support of dentures due to lost POPs and afferent signals arising from dentoalveolar ligaments, which have been shown to modulate masticatory behaviour in the laboratory (Inoue *et al.*, 1989).

The findings of the present study showed that the advanced periodontal status (code 4 of CPI) was associated with self-assessed impairment of masticatory ability ($p=0.012$). It is thought that advanced periodontal conditions would cause biting pain, mobile teeth and a decline in biting force during mastication and consequently lead to an impairment of masticatory ability. Mobile teeth have been associated with eating difficulties in an old Chinese population (Zeng *et al.*, 2008). No correlation has been found between periodontal status and biting force in persons with slightly reduced periodontal tissue support (Morita *et al.*, 2003), but significant correlations have been established in persons with moderately to severely reduced periodontal tissue support (Takeuchi *et al.*, 2008). It has been suggested that maximal occlusal force positively correlates with the masticatory performance (Okiyama *et al.*, 2003).

The results of the data for dentures suggest that the masticatory ability may be impaired by not using dentures and pain when using dentures. Pain when using dentures is thought to be dependent chiefly on discordance of occlusal relationships of dentures and ill-fitting dentures. The absence of relationships between the self-assessed masticatory ability and denture adhesion ($p=0.070$) could be explained by several mechanisms; psychological factors may also influence the acceptance of dentures (Ozdemir *et al.*, 2006), individuals wearing ill-fitting dentures may modify their chewing habits to optimise masticatory performance with such dentures (Demers *et al.*, 1996), masticatory ability with dentures is thought to be influenced by factors other than denture adhesion such as occlusal relationships, the motion of the soft tissues and denture-supporting tissues.

The present study suggests that self-assessed masticatory ability may be influenced by dentition status, periodontal status and denture-related factors, providing a possibility that masticatory ability could be improved by dental interventions among community-dwelling elderly persons.

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〈原　著〉

地域高齢者における活力度指標と摂食・嚥下関連要因との関連性

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要　約　**目的**：地域における自立高齢者の活力度指標と誤嚥リスク等の摂食・嚥下関連要因との関連性を明らかにした．**方法**：対象者は宮崎県北部に居住する自立高齢者675名である．自記式質問紙による留置調査を行うことにより，包括的QOL，誤嚥リスク，年齢，性別，食欲，食生活満足度，会話満足度等のデータを545名より得た．包括的QOLについては活力度指標を用いて評価した．また，誤嚥リスクについては，地域高齢者誤嚥リスク評価指標を用いて評価した．得られた結果について2変量解析とステップワイズ重回帰分析を行い，活力度指標と有意な関連性を有する項目を抽出した．**結果**：活力度指標と誤嚥リスクについて年代差を検証したところ，両変数ともに有意差が認められた（$p<0.01$）．ピアソンの相関係数を求めたところ，活力度指標はいずれの摂食・嚥下関連諸要因とも有意な相関性を有した．年齢を制御変数とした偏相関係数でも同様の傾向であった．また，活力度指標を従属変数とするステップワイズ重回帰分析の結果，活力度と有意な関連性を有する項目として，会話満足度，誤嚥リスク，年齢，食欲が抽出された（$R=0.66$，調整済 $R^2=0.43$，$p<0.01$）．**結論**：本研究の結果，地域高齢者の活力度は会話満足度，誤嚥リスク，食欲といった摂食・嚥下に関連する諸要因と有意な関連性を示した．

Key words：誤嚥リスク，健康関連QOL，地域高齢者，活力

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緒　言

高齢期において，摂食・嚥下機能の維持・向上は健全な経口摂食を保つ上で極めて重要である[1)]．また，摂食・嚥下機能の低下は誤嚥性肺炎を引き起こし，高齢者の生命予後にも大きな影響を与えるものである[2)]．老人保健施設の入所高齢者では29.5％の者が嚥下障害を有しているとの報告[3)]がある等，施設高齢者における摂食・嚥下機能低下の状況については研究知見が集積されつつある．しかし，地域高齢者については調査研究が少なく，その摂食・嚥下機能の現状は十分に明らかになっていない．

要介護高齢者では，摂食・嚥下機能の低下がもたらす身体的健康への影響はしばしば見られるところであるが[4)5)]，健康寿命の延伸を図る上でも，地域での自立高齢者における誤嚥リスクと健康関連QOLとの関連性について検討を行う必要性がある．内閣府が実施した自立高齢者の調査では，健全な経口摂食を営むことは日常生活における楽しみであり，食事を味わい楽しむことや親しい者との共食の機会を，人生の生きがいとして捉えている者が高率に認められた[6)7)]．地域高齢者の摂食・嚥下機能の状態は，心身の健康状態だけでなく，社会的な健康とも密接な関連性を有する可能性があるが，地域高齢者の摂食・嚥下機能と包括的QOLとの関連性についての疫学研究は数少ない．Miuraらは，地域高齢者の誤嚥リスクは健康関連QOL尺度SF-8の下位スコアである「心の健康」と密接な関連性を有することを報告しているが[8)]，社会活動性を含めた包括的QOLと摂食・嚥下に関する諸要因との関連性については十分に明らかになっていない．

