Original Article

pISSN, eISSN 0125-5614
M Dent J 2019; 39 (1) : 21-33

Relationship between oral health status and nutritional status in a group of older persons: Number of functional units and number of teeth

Passawich Tubtimtong[1], Potchaman Sinavarat[2], Chuchai Anunmana[2]

[1] *Chiangrai Regional Hospital, Chiangrai, Thailand*
[2] *Department of Prosthodontics, Faculty of Dentistry, Mahidol University, Bangkok, Thailand*

Objective: The objectives of this study were to evaluate the oral health status i.e., dental decay, periodontal disease, number of teeth, and number of functional units and investigate the relationship between oral health status and nutritional status in the pre-ageing and ageing groups.

Materials and Methods: The oral health status and nutritional status of 290 persons in Tubtao subdistrict, Thoeng district, Chiangrai province, Thailand, aged 50 years and over were evaluated. Study measurements included: a) questionnaire to assess sociodemographic, behavioral, general health, and oral health data of the participants; and b) oral examinations to evaluate caries, periodontal status, oral lesions, number of teeth, and number of functional units (FUs). Nutritional status was determined using the Short-Form Mini-Nutritional Assessment (MNA-SF). Association between participants' characteristics, oral health status, and nutritional status were tested using chi-square analysis.

Results: Participants aged 50-88 years were classified into pre-ageing group (50-59 years) and ageing group (≥60 years). One hundred and fifteen subjects were classified as pre-ageing group and 175 were in the ageing group. In the pre-ageing group, most participants had oral health status better than the ageing group. According to MNA-SF, about 46% and 3.5% of the pre-ageing group were at risk of malnutrition and malnutrition, respectively. Living condition and periodontal status showed significant difference of nutritional status ($p<0.05$). In the ageing group, the results of the nutritional status according to MNA-SF and BMI were the same as those in the pre-ageing group. The participants' characteristics related to education, living condition, systemic diseases, feeling of mouth dryness, and avoidance of eating vegetables and fruits significantly associated with nutritional status ($p<0.05$). Furthermore, significant association were observed between the number of functional units, number of present teeth, and MNA-SF ($p<0.05$).

Conclusion: The results of the study indicated that the participants in both groups had poorer oral health than the reports of the 7th Thailand Oral Health Survey of northern Thailand and the number of present teeth, and number of FUs of the ageing participants had association with nutritional status. Many demographic characteristics of the ageing group also related to nutritional state. The results imply the need to develop effective strategies for improving oral health care of the populations and prevent oral and dental diseases and maintain the existing natural dentition. The strategies of preventive programme should include improving of oral hygiene care, providing oral health care, promotion of social activities for the pre-ageing and ageing people, and providing diet counseling. It is without doubt that the preventive programme should be commenced before they reach old age.

Keywords: BMI, functional units, MNA-SF, nutrition, older persons, oral health

How to cite: Tubtimtong P, Sinavarat P, Anunmana C. Relationship between oral health status and nutritional status in a group of older persons: Number of functional units and number of teeth. M Dent J 2019; 39: 21-33.

Correspondence author: Potchaman Sinavarat
Department of Prosthodontics Faculty of Dentistry, Mahidol University Bangkok, Thailand
6 Yothi Road, Ratchathewi District Bangkok 10400 Thailand
Tel: 02-200-7817-18 Email: potchaman.sin@mahidol.ac.th
Received : 1 October 2019 Accepted : 21 January 2019

Introduction

As oral health is a prerequisite for good chewing function which may have an impact on food selection and quality of life, older persons should maintain their good oral health for life. Adequate nutritional status is essential for people of all ages and it is a requirement for healthy ageing in older persons. However, in the ageing population malnutrition is an important problem that has been seen in hospitals and in communities. The causes of malnutrition are extremely varied. The major causes include poor dentitions, poor general health, multiple medications, physical handicaps, depression, existing food habits, and lack of knowledge [1-2]. Although elderly population tends to retain more natural teeth than ever before, many of their own teeth are affected by oral diseases, including root and coronal decay, periodontal disease, tooth wear, tooth fracture and finally tooth loss. These conditions may cause the older individuals avoid fiber and protein containing foods that are considered difficult-to-chew and prefer soft and processed food [3-4]. Therefore, natural dentition and well-fitting dentures will contribute to the consumption of a diet rich in fiber and adequate nutrient which can lead to an adequate health status. In general, masticatory status is related to features of dentition, such as the number of teeth and the quality of occlusal relationship, which is a main factor for good chewing function.

Käyser [5] has suggested a concept of shortened dental arch (SDA) which is proposed for middle-aged and elderly adults with a history of compromised oral health. Clinical studies have been performed regarding the number of teeth to be saved to guarantee satisfactory oral function and they concluded that most people require, in addition to their anterior teeth, at least four occlusal units of posterior teeth, preferably in a symmetrical position [5-11].

