Table 1 Subject details

Population of older adults	n	Age	Male(%) : Female(%)
Group: requiring care	329	82.0 ± 7.5	67(21%) : 262(79%)
Bedridden status: Not	33	81.8 ± 6.6	5(15%) : 28(85%)
Slightly	99	84.0 ± 6.9	23(24%) : 76(76%)
Moderately	105	83.3 ± 8.7	21(20%) : 84(80%)
Completely	76	85.2 ± 8.0	19(25%) : 57(75%)

Age is given as a mean ± SD, all other data are no. (%).
Bedridden status: terms were described in Materials and Methods

Table 2 Lists of bacteria and fungi detected in the plaque and pharynx samples

Bacteria and fungi	
Coagulase(-)staphylococcus	*Haemophilus influenzae*
Staphylococcus aureus (MSSA, MRSA)	*Haemophilus parainfluenzae*
Streptococcus pneumoniae	*Klebsiella oxytoca*
Streptococcus anginosus	*Klebsiella pnuemoniae*
β-Streptococcus (type A)	*Moraxella catarrhalis*
β-Streptococcus (type B)	*Morganerlla morganii*
β-Streptococcus (type C)	*Proteus mirabilis*
β-Streptococcus (type D)	Pseudomonas sp.
Enterococcus faecalis	*Pseudomonas aeruginosa*
Enterococcus faecium	*Pseudomonas cepacia*
Citrobacter freundii	*Serratia marcescens*
Enterobacter aerogenes	*Xanthomonas maltophilia*
Enterobacter cloacae	*Candida albicans*
Flavobacterium meningosepticum	*Candida glabrata*
	Candida tropicalis

Table 3 Isolation frequency of microbial infection in plaque and pharynx samples from older adults

細菌	要介護者		
	歯垢 n=329	咽頭 n=253	舌 n=75
Candida albicans	128 (38%)	97 (38%)	30 (40%)
Enterobacter cloacae	53 (16%)	27 (11%)	10 (13%)
Pseudomonas sp.	41 (12%)	7 (3%)	13 (17%)
Klebsiella pneumoniae	30 (9%)	35 (14%)	10 (13%)
Xanthomonas maltophilia	26 (8%)	7 (2%)	3 (4%)
Klebsiella oxytoca	21 (6%)	3 (1%)	12 (16%)
Staphylococcus aureus (MSSA)	18 (5%)	8 (2%)	4 (5%)
Coagulase negative staphylococci: CNS	17 (5%)	8 (2%)	3 (4%)
Serratia marcescens	12 (4%)	4 (1%)	7 (9%)
Psudomonas aeroginosa	12 (4%)	19 (6%)	5 (7%)
Staphylococcus aureus (MRSA)	8 (3%)	5 (2%)	3 (4%)
Acinetobacter calcoaceticus	8 (2%)	6 (2%)	2 (3%)
Candida glabrata	8 (2%)	4 (1%)	0 (0%)
Candida parapsilosis	7 (2%)	3 (1%)	3 (4%)
Haemophilus parainfluenzae	7 (2%)	4 (1%)	0 (0%)
Candida freundii	5 (2%)	4 (1%)	0 (0%)
Streptococcus anginosus	4 (1%)	2 (1%)	1 (1%)
Haemophilus influenzae	3 (1%)	2 (1%)	0 (0%)

Table 4 Correlation between bacteria in dental plaque and bedridden degree in the elderly

Bacteria	Bedridden degree			
	Not (n = 29)	Slightly (n = 88)	Moderately (n = 94)	Completely (n = 67)
Candida albicans	8 (28%)	30 (34%)	34 (36%)	30 (45%)
Enterobacter cloacae	7(24%)	7 (8%)*	14 (15%)	9 (13%)
Pseudomonas sp.	0 (0%)	15 (17%)**	14 (15%)**	6 (9%)
Klebsiella pneumoniae	5 (17%)	10 (11%)	4 (4%)	9 (13%)
Xanthomonas maltophilia	5 (17%)	7 (8%)	5 (5%)	1 (2%)
Klebsiella oxytoca	3 (10%)	4 (5%)	5 (5%)	10 (15%)
Staphylococcus aureus (MSSA)	1 (3%)	5 (6%)	2 (2%)	3 (4%)
Coagulase negative staphylococci: CNS	2 (7%)	2 (2%)	3 (3%)	6 (9%)
Serratia marcescens	0 (0%)	2 (2%)	1 (1%)	7 (10%)*
Pseudomonas aeroginosa	2 (7%)	3 (3%)	2 (2%)	2 (3%)
Acinetobacter calcoaceticua	0 (0%)	3 (3%)	3 (3%)	1 (2%)
Candida parapsilosis	6 (21%)	3 (3%)**	1 (1%)**	0 (0%) **
Staphylococcus aureus (MRSA)	1 (3%)	1 (1%)	2 (2%)	3 (4%)