そこで，本研究では，地域高齢者のために開発された活力度指標[9)]と地域高齢者誤嚥リスク評価指標（Dysphagia Risk Assessment for Community-dwelling Elderly，以下DRACEと略す）[10)]を用い，地域高齢者における包括的QOLと誤嚥リスクとの関連性について調べた．また，高齢者の食生活に関する主観的指標として，食生活満足度，食欲，日常会話満足度についても評価を行い，地域高齢者の活力度指標スコアとの関連性を調べた．

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方　法

1. 調査対象ならびに調査方法

本研究の調査対象は，宮崎県北部地域の諸塚村に居住する65歳以上の高齢者のうち，要介護度が付与されておらず，地域で自立した生活を営んでいると考えられる675名である．これらの対象者に対して，無記名の自記式質問紙を平成22年11月に配布し，1カ月の留置期間を置いたのち回収した．調査実施前には，予定対象者のための地域説明会を開催した．併せて，自記式質問紙配布時にも書面にて調査内容等を説明し，同意が得られた者のみ記入済み質問紙を送付してもらい，連結不可能匿名化によるデータ収集を行った．その結果，上記の対象者の80.7%にあたる545名より記入済みの質問紙を回収することができた．なお，本研究は，国立保健医療科学院研究倫理審査委員会での承認（承認番号NIPH-IBRA#10050）を受けた後に実施した．

回答が得られた対象者の平均年齢は76.2±6.8歳であり，男性は40.4%，女性は59.6%であった．また，65～74歳の前期高齢者は49.2%，75～84歳の後期高齢者は40.4%，85歳以上の超後期高齢者は10.5%であった．

2. 調査項目

主要な調査項目は，基本属性（性別と年齢），包括的QOL，誤嚥リスク，食欲，食生活満足度，会話満足度である．包括的QOLと誤嚥リスクについては，以下に詳細を記す評価指標を用いて調べた．また，食生活満足度，食欲と会話満足度については，リッカート尺度を用いて対象者による自己評価にて調べた．

(1) 日常生活の活力に関する調査

わが国の地域高齢者の包括的QOLを評価するために開発された活力度指標[9]を用いて，「気分・意欲」，「認知」，「心身の健康」，「社会参加」の4つの概念を包含するQOLスコアを求めた．活力度指標は，Lawtonの理論[11]をもとに20個の調査項目が設定されており，地域高齢者を対象とした妥当性と信頼性が検証された40点満点の評価スケールである．総スコアが高い程，QOLが高い状態を示す．

(2) 誤嚥リスクに関する評価

本研究では，地域高齢者の摂食・嚥下機能の低下を評価するために開発されたDRACE[10]を用いて，対象者の摂食・嚥下機能を評価した．DRACEは，臨床現場にて汎用されるいくつの質問紙法[12][13]と比較して，評価項目が12個と簡便性に優れており，かつ地域高齢者において，しばしば観察される準備（咀嚼）期に関する項目を加える等，地域高齢者に応用しやすい特性を有する36点満点の評価スケールである．総スコアが高い程，摂食・嚥下機能低下のリスクが高いことを示す．

(3) 食生活満足度，食欲ならびに日常会話満足度に関する主観的評価

現在の食生活に関する満足度，食欲ならびに日常会話に関する満足度については，対象者自身による5段階の主観的評価によって調べた．食生活満足度については，その食事をおいしいと感じたかについて，「いつも美味しかった」，「だいたい美味しかった」，「時々美味しかった」，「だいたい不味かった」，「いつも不味かった」のリッカート尺度で評価を行い，各々に1～5点のスコアを付与した．同様に，食欲についても「非常にあった」，「だいたいあった」，「時々あった」，「ほとんどなかった」，「全くなかった」の5段階で評価し，各々に1～5点のスコアを付与した．また，日常会話に関する満足度については，「とても満足」，「ほぼ満足」，「やや満足」，「不満足」，「大変不満足」の5段階での評価を行い，同様に不満足度が高くなるに従い，評点が高くなるようにスコアを付与した．