In 1992, the World Health Organization [12] set treatment goals to provide functional rather than complete dentitions for older adults. They recommended that at least 20 natural teeth should be kept to maintain good chewing function, esthetics and general well-being. However, the number of teeth may not be accurate for estimation of masticatory potential. Hildebrandt et al. [13] used a functional unit (FU) which was defined as any opposing natural or prosthetic tooth pairs as an indicator to describe masticatory potential while Sahyoun et al. [14] used the number of posterior pairs of teeth to indicate dental status. This is because the function of the posterior teeth is to grind food. These posterior teeth consist of two premolars and two molars in each arch for a total of 16 teeth or 8 pairs. They stated that the number of functional units in a dentition should represent a more accurate measure of masticatory potential than the number of present teeth [15]. Many authors have reported that there is a relationship between a change in oral and dental status, such as loss of teeth and wearing prostheses and an inadequate dietary intake [14,16-17]. However, the association between number and position of the remaining teeth and functional units and nutritional status are uncertain. Witter et al. reported that elderly persons with reduced dentition are able to compensate for tooth loss, either by chewing on the side where most teeth are left, by chewing longer, or by swallowing larger food particles [18]. Moreover, the advent of processed foods has made it possible for older persons with inadequate dentition to eat an adequate diet without chewing [14].

There are only few epidemiological studies to investigate the oral health status, including oral and dental diseases, the number of functional units and the number of present teeth related to nutritional status of the pre-ageing and ageing group. As dental decay and periodontal diseases are the major problems of tooth loss, the oral health status in this study was concentrated on these two diseases. Furthermore, older persons who have fewer natural teeth with other medical and social conditions are vulnerable to nutritional deficiency [19]. For this reason, it is an important

challenge for the health care providers that prevention of malnutrition should be performed at the pre-ageing period. An understanding of the causes contributed to malnourishment could be used as the basis essential to formulate appropriate management strategies for the development of oral health programme in the community as early as possible. Therefore, the aims of this study were to (i) evaluate the oral health status (dental decay, periodontal diseases and tooth loss) and (ii) investigate the relationship of these oral factors, including dental decay, periodontal disease, the number of present teeth and number of functional units, in particular, that contributed to nutritional status in the pre-ageing and ageing group residing at home.

Materials and Methods

Study design and study population

This cross-sectional study was conducted in a rural area in Tubtao subdistrict, Thoeng district, Chiangrai province, northern Thailand, because of its large population of older adults (17.8% as compared with 14% of the total Thai elderly population in 2016-2017). The target population was the Thai individuals, living at home, aged 50 and over. This was to include the pre-ageing group (aged 50-59) in the study. The sample size was calculated using the multistage cluster sampling method and the number of 290 participants was obtained from 1049 persons. The subjects were simple random sampling selected from the census registration using table of random number.

The research protocol was approved by Mahidol University Institutional Review Board (COA.No.MU-DT/PY-IRB 2016/031.2606). The subjects were informed of the aims of the research. Written consent was obtained from participants or their representatives. The inclusion criteria were that the subjects were cognitively able to answer questions, and were willing to participate in the study. Persons who needed to have antibiotic prophylaxis before being assessed the periodontal status using a CPI probe, such as having history of infective endocarditis and prosthetic heart valve, were excluded from the study. The participants were divided into two groups: (i) the age of 50-59 years as pre-ageing group (ii) 60 years and over as ageing group.

Measurements

The study was conducted between December 2016 and May 2017 and data collection was carried out in two phases. During the first phase, trained examiners collected information by interviewing using a questionnaire to obtain baseline demographic data including personal data, ability to perform daily activities, food avoidance, feeling of mouth dryness, and chewing and swallowing problems. Nutritional status was assessed using the Thai version of the Short-Form Mini Nutritional Assessment (MNA-SF) and the body mass index (BMI-kg/m^2). In the second phase dental status including caries, periodontal status, number of present teeth and number of functional units were recorded. Before conducting this part, two dentists calibrated in their ability to perform oral examination and record the number of natural teeth present and number of pairs of opposing teeth in five given persons. The Kappa statistics was used to test inter-examiner reliability. The result ranged from 0.83 to 0.87 which was considered as high consistency for each examiner [20].

Nutritional status assessment

There were several nutritional screening tools that could be used by persons without specific skills or training, such as the Nutritional Risk Index (NRI), the Geriatric Nutritional Risk Index (GNRI), the Mini Nutritional Assessment (MNA) and its shorter version [21]. Among these screening tools the MNA had been accepted as a practical and reliable tool [22-23] but it was rather complex and too long to use in the community screening. It took approximately 10 to 15 minutes to assess. For this reason, the Short-Form Mini Nutritional Assessment

(MNA-SF) has been revised to shorten to an optimal six-question which comprised of total score ranging from 0 to 14, using a score of ≥12 points as normal, 8-11 points as at risk of malnutrition and 0-7 points as malnourished. The questions in MNA-SF had 6 items including food intake, weight loss, mobility, self-assessment of mental and physical health, and body mass index (BMI). This tool made nutritional screening easier and quicker and now was the preferred form for clinical use. It took approximately 3 minutes to assess elderly patients who were malnourished or at risk of malnutrition and it was available in many languages [24-25].

To measure the BMI which was one of the items recorded in the MNA-SF, height and weight measurements were performed and calculated in a ratio of weight in kilograms and height in meters squared. The BMI could also be used alone to determine nutritional status. It had the cut-off points as follows: underweight (<18.5 kg/m^2), normal range (18.5-22.9 kg/m^2), overweight (23-24.9 kg/m^2) pre-obese (25-29.9 kg/m^2) and obese (≥30 kg/m^2) [26].