All data are no (%). Bedridden status: terms were described in Materials and Methods.
*: $p<0.05$, (χ^2 test with continuing correction, Not vs Slightly, Moderately and Completely)
**: $p<0.01$, (χ^2 test with continuing correction, Not vs Slightly, Moderately and Completely)

Table 5 Correlation between *C. albicans* or *K. pneumoniae* infection in oral and systemic disease

Systemic disease	Plaque		Pharynx	
	Negative n=164	Positive n=127	Negative n=114	Positive n=103
Cerebrovascular disease	81 (49%)	69 (54%)	57 (50%)	50 (49%)
Hypertension	61 (37%)	56 (44%)	41 (36%)	54 (52%) **
Heart disease	22 (13%)	31 (24%) *	26 (23%)	28 (27%)
Diabetes	16 (10%)	9 (7%)	10 (9%)	9 (9%)
Hepatic disease	2 (1%)	1 (1%)	1 (1%)	1 (1%)
Kidney disease	4 (2%)	1 (1%)	3 (3%)	1 (1%)
Parkinson's disease	2 (1%)	8 (7%)	2 (2%)	3 (3%)
Orthopaedic disease	20 (12%)	14 (11%)	11 (10%)	17 (17%)
Rheumatism	4 (2%)	4 (3%)	5 (4%)	2 (2%)
Malignant tumor	4 (2%)	6 (5%)	2 (2%)	4 (4%)