(4) 統計解析

各変数における年代間の差の検定には，一元配置分散分析を用いた．また，性差の検定にはunpaired　t検定を用いた．一方，活力度指標と摂食・嚥下にかかわる関連諸要因との関連性については，ピアソンの相関係数を求めるとともに，交絡要因となりうる年齢を制御変数とした偏相関係数を併せて求めた．さらに，本研究で調べた摂食・嚥下関連要因が，地域高齢者の活力度指標に及ぼす影響を詳細に調べるために，ステップワイズ重回帰分析を行った．なお，これらの一連の統計解析にはSPSS Ver.19（エス・ピー・エス・エス株式会社）を用いた．

結　果

図1に，活力度指標スコアの年代別ならびに性別ごとの分布を箱ひげ図として示す．65～74歳では26.41±5.30，75～84歳では23.93±6.11，85歳以上では19.74±5.48と低減傾向を示し，一元配置分散分析の結果において有意差が認められた($p<0.01$)．一方，男性では24.36±6.08，女性では26.41±5.45であり，有意な性差は認められなかった．

図2に，DRACEスコアの年代別ならびに性別ごとの分布を箱ひげ図として示す．65～74歳では2.37±2.58，75～84歳では3.47±3.32，85歳以上では5.07±3.36と増加傾向を示し，一元配置分散分析の結果において有意差が認められた（$p<0.01$）．一方，男性では3.10±3.14，女性では3.14±2.90であり，DRACEスコアについても有意な性差は認められなかった．

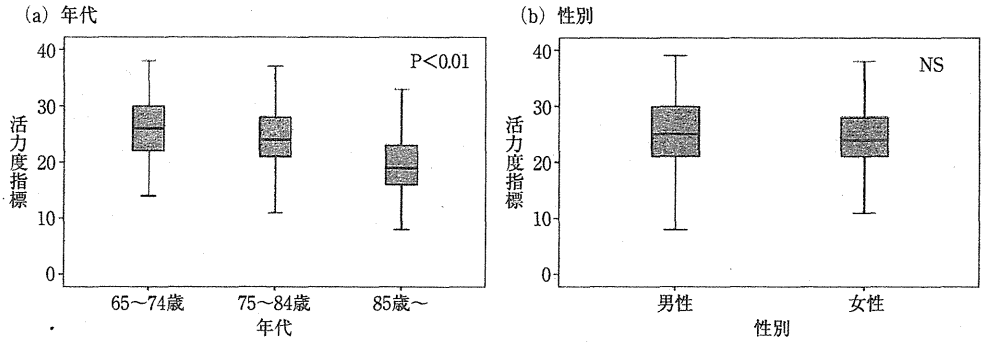

図1　活力度指標（ASE）による評価値の箱ひげ図

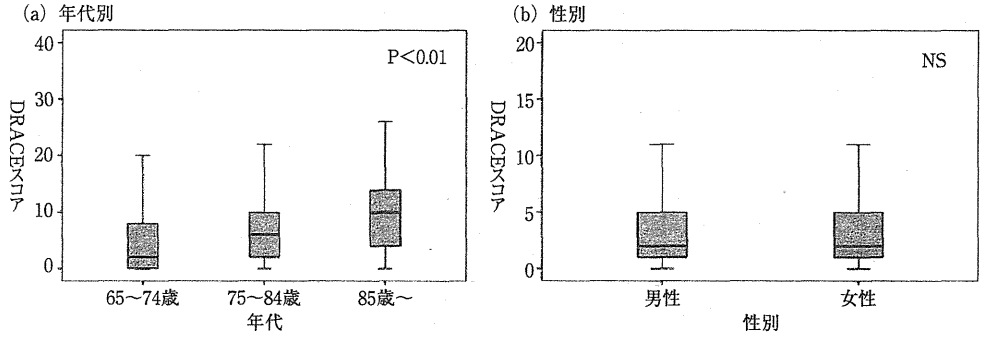

図2　地域高齢者誤嚥リスク評価指標（DRACE）による評価値の箱ひげ図

表1　食生活満足度[1]，食欲[2]と日常会話満足度[3]における年代差ならびに性差の分析

(a) 年代

	65～74歳（N=268）	75～84歳（N=220）	85歳以上（N=123）	F値	p値
食生活満足度[1]	1.46±0.69	1.47±0.62	1.63±0.65	1.69	0.19
食欲[2]	1.65±0.65	1.71±0.58	1.81±0.48	1.81	0.16
会話満足度[3]	1.92±0.74	2.14±0.87	2.18±0.85	6.17	0.002

(b) 性別

	男性（N=220）	女性（N=325）	t値	p値
食生活満足度[1]	1.52±0.70	1.46±0.64	1.06	0.29
食欲[2]	1.69±0.64	1.69±0.59	0.04	0.97
会話満足度[3]	2.07±0.77	2.01±0.82	0.84	0.40