Dental examination

The dental examination recorded the number of teeth affected by caries, depth of periodontal pocket, the number of natural teeth present and the number of functional units (third molars were excluded). The presence and type of dental prostheses was also recorded in accordance with World Health Organization criteria [27]. The participants who wore complete dentures were classified into a particular group. As third molars were not counted, the maximum possible number of FUs in a dentition was 14 and the maximum number of present teeth was 28. Functional units were subdivided by composition into: natural maxillary teeth occluding with natural mandibular teeth (N/N), prosthetic maxillary teeth occluding with prosthetic mandibular teeth (P/P), mixed FUs (N/P and P/N), and no occluded teeth.

Statistical analysis

A descriptive analysis (percentage, median, mean and standard deviation) was applied to inform characteristics of the participants, oral health status, BMI and nutritional status. Pearson Chi-square and Fisher's exact test were used to compare characteristics of the participants, oral health status, and nutritional status. The correlation between types of FUs and nutritional status was analyzed using Kruskal-Wallis test and Mann-Whitney U test. The maximum p-value considered significant was set 0.05. The data was processed and analyzed using the Statistical Package for Social Sciences 18.0 (SPSS 18.0, SPSS Inc. Chicago, IL, USA) [28].

Results

Sociodemographic and behavioral characteristics assessments

A total of 290 persons, 115 (39.7%) subjects in the pre-ageing group and 175 (60.3%) in the ageing group, participated in the study. In the pre-ageing group the mean age was 54.7±2.8 yrs. (range 50-59 yrs.); in the ageing group the mean age was 66.5±6.2 yrs. (range 60-88 yrs). The percentage of women in the pre-ageing and ageing group were 50.4 and 45.1, respectively. The majority of both group (73.0 and 85.7%) had complete elementary education and lived with their families (95.7 and 93.7%). Only 5 (4.3%) participants in the pre-ageing group and 11 (6.3%) participants in the ageing group lived alone. About half of the participants in both group (58.3 and 44.6%) had problems with their monthly income. All participants of both groups, except 1 in the ageing group, could perform their activities of daily living. The self-report of mouth dryness in the pre-ageing and the ageing group were 24.3% and 16.6% respectively. Thirty-five percent of the pre-ageing group reported of chewing problem while 40% of the elders reported of such problem. (Table 1)

Table 1 Socio-demographic characteristics in pre-ageing and ageing groups

Characteristics	n (%)	
	pre-ageing (N=115)	ageing (N=175)
Gender		
Male	57 (49.6%)	96 (54.9%)
Female	58 (50.4%)	79 (45.1%)
Education		
Illiterate	2 (1.7%)	10 (5.7%)
Elementary education	84 (73.0%)	151 (86.3%)
Higher	29 (25.3%)	14 (8.0%)
Living condition		
With family	110 (95.7%)	164 (93.7%)
Alone	5 (4.3%)	11 (6.3%)
Problem of monthly income	67 (58.3%)	78 (44.6%)
Systemic diseases (i.e., hypertension, diabetes, etc.)	29 (25.2%)	81 (46.3%)
Mouth dryness	28 (24.3%)	29 (16.6%)
Chewing problem	41 (35.7%)	71 (40.6%)
Type of food avoidance: vegetable and fruits	21 (18.3%)	75 (42.9%)

Dental examination

Table 2 shows the oral health status of the pre-ageing and the ageing groups. Caries and periodontal pocket could be observed in both groups. Most of the participants still retained their natural teeth. The mean number of present teeth of the pre-ageing and ageing group were 25.0±4 and 20.7±8, respectively, (maximum=28 teeth). Among the participants in pre-ageing, 94% had 20 teeth or more while 74% was shown in ageing group. When the functional unit was considered, the results revealed that the mean number of FUs in the pre-ageing and ageing were 11.9±2.7 and 10.5±4.0, respectively, (maximum=14 pairs).

Nutritional status

Nutritional status described by the MNA-SF and BMI in the pre-ageing and ageing group are listed in Table 3. In the pre-ageing group, according to the MNA-SF assessment 50.4% of the participants had normal nutrition, 46.1% were at risk of malnutrition and 3.5% had malnutrition. When BMI was considered, it revealed that the number of participants with underweight were greater than those with overweight and pre-obese. Compared to the ageing group according to the MNA-SF, 45% of the elderly participants had normal nutrition, 46.9% were at risk of malnutrition and 5.7% had malnutrition. The results according to the BMI were the same as those in the pre-ageing. Slightly greater number of normal nutrition could be observed in pre-ageing group using either assessment of MNA-SF or BMI.

Table 2 Characteristics of oral health status* in pre-ageing and ageing groups

Oral health status	pre-ageing (N=115)	ageing (N=175)
Coronal caries (teeth/person)	3.00 (0,21)	2.00 (0,21)
Root caries (teeth/person)	1.00 (0,15)	1.00 (0,19)
Periodontal status		
Bleeding	0 (0.0%)	4 (2.3%)
Calculus	76 (66.1%)	82 (46.9%)
Periodontal pocket 4-5 mm.	24 (20.9%)	52 (29.7%)
Periodontal pocket ≥ 6 mm.	14 (12.2%)	22 (12.6%)
Oral lesions (person)	1	2
Number of teeth (teeth/person)	25.03 ± 4.11	20.67 ± 8.42
Number of teeth ≥ 20 teeth/person	108 (93.9%)	129 (73.7%)
Number of FUs (pair/person)	11.89 ± 2.7	10.55 ± 4.0
Number of FUs ≥ 10 teeth/person	97 (84.3%)	129 (73.7%)
Number of posterior FUs (pair/person)	6.23 ± 2.0	5.32 ± 2.7
Number of posterior FUs ≥ 4 pairs/person	103 (89.6%)	136 (77.7%)

*Data are presented as number of subjects (percentage), mean±SD for number of teeth and functional units or median (min,max) for coronal and root caries.