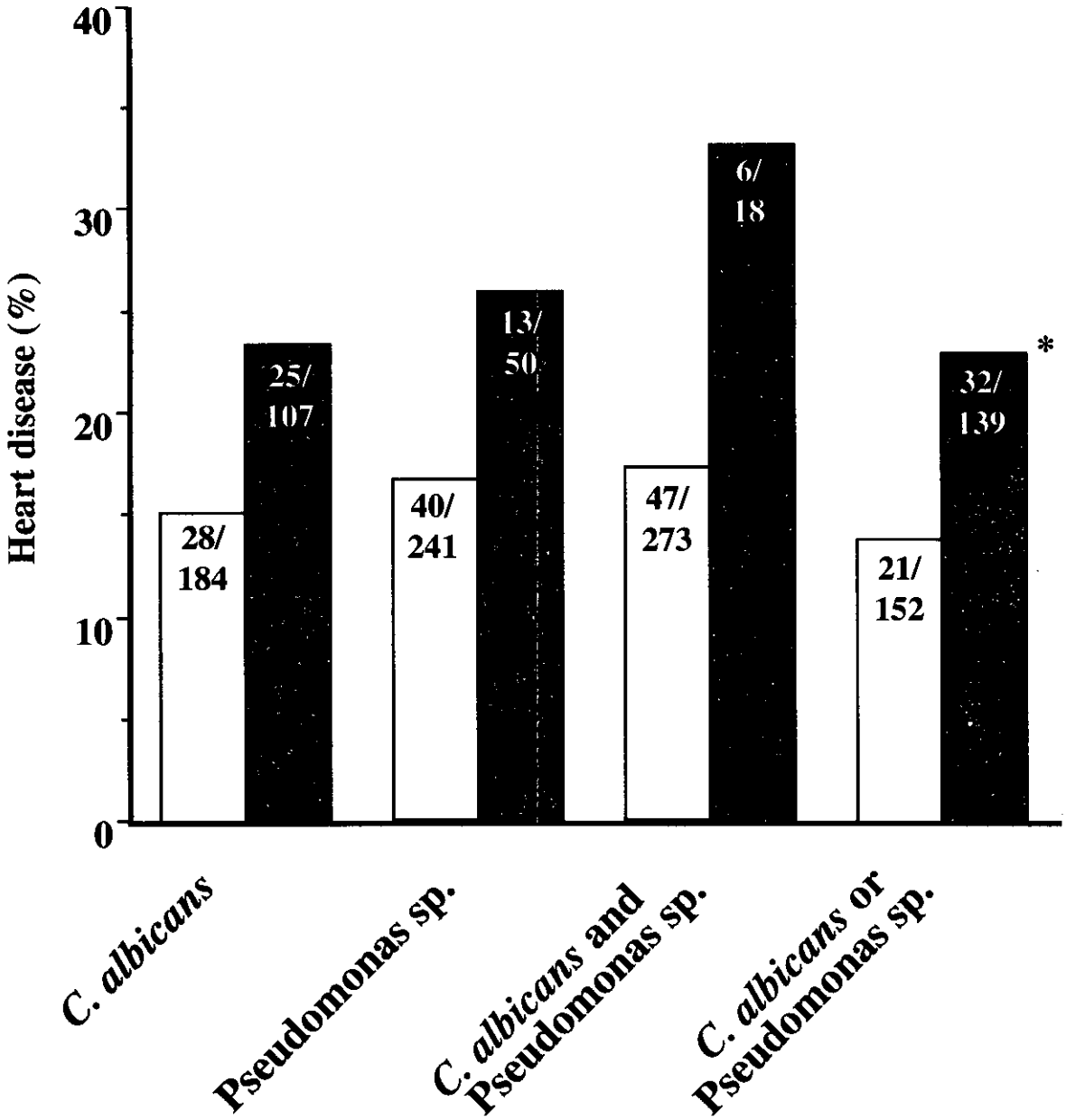

Fig. 1 ***H. Senpuku et al.***

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P.169-186は雑誌/図書等に掲載された論文となりますので下記の「研究成果の刊行に関する一覧表」をご参照ください。

「研究成果の刊行に関する一覧表」

う蝕の原因と対策—21世紀の歯と全身の健康を考える一
泉福英信　花田信弘
感染・炎症・免疫　30(1)　2000　P.1-10

歯科における外注臨床検査 3
培養法による口腔の日和見感染菌の検出
泉福英信　花田信弘　由川英二
アポロニア21　11月号　P.4-11

高齢者の口腔健康状態と運動機能との関係

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「高齢者の口腔保健と全身的な健康状態の関係についての総合研究」

C．研究課題名：「高齢者の口腔健康状態と運動機能との関係」

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E．研究目的：

加齢による口腔状況の悪化は全身の様々な機能低下と関連性があることが明らかにされている。しかし、高齢者の体力と口腔状況との関連に関する疫学研究は、ほとんど行われていない。そこで本研究は70歳の集団を対象とした10年間の縦断研究において参考として得られた80歳のデータを含む初年度データより高齢者における体力と咬合機能・形態の関連性の疫学的検討、および縦断調査における仮説形成を目的として分析を行った。

F．研究方法：

調査対象者は新潟市在住の70歳600名、80歳163名の計763名であった。体力測定は、その中から医学的所見をもとに測定が可能と判定されたものについて実施し、最終的な分析対象者は70歳591名（男性302名、女性289名）、80歳158名（男性71名、女性87名）の計749名であった。体力は、最大握力(kg)、体重あたりの最大脚伸展力(kg/body mass kg)、体重あたりの最大脚伸展パワー(W/body mass kg)、10秒間のステッピング回数、および開眼片足立ち時間(秒)を測定した。口腔状況は、現在歯数、Eichner index(以下 EI)、そして咀嚼能力、さらに補綴必要度について調べた。また、身長、体重、質問紙票により身体活動性、配偶者の有無など社会的要因、全身の身体的不調、さらに保健行動についても調べた。統計解析は、各体力測定項目を従属変数とした多変量解析を行った。

G．研究結果・考察：

多変量解析の結果、握力、脚伸展力と口腔状況との有意な関連性は認められなかったが、脚伸展パワーがEIと、ステッピング回数が現在歯数、EIと、開眼片足立ち時間が現在歯数、EI、咀嚼能力と有意な関連がそれぞれ認められた。また、他の交絡因子の影響を除外して