[1]「いつも美味しかった」，「だいたい美味しかった」，「時々美味しかった」，「だいたい不味かった」，「いつも不味かった」の5段階評価を行い，各々に1～5点のスコアを付与
[2]「非常にあった」，「だいたいあった」，「時々あった」，「ほとんどなかった」，「全くなかった」の5段階評価を行い，各々に1～5点のスコアを付与
[3]「とても満足」，「ほぼ満足」，「やや満足」，「不満足」，「大変不満足」の5段階評価を行い，各々に1～5点のスコアを付与

表1（a）に，食生活満足度，食欲ならびに日常会話満足度に関しての一元配置分散分析による年代間比較の結果を示す．食生活満足度と食欲については年代間で有意差は認められなかったが，会話満足度に関して，65～74歳では1.46±0.69，75～84歳では1.47±0.62，85歳以上では1.63±0.65と有意差が認められ，年代の上昇に随伴して日常会話に関する不満が増加した（$p<0.01$）．表1（b）には，食生活満足度，食欲ならびに日常会話満足度に関するunpaired　t検定による性別間比較の結果を示す．食生活満足度，食欲ならび日常会話満足度のい

表2　活力度指標による評価値と年齢ならびに摂食・嚥下関連項目とのピアソンの相関係数（r）

活力度指標に対する項目	r値	p値
会話満足度	−0.53	<0.01
DRACE スコア	−0.45	<0.01
食欲	−0.43	<0.01
食生活満足度	−0.42	<0.01
年齢	−0.36	<0.01

表3　年齢を制御因子とした活力度指標と摂食・嚥下関連項目との偏相関係数

活力度指標に対する項目	偏相関係数	p値
会話満足度	−0.52	<0.01
DRACE スコア	−0.39	<0.01
食欲	−0.41	<0.01
食生活満足度	−0.41	<0.01

ずれにおいても，有意な性差は認められなかった．

表2に活力度指標に対する摂食・嚥下関連要因とのピアソンの相関係数について示す．年齢，DRACE スコア，食生活満足度，食欲，日常会話満足度といったすべての変数との間において有意な相関性が認められた（$p<0.01$）．

次に，代表的な交絡要因である年齢を制御因子とし，偏相関係数を求めた（表3）．各々の偏相関係数はピアソンの相関係数に比べて低下したが，単相関係数の結果と同様に，会話満足度，誤嚥リスク，食欲，食生活満足度といった摂食・嚥下関連項目と活力度指標との間に有意な相関性が認められた（$p<0.01$）．

そこで，活力度指標と特に関連性が深い要因を見出すために，ステップワイズ重回帰分析を行ったところ，有意な関連性が認められた変数として会話満足度，誤嚥リスク，年齢，食欲の4項目が抽出され，その調整済み決定係数（R^2）は0.43（$p<0.01$）であった（表4）．

表4　活力度指標による評価値を従属変数としたステップワイズ重回帰分析の結果

独立変数	β値	t値	p値
会話満足度	−0.33	−8.36	<0.01
DRACE スコア	−0.23	−6.63	<0.01
年齢	−0.22	−6.11	<0.01
食欲	−0.10	−2.87	<0.05

重相関係数（R）＝0.66
調整済み決定係数（R^2）＝0.43（$p<0.01$）

考　察

本研究の結果，地域高齢者においても，加齢により活力度が低下する一方，誤嚥リスクは増加する傾向が認められた．また，活力度と摂食・嚥下関連項目との間に有意な相関性が示されたことより，摂食・嚥下に関連する諸要因は，自立して居住している地域高齢者のQOLに大きく関与することが明らかになった．会話満足度，誤嚥リスク，食欲ならびに食生活満足度と活力度指標との間には有意な相関性が認められ，地域高齢者の活力を維持しQOLが高い生活を送るためには，他者とのコミュニケーションや摂食・嚥下機能をはじめとする口腔にかかわる要因が大きく関与することが示唆された．

Miuraらの虚弱高齢者を対象とした調査結果において，口腔関連QOLと密接な関連性を有していたのは誤嚥リスクとコミュニケーションADLであり[14]，本研究で得られた結果と同一の方向性を示したことより，高齢期のQOLの維持・向上には良好な会話と摂食が大きな役割を果たすことが示唆された．特に，会話満足度は舌・口唇などの構音機能の状況と言語コミュニケーションによる社会参加等の諸要因を包含する複合的評価項目であるため[15]，自立高齢者のQOLに特に密接に関与したと考えられる．