Table 3 Nutritional status according to MNA-SF and BMI in pre-ageing and ageing groups

Nutritional status	n (%)	
	pre-ageing (N=115)	ageing (N=175)
MNA-SF		
normal	58 (50.4%)	79 (45.1%)
risk of malnutrition	53 (46.1%)	86 (46.9%)
malnutrition	4 (3.5%)	10 (5.7%)
BMI		
underweight	25 (21.7%)	52 (29.7%)
normal	70 (60.9%)	82 (46.9%)
overweight	17 (14.8%)	30 (17.1%)
pre-obese	3 (2.6%)	11 (6.3%)

The relationship between participants' characteristics, oral health and nutritional status

The association between the participants' characteristics and MNA-SF of the pre-ageing are shown in Table 4. Only the living condition (with family or alone) had statistically significant association with nutritional status (p=0.048). Gender, education, income, having systemic disease, mouth dryness, chewing problem and food avoidance did not relate to nutrition. When considering the oral health status, the periodontal pocket (4, 5, ≥6 mm) had significant relation to nutritional status (p= 0.047). No significant association was observed between the number of teeth, number and type of FUs and MNA-SF. (Table 5)

Table 4 Relationship between participants' characteristics and nutritional status* in the pre-ageing group

Characteristics	MNA-SF			*P*-value
	Normal nutrition (n=58)	Risk of malnutrition (n=53)	Malnutrition (n=4)	
Gender				
Male	30 (26.1%)	24 (20.9%)	3 (2.6%)	0.47γ
Female	28 (24.3%)	29 (25.2%)	1 (0.9%)	
Education				
Illiterate	1 (0.9%)	0 (0.0%)	1 (0.9%)	0.23γ
Elementary education	40 (34.8%)	41 (35.7%)	3 (2.6%)	
Higher	17 (14.8%)	12 (10.4%)	0 (0.0%)	
Living condition				
With family	56 (48.7%)	52 (44.3%)	2 (2.0%)	**0.048γ**
Alone	2 (2.0%)	1 (1.0%)	2 (2.0%)	
Problem of monthly income	29 (25.2%)	35 (30.4%)	3 (2.6%)	0.18γ
Systemic diseases	13 (11.3%)	16 (13.9%)	0 (0.0%)	0.39γ
Mouth dryness	11 (9.6%)	16 (13.9%)	1 (0.9%)	0.32γ
Chewing problem	13 (11.3%)	28 (24.3%)	0 (0.0%)	0.06γ
Type of food avoidance: vegetable and fruits	12 (10.4%)	8 (7.0%)	1 (0.9%)	0.55γ

* Data are presented as number of subjects (percentage)

γ Fisher's exact test

Table 5 Relationship between oral health status and nutritional status* in the pre-ageing group

Oral health status	MNA-SF			*P*-value
	Normal nutrition (n=58)	Risk of malnutrition (n=53)	Malnutrition (n=4)	
Coronal caries				
< 5 teeth	44 (38.6%)	38 (33.3%)	2 (1.8%)	0.48γ
≥ 5 teeth	14 (12.3%)	14 (12.3%)	2 (1.8%)	
Root caries				
< 5 teeth	47 (41.2%)	44 (38.6%)	4 (3.5%)	0.91γ
≥ 5 teeth	11 (9.6%)	8 (7.0%)	0 (0.0%)	
Periodontal status				
Periodontal pocket 4-5mm.	8 (7.0%)	16 (14.0%)	0 (0.0%)	**0.047γ**
Periodontal pocket ≥ 6 mm.	7 (6.1%)	5 (4.4%)	2 (1.8%)	
Number of teeth				
< 20 teeth	4 (3.5%)	3 (2.6%)	0 (0.0%)	1.00γ
≥ 20 teeth	54 (47.0%)	50 (43.5%)	4 (3.5%)	
Number of FUs				
< 10 FUs	7 (6.1%)	9 (7.8%)	2 (1.7%)	0.12γ
≥ 10 FUs	51 (44.3%)	44 (38.3%)	2 (1.7%)	
Type of FUs				
No occluded teeth	1 (0,14)	1 (0,14)	5 (0,7)	0.28κ
N/N	12 (0,14)	12 (0,14)	9 (7,14)	0.43κ
N/P or P/N	0 (0,6)	0 (0,4)	0 (0,0)	0.58κ
P/P	0 (0,5)	0 (0,1)	0 (0,0)	0.96κ

* Data are presented as number of subjects (percentage) or median (min,max) for type of functional units.