も、口腔健康状態が良好なほど体力が優れていることが示された。

脚伸展パワーの低下は階段昇降、椅子からの起立などの、高齢者の日常生活動作に影響を及ぼすといわれている。またステッピングは高齢者の動作の機敏性および将来の転倒予測の指標として用いることができるといわれており、さらに開眼片足立ち時間が長い者ほど階段昇降や椅子からの起立動作が楽にできるといわれている。したがって、高齢者においてとくに咬合支持をはじめとした天然歯による良好な咬合機能・形態の維持が日常生活動作関連の体力維持につながる可能性が示唆された。

H. 結論:

70、80歳749名を対象として咬合機能・形態と体力との関連性についての分析を行った結果、脚伸展パワーが Eichner indexと、ステッピング回数が現在歯数、 Eichner indexと、開眼片足立ち時間は現在歯数、 Eichner index、咀嚼能力と有意な関連性が認められた。したがって、高齢者にとって良好な咬合機能・形態の維持は体力の維持につながる可能性が示唆された。

I. 研究発表論文:

投稿原稿

Relationship between oral conditions including occlusal features and function and physical fitness in the elderly population

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SUMMARY The purpose of the present study was to examine relationship between physical fitness and oral conditions in the elderly. The sample consisted of 591 individuals aged 70 years and 158 aged 80 years selected from the registry of residents in Niigata city. Hand grip strength, leg extensor strength, leg extensor power, stepping rate, and one-leg standing time with eyes open were measured. They were also accessed the number of present teeth, Eichner index, and the masticatory ability score by the questionnaire. In comparing physical fitness with oral conditions, multivariate models were developed to adjust confounding variables (age, gender, height, body weight, activities of daily living, social factors, or other physical factors). The results of this investigation were as follows; 1. Leg extensor power showed a significant correlation with Eichner index; 2. Stepping rate showed significant correlations with the number of present teeth and Eichner index; 3. One-leg standing time with eyes open showed significant correlations with the number of present teeth, Eichner index, and the masticatory ability score. These findings suggest that better occlusal conditions might contribute to protect physical deterioration.

Introduction

The age-related decline in physical fitness is related to many problems in the elderly (Grabiner & Enoka, 1995; Pendergast, Fisher & Calkins, 1993). For example, a reduced lower extremity function is positively related to an increase of risk for falls (Gehlsen & Whaley, 1990; Grabiner et al., 1995; Tinetti, Speechley & Ginter, 1988), loss of balance (Grabiner et al., 1995), and difficulty stair climbing (Bassey et al., 1992; Grabiner et al., 1995; Rantanen, Era & Heikkinen, 1994).

Functional impairment of oral cavity with ageing is reported to intimately be associated with the physical activity (Miura, Araki & Umenai, 1997). It was reported regarding to the relevancy between the oral status and physical fitness of the aged that there was relationship between the presence of the occlusal support by dentures in edentulous subjects and physical fitness (Ishijima et al., 1998).

It is the well-known fact that physical fitness decreases with ageing (Yoshitake et al., 1999). Therefore, it is necessary for evaluating relevancy to physical fitness to be carried out age-controlled

analyses. However, no literature has been found based on age-controlled statistics.

We started longitudinal epidemiological study that was included in large project participation in the elderly population aged 70 years old at baseline. The aim of present study was to evaluate the relationship between physical fitness and oral conditions (the number of present teeth, occlusal support, and masticatory ability) from the baseline data considering confounding factor, and to construct the hypothesis for the longitudinal study.

Subjects and Methods

Study sample

Initially, questionnaires were sent to all 6,629 inhabitants aged 70 and 80 years old on a registry of residents in Niigata city, and they were informed of the purpose of this survey and asked whether they wanted to participate. According to the replies, 763 individuals were selected randomly in order to be approximately same numbers in gender of each age. The examinations were carried out at community halls of seven places for a period of twelve days. Physical fitness measurements were carried out in only persons who were permissible based on electrocardiogram, blood pressure or physician's interview. Finally, sample size for analyses comprised 591 individuals aged 70 years (302 males and 289 females) and 158 aged 80 years (71 males and 87 females). In physical fitness tests, minimum participation-rate was 80.5% (leg extensor strength), and maximum was 98.2% (hand grip strength).