要介護高齢者での誤嚥リスクは，低栄養や誤嚥性肺炎との関係が指摘されていることから，主として生命予後や身体的健康度との関連性についての報告が多い[16][17]．一方，自立高齢者の場合，誤嚥リスクは身体的健康よりも精神的健康とより密接な関連性を示すとの報告もある[8]．自立高齢者の場合，誤嚥リスクを有する場合でも，その程度は比較的低いことが多いため，身体的健康に及ぼす影響は限局的なものと考えられる．むしろ自立高齢者の場合，誤嚥リスクの増大によって摂取できる食品群の制限が生じ，その結果として会食等の社会活動が制限され，日常生活を円滑に営むための活力やモラールの低下をもたらしたものと推察される．本研究で用いた活力度指標は，介護予防による総合的な効果を評価するための有効な手段の一つであるが，口腔機能向上プログラム等の効果をみる場合にも活力度指標による評価を活用することは，口腔機能向上プログラムの介護予防効果を高める上で，有効な手段のひとつと考えられる．

Miuraらは，地域高齢者における現在歯数と主観的咀嚼能力評価が，PGCモラールスケールによるQOL評価との間に有意な関連性を示すことを報告している[18]．しかし，地域高齢者の誤嚥リスクを評価した研究は報告例が少ないため，本研究で得られた知見は今後の口腔機能

向上プログラムの普及にも寄与するものと考えられる．また，本研究の結果は，吹田らが指摘しているように[19]，地域高齢者に対する口腔機能向上のための介入アプローチでは，直接的な口腔保健行動の改善だけでなく，周囲との会話や食事ならびに地域での行事等への社会参加を促し，日常生活を活性化させることが有効であるとの知見を支持するものであり，自立高齢者に対する社会活動性の向上を踏まえたアプローチの重要性を示唆しているものと考えられる．

一方，本研究の限界として，対象者の地域特性に関する事項を考慮する必要がある．本研究の対象地域は山間部であり，都市部における地域高齢者の社会環境と大きく異なる可能性は否定できない．このような地域性の相違が活力度の評価等に影響を与えることも十分に考えられるため，今後は，都市部を含めて他の地域に居住する高齢者での現状について引き続き研究を進める必要性がある．

しかし，このような研究の限界を考慮した上でも，本研究での重回帰分析の結果において，活力度指標が会話満足度や誤嚥リスク，年齢，食欲といった摂食・嚥下関連諸要因と有意な関連性を示したことは，自立高齢者におけるQOLの向上を図る上でも，口腔機能の維持・向上は重要な役割を果たすものと考えられる．

謝辞

本研究にご協力いただいた宮崎県諸塚村の地域住民の皆様ならびに関係各位にお礼申し上げる．

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Relationship between comprehensive quality of life and factors related to chewing and swallowing function among community-dwelling elderly individuals

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Abstract

Aim: The purpose of the present study was to examine the relationship between comprehensive quality of life (QOL) and some factors regarding chewing and swallowing function among community-dwelling elderly individuals.

Methods: The subjects were 675 independent elderly persons residing in the northern area of Miyazaki Prefecture, and we obtained the self-administered questionnaires from 545 elderly people. We used "active scale for the elderly (ASE)" and "dysphagia risk assessment for the community-dwelling elderly (DRACE)" to evaluate their comprehensive QOL and function of chewing and swallowing, respectively. Furthermore, we examined some factors such as age, gender, subjective satisfaction with diet and verbal communication.

Results: The score of ASE showed a significant decline with age ($p<0.01$) while the DRACE score increased significantly with age ($p<0.01$). Pearson's correlation coefficients revealed that the ASE score was significantly related to all of the factors regarding regulation of food intake. Partial correlation coefficients adjusted for age also revealed the same tendency. From the multiple regression analysis, subjective satisfaction with verbal communication, DRACE score, age and appetite were extracted as factors influencing ASE score (adjusted $R^2=0.43$, $p<0.01$).

Conclusion: Among independent elderly persons residing in the community, the comprehensive QOL was significantly related to factors such as subjective satisfaction with verbal communication, dysphagia risk, age, and appetite.