γ Fisher's exact test

κ Kruskal-Wallis and Mann-Whitney U test

In the ageing group, the results indicated that participants classified as at risk of malnutrition and malnutrition were likely to be female. The characteristics of participants related to education, living condition, having systemic diseases, feeling of mouth dryness, and avoidance of eating vegetables and fruits significantly associated with nutritional status ($p<0.05$) as shown in Table 6. The relationship between the oral health status and MNA-SF is shown in Table 7. The study found that the nutritional status was correlated with the periodontal pockets ($p=0.03$) but there was no significant relation with both coronal and root caries ($p>0.05$). Nutritional status also differed significantly between older adults with ≥20 teeth and those with <20 teeth ($p=0.003$). When considering the number of functional units, nutritional status showed significant difference between ≥10 FUs and <10 FUs ($p=0.029$). In addition, nutritional status significantly associated with FUs categorized as natural maxillary teeth occluding with natural mandibular teeth (N/N) ($p=0.008$). There was no significant association between nutrition and FUs when prosthetic maxillary teeth occluding with prosthetic mandibular teeth (P/P), mixed FUs (N/P and P/N), and no occluded teeth ($p>0.05$).

Table 6 Relationship between participant's characteristics and nutritional status* in the ageing group

Characteristics	MNA-SF			*P*-value
	Normal nutrition (n=79)	Risk of malnutrition (n=86)	Malnourished (n=10)	
Gender				
Male	54 (30.9%)	41 (23.4%)	1 (0.6%)	<0.0001℘
Female	25 (14.3%)	45 (25.7%)	9 (5.1%)	
Education				
Illiterate	3 (1.7%)	3 (1.7%)	4 (2.3%)	0.03γ
Elementary education	68 (38.9%)	77 (44.0%)	6 (3.4%)	
Higher	8 (4.6%)	6 (3.4%)	0 (0.0%)	
Living condition				
With family	74 (42.3%)	82 (46.9%)	8 (4.5%)	0.02γ
Alone	5 (2.9%)	4 (2.3%)	2 (1.1%)	
Problem of monthly income	39 (22.3%)	35 (20.0%)	4 (2.3%)	0.48℘
Systemic diseases	52 (64.2%)	24 (29.6%)	5 (6.2%)	0.037γ
Mouth dryness	12 (6.9%)	11 (6.3%)	6 (3.4%)	0.002℘
Chewing problem	39 (22.3%)	29 (16.6%)	6 (3.4%)	0.11γ
Type of food avoidance: vegetable and fruits	32 (42.7%)	35 (46.7%)	8 (11.6%)	0.032℘

* Data are presented as number of subjects (percentage)

℘ Pearson chi-square test

γ Fisher's exact test

Table 7 Relationship between oral health status and nutritional status* in the ageing group

Oral health status	MNA-SF			*P*-value
	Normal nutrition (n=79)	Risk of malnutrition (n=86)	Malnourished (n=10)	
Coronal caries				
< 5 teeth	57 (34.5%)	60 (36.4%)	6 (3.6%)	
≥ 5 teeth	19 (11.5%)	21 (12.7%)	2 (1.2%)	1.00 $^{\wp}$
Root caries				
< 5 teeth	63 (38.2%)	71 (43.0%)	7 (4.2%)	0.80 $^{\wp}$
≥ 5 teeth	13 (7.9%)	10 (6.1%)	1 (0.6%)	
Periodontal status				
Periodontal pocket 4-5mm.	26 (16.3%)	23 (14.4%)	3 (1.9%)	**0.03** $^{\gamma}$
Periodontal pocket ≥ 6 mm.	12 (7.5%)	9 (5.6%)	1 (0.6%)	
Number of teeth				
< 20 teeth	23 (13.1%)	16 (9.1%)	7 (4.0%)	**0.003** $^{\wp}$
≥ 20 teeth	63 (36.0%)	63 (36.0%)	3 (1.7%)	
Number of FUs				
< 10 FUs	25 (14.3%)	16 (9.1%)	5 (2.9%)	0.029 $^{\wp}$
≥ 10 FUs	63 (36.0%)	61 (34.9%)	5 (2.9%)	
Type of FUs				
No occluded teeth	2 (0,14)	2 (0,14)	2 (0,14)	0.53 $^{\kappa}$
N/N	11 (0,14)^{a}	10 (0,14)^{a,b}	1 (0,14)^{b}	**0.008** $^{\kappa}$
N/P or P/N	0 (0,11)	0 (0,12)	0 (0,3)	0.42 $^{\kappa}$
P/P	0 (0,11)	0 (0,10)	0 (0,9)	0.21 $^{\kappa}$

* Data are presented as number of subjects (percentage) or median (min,max) for type of functional units.

$^{\gamma}$ Fisher's exact test

$^{\wp}$ Pearson chi-square test

$^{\kappa}$ Kruskal-Wallis and Mann-Whitney U test

Discussion

Relationship between the condition of dentition and the nutritional status of older persons has been studied by several investigators [29-31]. Many studies assessed dental status using number of present teeth [32-34]. As suggested by Hildebrandt et al, the number of teeth may not be accurate for estimation of masticatory efficiency; the number of FUs and posterior occluding pairs appear to be better indicators to describe masticatory function [8,13,35]. For this reason, this investigation studied both the effect of number of FUs and number of teeth on nutritional status. Moreover, there are limited data to indicate the influence of functional tooth units and number of teeth on nutritional status in the pre-ageing people. This current study investigated oral status which might be risk indicators associated with malnutrition by means of oral examinations assessing the caries and periodontal pockets, number of teeth and number of FUs (natural and prosthetic teeth).