Physical fitness

The physical fitness tests were preceded by a medical examination.

Hand grip strength: maximum hand grip strength was measured using a Smedley hand dynamometer (Yagami Inc., DM-100s, Nagoya, Japan) in both the dominant and nondominant hand. The score obtained was the best of the trials for both grip strengths.

Leg extensor strength: the maximal isometric knee extensor strength was determined by a portable chair incorporating a strain gauge connected to a load cell. The subject sat on a seat in a vertical position that was adjusted so he or she sat comfortably with the legs hanging vertically and knee bent at ninety degrees. The test was alternatively performed twice on right and left legs, respectively. Left and right leg extensor strength were summed for this analysis.

Leg extensor power: The maximal leg extensor power was determined by an isokinetic dynamometer (Combi Co., Aneropress 3500, Tokyo, Japan). The subject was instructed to sit on the seat of the instrument and press their feet on the plate as fast as possible they can in the forward until the legs are fully extended. The body mass of each was applied as a resistance. The best score of five trials was used

for this analysis.

Stepping: maximal stepping rate for ten seconds was used as an index of agility using industrial stepping rate counter (Yagami Inc., Stepping Counter, Nagoya, Japan). The subject was instructed to step alternatively as fast as possible with each leg on sitting position for ten seconds, respectively. Stepping rate of left and right leg were summed for this analysis.

One-leg standing time with eyes open: The static balance function was measured with eyes open and arms out, standing on one foot with the other off the floor. The score was the number of seconds between the nonpreferred foot was raised and balance was lost (when the subject began to hop around or when the raised foot was lowered to the floor), or when two minutes had elapsed. The subjects performed one trial on their right and left foot, respectively, and the best score was recorded.

Oral conditions

As indices of oral conditions, the number of present teeth, Eichner index (Eichner, 1955), and masticatory ability were assessed. The subject was laid on the potable bed, and the number of present teeth except remaining roots and Eichener index were examined by calibrated four dentists.

Although Eichner Index was based on existing natural tooth contacts between maxilla and mandible in the bilateral premolar and molar regions, it was determined expediently (existence of tooth contact defined as existence of natural tooth in the maxilla and mandible correspondingly) the classification. Class A represents contact in all four support zones. Class B represents in from three to one zone or in the frontal region only. Class C means absence of tooth contact.

Masticatory ability was evaluated by questionnaire regarding to fifteen food items that were chosen according to texture and hardness. The sample was divided into two groups according to ability of chewing every food. In addition, prosthetic treatment needs were seessed and recorded.

General health conditions

Activities of daily living (ADL) levels were decided applying three indices: the guidelines of the Ministry of Public Welfare of Japan, Tokyo Metropolitan Institute of Gerontology (TMIG) index (Koyano et al., 1991), and functional performance score (FPS) (Yoshitake et al., 1999).

Additionally, the following variables were used to analyze: height (cm), body weight (kg), body mass index (BMI), three social factors (e.g. presence of a spouse), thirty items interviewed concerning physical conditions (e.g. gastrointestinal condition), and seven variables referred to health habits (e.g. smoking habit) (Belloc & Breslow, 1972).

Statistical methods

Unpaired t-test or ANOVA was performed in each gender/age to examine relationships between each measurements of physical fitness and categorized other variables including oral conditions. The frequency distribution of one-leg standing time with eyes open was not normal distribution, therefore subjects were categorized four groups as follows; less than 20 seconds, less than 40 seconds, less than 120 seconds, and greater than or equal 120 seconds, respectively, and the correlations with the variables were analyzed by chi-square test.

Furthermore, multivariate analysis was carried out using physical fitness measurements as dependent variables. The other investigated items including oral conditions were independent variables. Except oral conditions, the items that showed at least one difference ($p<0.10$) in cross tabulations by gender and age were used as the dependent variables. Moreover, the variables with obviously confounding relationships between each data (e.g. BMI to body weight) were excluded. In order to examine the relationships between each oral conditions and physical fitness, the multivariate analyses were carried out using the number of present teeth, Eichner index, and masticatory ability, respectively as the independent variables.