Key words: *Dysphagia risk, Health-related quality of life, Community-dwelling elderly, vitality*
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Gerodontology

Original article

Influence of dental treatment on physical performance in community-dwelling elderly persons

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Influence of dental treatment on physical performance in community-dwelling elderly persons

Objective: The aim of the study was to investigate the influence of dental treatment on physical performance (muscle strength and balance function) among the elderly.
Background: Oral conditions have been associated with physical performance. We hypothesised that improved oral conditions by dental treatment would lead to improved physical performance.
Methods: A total of 154 persons aged 65 years or over were judged to be in need of dental treatment as a result of dental examination; of these, 121 persons underwent dental treatment. After 1 year, differences in each parameter of physical performance before and after the intervention were evaluated using the Wilcoxon signed rank sum test. The Spearman rank correlation coefficient was calculated to examine correlations between changes in self-assessed masticatory ability (masticatory ability) and each parameter of physical performance, and multivariate logistic regression analysis was performed using changes in each parameter of physical performance as the dependent variable and changes in masticatory ability as the principal independent variable.
Results: Improved physical performance was not observed for the total study population with dental treatment; however, in subjects with improved masticatory ability, one-leg standing times with eyes open increased significantly. A significant correlation was established between changes in masticatory ability and each parameter of physical performance. These relationships were not found in those without dental treatment. A significant relationship was also established for one-leg standing time after adjusting for age, gender, dentition status and needs of dental treatments.
Conclusion: Chewing ability may be a positive contributing factor to balance function among the elderly.

Keywords: the elderly, oral conditions, chewing ability, physical performance.

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Introduction

Prolonged life expectancy in Japan has led to an increase in the number of elderly persons. In 2009, 22.7% of the total Japanese population was over the age of 65 years, and this proportion continues to grow[1]. Such growth stresses the importance of preventing decline in functioning in activities of daily living (ADLs) among the elderly, as this is considered to be a major component of quality of life. It has been shown that decline in functioning in ADLs is induced by functional impairment, frailty, the risk of falls and gait disturbances and that these factors are significantly influenced by parameters of physical performance such as muscle strength and balance function[2–7].

A number of epidemiological studies have shown that physical performance is significantly associated with dental status, periodontal status and chewing ability among elderly persons[8–11]. Dental treatment has been shown to improve functioning in ADLs and prevent falls among the elderly[12,13]. These findings suggest that improvement in some oral conditions by dental treatment may positively influence physical performance parameters and

subsequently lead to improvement in functioning in ADLs and prevention of falls.

Therefore, we investigated the causal relationships between oral conditions and physical performance among the elderly. We hypothesised that improvement in oral conditions by dental treatment would positively affect muscle strength and balance function among the elderly, thereby applying a community-based intervention strategy for dental treatment.

Materials and methods

A total of 294 individuals aged 65 years or over and living independently underwent a dental health examination sponsored by the public authority in a rural community (Iwanai) in Hokkaido, the northernmost prefecture of Japan. The examination was performed over 10 days from August to September 2006. Of these 294 persons, 174 (59.2%) were judged to be in need of dental treatment and were advised to undergo treatment as a result of the oral examination (the baseline survey). Consequently, 154 (88.5%) of these 174 persons participated in the follow-up survey, which was performed 1 year after the baseline survey. Of these 154 persons, 121 (78.6%) underwent dental treatment during the last year as advised, but the other 33 persons (21.4%) did not undergo any dental treatment. These 154 individuals were enrolled in this study. All persons were informed of the purpose and methods of the study and the routine that they informed us of significant changes in general health status during the follow-up period, and then they provided written informed consent to participate. Ethical approval for the study was obtained from the ethics committee of the Graduate School of Dental Medicine, Hokkaido University.

Subjects were interviewed based on questionnaires about self-assessed masticatory ability (masticatory ability), demographic factors such as gender and age, and general health status such as hypertension, diabetes, cardiac, cerebrovascular, respiratory, hepatic, renal and mental diseases (absence vs. presence). Information about whether the participants could live independently or dependently was obtained from the Long-Term Care Insurance System of Japan (LTCI)[14], which was under control of the public authority.

Masticatory ability was assessed using the following question: 'How do you rate your masticatory ability?' Answers were classified into one of the following: 'I can chew all kinds of food' (good); 'I can chew only slightly hard food' (fair); or 'I can chew only soft or pureed food' (poor)[10].

Intra-oral examination was performed by two dentists. The intra-examiner reliability of the two dentists was considered to be good, as they had worked together at the same dental hospital for more than 5 years and calibration was conducted to obtain close agreement in the assessment of dental status, periodontal status, crown and bridge prostheses and dentures prior to the survey. Periodontal status was evaluated using the WHO Community Periodontal Index of Treatment Needs (CPITN), and a person in need of periodontal treatment was defined as a person with a CPITN code 2 or above. Need for treatment with dentures was defined as the presence of pain when using dentures, poor retention and stability of dentures clinically and not using dentures regardless of having missing teeth in the pre-molar or molar regions. A person with ill-fitting crown and bridge prostheses was also defined as a person in need of treatment. The pattern of occluding pairs of natural teeth was classified into one of the three classes based on the presence or absence of occluding pairs of natural teeth, that is, (1) tooth contact in all of the bilateral pre-molar and molar regions (total support), (2) tooth contact at least in one region except (1) (partial support) or (3) an absence of tooth contact (lost support).