Regarding the oral health status, the results of this study revealed that coronal caries, root caries and periodontal pocket ≥6 mm were the oral health problems of both pre-ageing and ageing groups (3.0 teeth, 1.0 teeth, 12.2% and 2.0 teeth, 1.0 teeth, 12.6%, respectively). Compared with the reports of the 7th Thailand Oral Health Survey of northern Thailand [36] of the adult group and the ageing group, the mean number of coronal caries, root caries and the percentage of people with periodontal pocket ≥6 mm were 0.6 teeth, 0.0 teeth, 3.5% and 1.1 teeth, 0.1 teeth, 9.1%, respectively. The results of this study are not consistent with the report of the 7th Thailand Oral Health Survey of northern Thailand indicating poorer oral health in this study group. Loss of teeth seemed not to be the problems of both groups because they still had 25 and 20 teeth per person in pre-ageing and ageing groups, respectively. This finding is in agreement with the published data reporting of the number of teeth of the adult and ageing groups in northern Thailand (27.9 and 18.6 teeth, respectively). Based on the results, control of oral disease i.e. dental caries and periodontal disease should be strengthened through public health policy to provide affordable oral health services, and adequate oral hygiene care education before they reach old age.

The reliability of the collected data was obtained through the use of well-defined clinical criteria, [27] and the calibration of the examiners [20] which should have confirmed a minimal examiner's variability. Data of the ageing group in this study revealed that nutritional status had relationship with the periodontal status, and both the number of teeth and FUs. This is in agreement with the findings of the previous studies [29-30, 33, 37-39]. They reported that chewing ability seemed to be satisfactory with at least 20 teeth and the FUs (natural or artificial) seemed to be important factors for chewing ability and chewing difficulty increased with decreasing the numbers of functional tooth units which could influence the nutritional status. In addition, nutritional status showed significant association with types of FUs which was categorized as N/N. No association was found with other types of FUs related to prosthesis used (N/P, P/N and P/P). Moreover, where nutritional status found to be at risk of malnutrition or malnutrition, some factors other than the condition of oral and dental status, such as educational level, living condition, systemic diseases and increasing use of medicine had association with nutritional status as well. Previous studies have also shown the same results [40-41].

In the pre-ageing group, there were only two risk indicators of malnutrition, namely, living condition and periodontal pocket. There were no relationship among nutritional status and other participants' characteristics and number of teeth and FUs. This probably resulted from an adaptive capacity of the pre-ageing participants to perform acceptable chewing function with compromised dentition. The results from pre-ageing and ageing group demonstrated that when people lived alone they tended to have malnourishment. This resulted from the fact that eating is a social function. I f one lives alone, he/she may lose interest of food consumption. Moreover, loneliness or social isolation might give little or no incentive for the preparation of nourishing meals and influenced the nutrition [1].

When determining the association between oral health status and nutritional status (Table 5, Table 7) the cut-points of number of teeth, number of FUs and number of posterior FUs had to be set to suggest the "turning point" from adequate to insufficient function. This study set the number of present teeth at ≥20 teeth as adequate function and <20 teeth as insufficient function according to the World Health Organization [12] which proposed that at least 20 natural teeth should be maintained for any elderly people as a treatment goal. The cut-points of the posterior FUs were set at ≥4 pairs of occluded teeth as adequate function according to the results of the previous studies [18,42-44]. They suggested a "turning point" from adequate function that could provide sufficient oral comfort to insufficient function at

3-4 posterior FUs. When the total number of FUs was considered, the cut-points were set at ≥10 pairs as adequate function and <10 pairs as insufficient. These criteria came from the studies of Käyser and his co-workers [5-6,45] related to the shortened dental arch concept. They concluded that most people require, in addition to their anterior teeth (6 pairs), at least four occlusal units of posterior teeth. Therefore, the summation of anterior and posterior FUs was 10 pairs.

Malnutrition in older persons seems to be in a very high number. It is not a side effect of ageing, but many changes related to the process of ageing can promote malnutrition. The risk factors for malnutrition include medical factors, lifestyle and social factors, and oral health and dental status [46]. Generally, the nutritional assessment should include (i) energy and nutrients balance (:-recording of energy and nutrients intake) (ii) body composition (:-recording weight variations, body mass index, triceps and sub-scapular skinfolds, etc.) and (iii) organ functionality (:- biochemical parameter: albumin, pre-albumin, cholesterol, etc.) [46]. However, not all procedures can be applied for all patients, especially in epidemiological surveys, due to time consuming and high expense. This study used the MNA-SF to rapidly screen for at risk of malnutrition and malnutrition and BMI was used to determine the status of nutrition (underweight, normal, overweight, pre-obese and obese). The BMI risk cut-off points for Asian population were used in grading of overweight and obesity [26]. Results of this current study revealed that 47% of the ageing participants and 46% of the pre-ageing were at risk of malnutrition, whereas 5.7% of the ageing group and 3.5% of the pre-ageing had malnutrition. The number of underweight was greater than overweight and pre-obese in both ageing and pre-ageing groups. (Table 3) Any change in food intake can cause nutritional problems which may lead to a poorer quality of life and increasing the risk of developing chronic diseases. For instance, overweight and obesity in older people are associated with an increased risk of stroke, diabetes, hyperlipidemia, cardiovascular disease and hypertension, whereas underweight may have a connection with increased risk of infection, low bone mineral density (BMD) and osteoporosis [4]. Therefore, participants categorized as malnutrition should be referred to physicians to confirm by clinical evaluation. Diet counseling should be provided to participants who were at risk of malnutrition. Moreover, the risk indicators of malnutrition found in this study, such as periodontal disease and problem of mouth dryness should be considered and provided an appropriate management as early as possible. To detect nutritional risk in the pre-ageing and ageing participants has been found to be cost-effective in reducing morbidity and improving their quality of life [47].