Since one-leg standing time with eyes open did not show normal distribution as stated above, logistic regression models were constructed for analyzing one-leg standing time with eyes open (coded as dummy variables <40 seconds/greater or equal). Then multiple regression models were constructed for analyzing other physical fitness measurements. When the multivariate analyses were performed, nominal scales were converted to dummy variables. All data were analyzed using StatView 5.0 (SAS Institute Inc., NC, USA).

Results

Table 1 shows mean values of hand grip strength, leg extensor strength, leg extensor power and stepping, and Table 2 shows the distribution of categorized one-leg standing time with eyes open. All measurements of 70 years old men or women were higher than 80 years old men or women; there are significant differences ($p<0.001$) by gender or by age.

Table 3 shows the distribution of the categorized oral condition items. There were significant differences ($p<0.001$) in the number of present teeth and Eichner index by age, however, not by gender. In masticatory ability, there were significant differences ($p<0.001$) by age and gender.

Table 4 and Table 5 show the overview of the relationship between physical fitness and the oral conditions. The multiple regression statistics did not show the relationship between maximal hand grip strength and each oral condition; however, there were significant correlations ($p<0.01$) between hand grip strength and age, gender, body weight, or FPS (data are not shown in the table). Furthermore, the multiple regression statistics did not show the relationship between maximal leg extensor strength and

each oral condition; however, there were significant correlations ($p<0.01$) between maximal leg extensor strength and age, gender, or FPS (data are not shown).

Table 6 shows the results of the multiple regression analyses in maximal leg extensor power. Eichner index was significantly related to maximal leg extensor power ($p<0.05$). Moreover, there were significant correlations ($p<0.01$) between maximal leg extensor power and age, gender, FPS, movement of the bowels, or regularly taking prescribed medicine.

Table 7 shows the results of the multiple regression analyses in stepping. The number of present teeth ($p<0.10$) and Eichner index ($p<0.05$) were associated with stepping rate.
Moreover, there were significant correlations ($p<0.01$) between stepping rate and age, gender, or recent physical condition.

Table 8 shows the results of the logistic regression analyses in one-leg standing time with eyes open. The number of present teeth, Eichner index, and masticatory ability were significantly related ($p<0.05$) to one-leg standing time with eyes open. Moreover, there were significant correlations ($p<0.01$) between one-leg standing time with eyes open and age, gender, BMI, or FPS.

Discussion

Almost all subjects of this study were individuals who could come to examination places independently. Furthermore, the participants in the physical fitness tests were limited for prevention against accidents (e.g., falls). Accordingly, the subjects for present analyses almost live independently.

In the present study, the number of present teeth and Eichner index were examined as objective indicator of oral condition, and masticatory ability according to questionnaire was assessed as subjective index. In several epidemiological studies, masticatory ability has been estimated using by questionnaire (Agerberg & Carlsson, 1981; Miura et al., 1997). Though the food intake questionnaire is useful for evaluating masticatory function in comparison with objective indicator using by test food (Hirai et al., 1994), there were the reports that objective estimation by subject might or might not agree with subjective estimation by dentist (Arnbjerg, Soderfeldt & Palmqvist, 1992). Therefore, in this study, Eichner index was also examined as a measurement of deterioration in dental state and dental functional impairment (Österberg, Mellstrom & Sundh, 1990).

Leg extensor power is indicator of lower extremity dynamic strength. The loss of muscle power of the lower extremities can have an important impact on the ability to perform activities of daily living such as walking and stair climbing (Aniansson, Rundgren & Sperling, 1980; Brown, Sinacore & Host, 1995; Young & Skelton, 1994). It was also reported that the leg extensor power to be closely related to the speed of walking up stairs, standing up from a chair, and gait speed for the frail elderly and the very old (Bassey et al., 1992). In the present study, multiple regression statistics showed the significant correlation between maximal leg extensor power and Eichner index consequently, that is to say, a loss of occlusal

support might be associated with the reduction of lower extremity dynamic strength in the elderly. Moreover, it was presented that leg extensor power was influenced by movement of the bowels, smoking habit, and regularly taking prescribed medicine. This might suggest that lower muscle power was potentially affected by health status.