Handgrip strength (kg) and one-leg standing time with eyes open (s) were measured for the evaluation of muscle strength and static balance function, respectively. The single greatest value of handgrip strength was measured with the subject standing upright holding a hand dynamometer (Tanita, Ltd., Tokyo, Japan) in both hands. The maximum measurement of the right or the left hand was used for each subject. For one-leg standing time with eyes open, subjects were asked to stand on one leg with their eyes open and with arms stretched out, once on each foot until balance was lost, and the maximum measurement of the right or the left was used as the value for each subject.

The chi-squared test was used to compare distribution of participants according to each characteristic between those with and without dental treatment. The Wilcoxon signed rank test was used to examine changes in handgrip strength and one-leg standing time with eyes open between before and after the intervention. The Spearman rank correlation coefficients were used to examine correlations between changes in handgrip strength and one-leg standing time with eyes open, and those in masticatory ability. After significant correlations were identified, multivariate logistic regression analysis was performed with handgrip

strength and one-leg standing time with eyes open (improved vs. unchanged or impaired) as dependent variables and changes in masticatory ability as the principal independent variable. These models presented the odds ratio (OR) and 95% confidence interval (CI) for the impairment and improvement in masticatory ability as compared with the unchanged status. Only p values smaller than 0.05 were defined as statistically significant. Statistical analysis was performed using the IBM SPSS statistical package (IBM SPSS PASW® Statistics Base 18.0, IBM Japan, Tokyo, Japan).

Results

Characteristics of the subject at the baseline survey are shown in Table 1. Although the participants had some chronic medical diseases, all of them were kept under good medical control and none of them were certificated for care-needs in the LTCI during the follow-up period. The percentage distribution by masticatory ability before and after the intervention is shown in Table 2. In the participants with dental treatment, the number of subjects with good masticatory ability did not change, but the number with fair masticatory ability increased, and the number with poor masticatory ability decreased. Percentage distributions by the type of changes in masticatory ability before and after the intervention are shown in Table 3. In the participants with dental treatment, 12 (9.9%), 91 (75.2%) and 18 (14.9%) subjects had impaired, unchanged and improved masticatory ability, respectively. In those individuals without dental treatment, 3 (9.1%), 28 (84.8%) and 2 (6.1%) subjects had impaired, unchanged and improved masticatory ability, respectively.

Comparisons of handgrip strength and one-leg standing time with eyes open between before and after the intervention are shown in Table 4. Handgrip strength decreased significantly in the total subjects and those with impaired masticatory ability, but no significant changes were observed in those with unchanged and improved masticatory ability. The one-leg standing time with eyes open did not change significantly in the total subjects and those with impaired masticatory ability; it decreased significantly in subjects with unchanged masticatory ability, but increased significantly in those with improved masticatory ability. No statistically significant changes in physical performance were observed in those without dental treatment.

There were significant correlations between changes in masticatory ability and each parameter of physical performance before and after the

Table 1 Characteristics of the subjects.

	Participants with dental treatment n = 121		*Participants without dental treatment* n = 33		
	n	%	n	%	p-values[a]
Gender					
Female	60	49.6	19	57.6	0.416
Male	61	50.4	14	42.4	
Age (years)					
65–69	41	33.9	11	33.3	0.119
70–74	37	30.6	4	12.1	
80–84	29	24.0	13	39.4	
>85	14	11.6	5	15.2	
The pattern of occluding pairs of natural teeth					
Lost support	44	36.4	19	57.6	0.038
Partial support	44	36.4	5	15.2	
Full support	33	27.3	9	27.3	
Self-assessed masticatory ability					
Good	81	66.9	24	72.7	0.729
Fair	30	24.8	6	18.2	
Poor	10	8.3	3	9.1	
Need for dental treatment					
Periodontal disease					
Needed	93	76.9	22	66.7	0.233
Needless	28	30.1	11	33.3	
Dentures					
Needed	44	36.4	17	51.5	0.115
Needless	77	63.6	16	48.5	
Others[b]					
Needed	5	4.1	1	3.0	0.772
Needless	116	95.9	32	97.0	
Chronic medical diseases					
Hypertension					
Absence	72	59.5	20	60.6	0.909
Presence	49	40.5	13	39.4	
Diabetes					
Absence	109	90.1	31	93.9	0.495
Presence	12	9.9	2	6.1	
Cardiac diseases					
Absence	103	85.1	30	90.9	0.391
Presence	18	14.9	3	9.1	
Cerebrovascular disease					
Absence	114	94.2	32	97.0	0.527
Presence	7	5.8	1	3.0	
Respiratory diseases					
Absence	119	98.3	33	100.0	0.457
Presence	2	1.7	0	0.0	
Hepatic disease					
Absence	119	98.3	32	97.0	0.612
Presence	2	1.7	1	3.0	
Renal disease					
Absence	121	99.2	33	100.0	0.600
Presence	1	0.8	0	0.0	
Mental disease					
Absence	119	98.3	32	97.0	0.612
Presence	2	1.7	1	3.0	

[a]chi-squared test.
[b]Dental caries or impairment of crown prosthesis.