Because of the limited number of the participants and the restricted area of data collection, the results of this study may not be representative for all ageing and pre-ageing people in Thailand. However, data obtained from this research would be beneficial in developing preventive measures for adults and older adults in northern Thailand. The strategies of preventive programme should include improving of oral hygiene care, providing oral health care, promotion of social activities for the pre-ageing and ageing people, and providing diet counseling. It is without doubt that the preventive programme should be commenced before they reach old age. More studies in different populations and longitudinal studies are needed to better understanding the nature of these associations, and to develop preventive strategies.

Conclusion

The results of the current study indicated that the participants in both groups had poorer oral health than the reports of the 7th Thailand Oral Health Survey of northern Thailand and the number of present teeth, number of FUs and posterior FUs

of the ageing participants had association with nutritional status while no association was found in the pre-ageing. Many demographic characteristics of the ageing group, such as gender, education, systemic diseases, mouth dryness, and avoidance of vegetable and fruits, also related to nutritional state. In addition, this study found that periodontal disease with pocket depth of ≥4 mm and the condition of living alone were correlated with nutrition intake in both ageing and pre-ageing participants. The results imply the need to develop effective strategies for improving oral health care of the populations. This is to prevent oral and dental diseases and maintain the existing natural dentition. In cases where impairment of masticatory function occurs and only few teeth remained, prosthetic treatment is needed to increase the functional tooth units. Good condition of oral and dental health can enhance food selection and improve the intake of essential nutrients. However, only this intervention alone the management of malnutrition may not be successful. Other causative factors such as medical and social factors must also be considered so that the ageing population can maintain their general well-being as long as possible.

References

1. Ettinger RL. Changing dietary patterns with changing dentition: how do people cope? *Spec Care Dentist.* 1998; 18: 33-9.
2. Gariballa SE, Sinclair AJ. Nutrition, ageing and ill health. *BR J Nutr.* 1998; 80: 7-23.
3. Sheiham A, Steele J. Does the condition of the mouth and teeth affect the ability to eat certain foods, nutrient and dietary intake and nutritional status amongst older people? *Public Health Nutr.* 2001; 4: 797-803.
4. Hickson M. Malnutrition and ageing. *Postgrad Med J.* 2006; 82: 2-8.
5. Käyser AF. Shortened dental arch: a therapeutic concept in reduced dentitions and certain high-risk groups. *Int J Periodontics Restorative Dent.* 1989; 9: 426-49.
6. Elias AC, Sheiham A. The relationship between satisfaction with mouth and number and position of teeth. *J Oral Rehabil.* 1998; 25: 649-61.
7. Witter DJ, van Palenstein Helderman WH, Creugers NH, Kayser AF. The shortened dental arch concept and its implications for oral health care. *Community Dent Oral Epidemiol.* 1999; 27: 249-58.
8. Meeuwissen JH, van Waas MA, Meeuwissen R, Kayser AF, van 't Hof MA, Kalk W. Satisfaction with reduced dentitions in elderly people. *J Oral Rehabil.* 1995; 22: 397-401.
9. Käyser AF. Shortened dental arches and oral function. *J Oral Rehabil.* 1981; 8: 457-62.
10. Käyser AF, Witter DJ, Spanauf AJ. Overtreatment with removable partial dentures in shortened dental arches. *Aust Dent J.* 1987; 32: 178-82.
11. Käyser AF. How much reduction of the dental arch is functionally acceptable for the ageing patient? *Int Dent J.* 1990; 40: 183-8.
12. World Health Organzation. Recent Advances in Oral Health. *WHO Technical Report Series No826 Geneva*, Switzerland; WHO. 1992: 16-7.
13. Hildebrandt GH, Dominigues BL, Schork MA, Loesche WJ. Functional units, chewing, swallowing, and food avoidance among the elderly. *J Prosthet Dent.* 1997; 77: 588-95.
14. Sahyoun NR, Lin CL, Krall E. Nutritional status of the older adult is associated with dentition status. *J Am Diet Assoc.* 2003; 103: 61-6.
15. Hildebrandt GH LW, Lin CF, Bretz WA. Comparison of the number and type of dental functional units in geriatric populations with diverse medical backgrounds. *J Prosthet Dent.* 1995; 73: 253-61.
16. Kapur KK, Soman SD. Masticatory performance and efficiency in denture wearers. *J Prosthet Dent.* 2006; 95: 407-11.
17. Appollonio I, Carabellese C, Frattola A, Trabucchi M. Influence of dental status on dietary intake and survival in community-dwelling elderly subjects. *Age Ageing.* 1997; 26: 445-56.
18. Witter DJ, De Haan AF, Kayser AF, Van Rossum GM. A 6-year follow-up study of oral function in shortened dental arches. Part II: Craniomandibular dysfunction and oral comfort. *J Oral Rehabil.* 1994; 21: 353-66.
19. Krall E, Hayes C, Garcia R. How dentition status and masticatory function affect nutrient intake. *J Am Dent Assoc.* 1998; 129:1261-9.
20. McHugh ML. Interrater reliability: the kappa statistic. *Biochemia medica.* 2012; 22: 276-82.