Stepping rate is an index of agility estimated by the repetition of left and right footsteps at sitting a chair. Subject sits a chair released from load of one's body weight; therefore, the maximum stepping rate is determined by a speed of the contraction and relaxation of the right and left each muscle of lower extremity. The present multiple regression analyses showed the association of maximum stepping rate with the number of present teeth and Eichner index, and then it was proposed that the maintaining of teeth and occlusal support of natural teeth to some extent might be contributed to agility of the elderly. On the other hand, recent physical condition had a positive influence upon stepping rate, furthermore, standardized partial regression coefficients of it were higher than of other independent variables next to age and gender in all multiple regression models (β=0.104 to 0.105, $p<0.01$). This suggests that agility of the elderly might be affected by the physical condition.

The test of standing on one leg with eyes closed has been frequently used to evaluate the balance function, but this method also has the risk of possibly influence a fall and is difficult to evaluate individual differences in the elderly due to finishing in several seconds (Yoshitake et al., 1999). Therefore, the test of standing on one leg with eyes open usually used to evaluate the equilibrium function in particularly the elderly (Kimura et al., 1996; Gehlsen et al., 1990; Yoshitake et al., 1999). In this study, one-leg standing time with eyes open associated with all of three items of oral conditions; thus, it was most strongly related to oral conditions.

Ishigami and colleagues reported that when the locus areas of body sway in the center of gravity were compared with the denture wearing or without in subjects with no occlusal support from remaining teeth, they were significantly increased without denture wearing (Ishigami et al., 1990). They supposed this reason as follows; the infraclusion by loss of teeth brought about the dislocation of mandible, as a result, labyrinths in rear of temporomandibular joints were impaired, and balance function might be deteriorated. Labyrinth is very important organ in postural reflex system, and the posture state was controlled by bathyesthesia mainly labyrinth, visual organ, and others (Miyata et al., 1988). Thus, it is inferred that the reduction of balance function might be brought on by the direct impairment of labyrinth followed by the malocclusion and the change of occlusal vertical dimension caused by loss of teeth. On the other hand, it was reported that the varieties of the habitual head position had any influences on bilateral balance of head and neck muscle activity (Omae et al., 1989). Therefore, abnormal habituations such as a one-side masticatory may be precipitated by decrease of the number of present teeth or reduction of occlusal support. Moreover, the abnormal habituations may lead to disequilibrium of systemic muscle balance and may some influences on systemic equilibrium function.

In conclusion, these findings suggest that maintaining natural teeth and occlusal support may

contribute to fair physical fitness in the elderly.

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Table 1. Mean values of each physical fitness measurements in subjects except one-leg standing with eyes open

	70 yr. Males		70 yr. Females		80 yr. Males		80yr. Females	
	mean ± SD	(N)	mean ± SD	(N)	mean ± SD	(N)	mean ± SD	(N)
Hand grip strength (kg)	39.0 ± 5.7	(302)	24.3 ± 3.7	(289)	32.4 ± 5.6	(71)	19.5 ± 3.8	(87)
Leg extensor strength (kg / body mass kg)	1.2 ± 0.3	(257)	0.8 ± 0.3	(252)	0.9 ± 0.3	(54)	0.7 ± 0.3	(51)
Leg extensor power (W / body mass kg)	14.3 ± 3.4	(274)	8.8 ± 2.9	(262)	10.4 ± 2.9	(64)	6.1 ± 2.7	(65)
Stepping (time/10sec)	79.7 ± 14.1	(295)	71.0 ± 12.6	(278)	70.4 ± 13.9	(65)	62.3 ± 14.1	(73)

Table 2. Distribution of one-leg standing with eyes open measurements in subjects

Time of measurements (sec.)	70 yr. Males		70 yr. Females		80 yr. Males		80yr. Females	
	N	(%)	N	(%)	N	(%)	N	(%)
-19	51	(17.4)	99	(36.0)	40	(61.5)	56	(76.7)
20-39	43	(14.7)	62	(22.5)	10	(15.4)	10	(13.7)
40-119	100	(34.1)	56	(20.4)	12	(18.5)	6	(8.2)
120-	99	(33.8)	58	(21.1)	3	(4.6)	1	(1.4)