Table 2 Percentage distribution of the participants by masticatory ability before and after intervention.

	Before		*After*	
Masticatory ability	*n*	%	*n*	%
Participants with dental treatment (*n* = 121)				
Good	81	66.9	81	66.9
Fair	30	24.8	38	31.4
Poor	10	8.3	2	1.7
Participants without dental treatment (*n* = 33)				
Good	24	72.7	23	69.7
Fair	6	18.2	6	18.2
Poor	3	9.1	4	12.1

Table 3 Percentage distribution by the type of changes in masticatory ability before and after intervention.

Type of changes in masticatory ability	*Before*	*After*	*n*	%
Participants with dental treatment (*n* = 121)				
Impaired[a]	Good	Fair	11	9.1
n = 12 (9.9%)	Fair	Poor	1	0.8
Unchanged[b]	Good	Good	70	57.9
n = 91 (75.2%)	Fair	Fair	20	16.5
	Poor	Poor	1	0.8
Improved[c]	Fair	Good	9	7.4
n = 18 (14.9%)	Poor	Good	3	2.5
	Poor	Fair	6	5.0
Participants without dental treatment (*n* = 33)				
Impaired[d]	Good	Fair	1	3.0
n = 3 (9.1%)	Good	Poor	1	3.0
	Fair	Poor	1	3.0
Unchanged[e]	Good	Good	22	66.7
n = 28 (84.8%)	Fair	Fair	4	12.1
	Poor	Poor	2	6.1
Improved[f]	Fair	Good	1	3.0
n = 2 (6.1%)	Poor	Fair	1	3.0

The ratios of participants with needs of each dental treatment are shown as follows:
[a]Periodontal diseases (58.3%), dentures (58.3%) and others (8.1%).
[b]Periodontal diseases (84.6%), dentures (29.7%) and others (3.3%).
[c]Periodontal diseases (55.6%), dentures (66.7%) and others (5.6%).
[d]Periodontal diseases (66.7%), dentures (66.7%) and others (33.3%).
[e]Periodontal diseases (71.4%), dentures (46.3%) and others (0.0%).
[f]Periodontal diseases (0.0%), dentures (100.0%) and others (0.0%).

intervention in those with dental treatment, but not in those without dental treatment (Table 5). Further multivariate logistic regression models were performed to examine the independent relationships between changes in masticatory ability and improvement in each parameter of physical performance in those with dental treatment (Table 6). In these models, improved masticatory ability was significantly related to improvement in one-leg standing time with eyes open (OR = 4.05, 95% CI = 1.25–13.16, $p = 0.020$), but these relationships were not established for handgrip strength.

Discussion

The present study revealed the influence of changes in masticatory ability following dental treatment on parameters of physical performance among community-dwelling elderly persons as follows. First, balance function improved significantly in subjects with improved masticatory ability. Second, there was a significant correlation between changes in masticatory ability and balance function. Finally, improvement in masticatory ability was significantly related to that of balance function after adjusting for age, gender, dentition status and the need for dental treatment. In regard to muscle strength, a significant correlation was observed between changes in masticatory ability and handgrip strength, but no significant improvement in muscle strength was seen in subjects with improved masticatory ability.

Subjects with unchanged masticatory ability accounted for about three-quarters (75.2%) of the total participants, because in this group, the number of subjects with good masticatory ability was large (76.9%) and the number of those in need of treatment with dentures was small (29.7%) at baseline (before intervention). The impairment in masticatory ability of 9.9% of the subjects may be explained by the possibility that the subjects in need of treatment with dentures (58.3%) were not satisfied with the results of the dental treatment they received. The subjectivity of evaluation for mastication can influence the results obtained. Since self-assessed masticatory ability has been shown to reflect dental status, periodontal status and denture-related factors in community-dwelling elderly persons[15], the self-assessed masticatory ability to evaluate change in mastication was used.

Handgrip strength decreased significantly in the total study population and those with impaired masticatory ability, and it tended to decrease in those with unchanged masticatory ability. This decline was thought to be mainly an age-related change. In those with improved masticatory ability, handgrip strength did not tend to decrease,