21. Sebring NG, Guckes AD, Li SH, McCarthy GR. Nutritional adequacy of reported intake of edentulous subjects treated with new conventional or implant-supported mandibular dentures. *J Prosthet Dent.* 1995; 74: 358-63.
22. de Andrade FB, de Franca Caldas A, Jr., Kitoko PM. Relationship between oral health, nutrient intake and nutritional status in a sample of Brazilian elderly people. *Gerodontology*. 2009; 26: 40-5.
23. Harris D, Haboubi N. Malnutrition screening in the elderly population. *J R Soc Med*. 2005; 98: 411-4.
24. Poulia KA, Yannakoulia M, Karageorgou D, Gamaletsou M, Panagiotakos DB, Sipsas NV, et al. Evaluation of the efficacy of six nutritional screening tools to predict malnutrition in the elderly. *Clin Nutr.* 2012; 31: 378-85.
25. Soini H, Routasalo P, Lagstrom H. Characteristics of the Mini-Nutritional Assessment in elderly home-care patients. *Eur J Clin Nutr.* 2004; 58: 64-70.
26. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet.* 2004; 363: 157-63.
27. World Health Organization, editor. Oral health surveys: basic methods 5th ed2013.
28. JH Z. Biostatistical analysis. 5th ed. New Jersey: Prentice Hall; 2009.
29. Chai J, Chu FC, Chow TW, Shum NC, Hui WW. Influence of dental status on nutritional status of geriatric patients in a convalescent and rehabilitation hospital. *Int J Prosthodont.* 2006; 19: 244-9.
30. Sheiham A, Steele JG, Marcenes W, Lowe C, Finch S, Bates CJ, et al. The relationship among dental status, nutrient intake, and nutritional status in older people. *J Dent Res.* 2001; 80: 408-13.
31. Wostmann B, Michel K, Brinkert B, Melchheier-Weskott A, Rehmann P, Balkenhol M. Influence of denture improvement on the nutritional status and quality of life of geriatric patients. *J Dent.* 2008; 36: 816-21.
32. De Marchi RJ, Hugo FN, Hilgert JB, Padilha DM. Association between oral health status and nutritional status in south Brazilian independent-living older people. *Nutrition.* 2008; 24: 546-53.
33. Srisilapanan P, Malikaew P, Sheiham A. Number of teeth and nutritional status in Thai older people. *Community Dent Health.* 2002; 19 :230-6.
34. Marshall TA, Warren JJ, Hand JS, Xie XJ, Stumbo PJ. Oral health, nutrient intake and dietary quality in the very old. *J Am Dent Assoc.* 2002; 133: 1369-79.
35. Leake JL, Hawkins R, Locker D. Social and functional impact of reduced posterior dental units in older adults. *J Oral Rehabil.* 1994; 21: 1-10.
36. Bureau of Dental Health DOH, Ministry of Public Health. The 7th national oral health survey report, Thailand 2012. Bangkok; 2013.
37. Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Category of functional tooth units in relation to the number of teeth and masticatory ability in Japanese adults. *Clin Oral Investig.* 2010; 14: 113-9.
38. Tatematsu M, Mori T, Kawaguchi T, Takeuchi K, Hattori M, Morita I, et al. Masticatory performance in 80-year-old individuals. *Gerodontology.* 2004; 21: 112-9.
39. Ow RK, Loh T, Neo J, Khoo J. Perceived masticatory function among elderly people. *J Oral Rehabil.*1997; 24: 131-7.
40. Agerberg G, Carlsson GE. Chewing Ability in Relation to Dental and General Health. *Acta odontologica Scandinavica.* 1981; 39: 147-53.
41. Osterberg T, Carlsson GE, Tsuga K, Sundh V, Steen B. Associations between self-assessed masticatory ability and some general health factors in a Swedish population. *Gerodontology.* 1996; 13: 110-7.
42. Witter DJ, van Elteren P, Kayser AF, van Rossum MJ. The effect of removable partial dentures on the oral function in shortened dental arches. *J Oral Rehabil.* 1989; 16: 27-33.
43. Witter DJ, Van Elteren P, Kayser AF, Van Rossum GM. Oral comfort in shortened dental arches. *J Oral Rehabil.* 1990; 17: 137-43.
44. Slade GD, Spencer AJ, Roberts-Thomson K. Tooth loss and chewing capacity among older adults in Adelaide. *Aust N Z J Public Health.* 1996; 20: 76-82.
45. Armellini D, von Fraunhofer JA. The shortened dental arch: a review of the literature. *J Prosthet Dent.* 2004; 92: 531-5.
46. Donini LM, Savina C, Rosano A, Cannella C. Systematic review of nutritional status evaluation and screening tools in the elderly. *J Nutr Health Aging.* 2007; 11: 421-32.
47. Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, et al. The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition.* 1999; 15: 116-22.