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FACULDADE DE ODONTOLOGIA DE PIRACICABA

Rosemary Sadami Arai Shinkai

FUNÇÃO ORAL E QUALIDADE DE DIETA: INFLUÊNCIA DE FATORES ESTOMATOGNÁTICOS E SÓCIO-DEMOGRÁFICOS.

Tese apresentada à Faculdade de Odontologia de Piracicaba, da Universidade Estadual de Campinas, para obtenção do título de Doutor em Clínica Odontológica, área de concentração Prótese Dental.

Piracicaba – SP

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UNIVERSIDADE ESTADUAL DE CAMPINAS

A Comissão Julgadora dos trabalhos de Defesa de Tese de DOUTORADO, em sessão pública realizada em 30 de Julho de 2001, considerou a candidata ROSEMARY SADAMI ARAI SHINKAI aprovada.

1. Profa. Dra. ALTAIR ANTONINHA DEL BEL CURY

2. Prof. Dr. FERNANDO DA CUNHA RIBEIRO

3. Prof. Dr. CARLOS EDUARDO VERGANI

4. Profa. Dra. RENATA CUNHA MATHEUS RODRIGUES GARCIA

5. Prof. Dr. RODRIGO NUNES RACHED

À minha família,

meus pais, Sadao e Mitsue,

meus irmãos, Roseli e Roberto,

por tudo
em minha vida

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Sumário

RESUMO

Estudos anteriores sobre o impacto da saúde bucal e da função oral na escolha e ingestão de alimentos apresentaram resultados contraditórios. Este trabalho, composto por três manuscritos, teve por objetivo explorar a relação entre função oral e qualidade de dieta em indivíduos com diferentes tipos de condições bucais. O primeiro capítulo estudou a influência de variáveis mastigatórias e de fatores sócio-demográficos na qualidade de dieta de indivíduos dentados e edentados. O segundo artigo avaliou se a deficiência técnica de próteses totais em termos de retenção, estabilidade e desgaste de dentes artificiais está relacionada à diminuição da performance mastigatória, à percepção de dificuldades em mastigar e à qualidade de dieta insatisfatória. O terceiro manuscrito abordou a relação entre função mastigatória, qualidade de dieta e problemas digestivos em pacientes de cirurgia ortognática. Os resultados destes estudos demonstraram que a qualidade de dieta não foi determinada pelas condições oclusais ou pelo grau de função oral. Quanto pior as condições oclusais, pior é a eficiência de função oral em termos de performance mastigatória e força de mordida. Em relação a próteses totais, próteses com qualidade técnica adequada permitiram um desempenho funcional superior às próteses com deficiências técnicas. Entretanto, não há reflexo na percepção de capacidade mastigatória ou na qualidade de dieta e adequação nutricional. Independentemente das condições oclusais, da qualidade técnica das próteses totais ou do grau de função oral, a maioria dos indivíduos apresentou qualidade de dieta deficiente.

Palavras-chave: Função oral, mastigação, dieta, nutrição

ABSTRACT

Previous studies about the impact of oral health and oral function on diet and food choices have shown contradictory results. This study, which is composed by three manuscripts, aimed to explore the relationship between oral function and diet quality in subjects with different oral conditions. The first chapter studied the influence of masticatory and sociodemographic variables on diet quality of dentate and edentulous subjects. The second paper evaluated if poor quality of complete dentures, in terms of retention, stability, and artificial tooth wear, is related to decreased masticatory performance, perceived difficulties in ability to chew, and poor diet quality. The third manuscript analyzed the relationship among oral function, diet quality, and digestive problems in orthognathic surgery patients. The results of these studies showed that diet quality was determined neither by occlusal conditions nor by the level of oral function. The worse the occlusal conditions, the worse the efficiency of oral function regarding masticatory performance and bite force. In relation to complete dentures, good quality complete dentures allowed superior functional performance compared to poor quality prostheses. However, this did not reflected in perception of masticatory ability or in diet quality and nutrition adequacy. The majority of subjects had deficient diet qualities independently of occlusal conditions, technical quality of complete dentures, and level of oral function.

Key words: Oral function, mastication, diet, nutrition

INTRODUÇÃO GERAL

A atuação da Odontologia como profissão da área de saúde está cada vez mais vinculada a outras especialidades. No atual contexto de saúde, os paradigmas de interdisciplinaridade e de atenção integral ao indivíduo visam estabelecer um modelo de ação coordenada e abrangente tendo como metas a promoção de bem-estar geral e a melhoria de qualidade de vida (ABOPREV, 1999). Para atingir este fim, o interrelacionamento das diversas profissões de saúde torna-se peça fundamental. Dentre as especialidades que interagem com a Odontologia, a Nutrição se destaca por dividir um espaço comum, a cavidade bucal, e funções comuns, mastigação e deglutição. Assim, além de reflexos individuais na saúde geral, nutrição e saúde bucal influenciam uma e outra de forma mais direta.

O impacto de dieta e condições nutricionais na saúde bucal tem sido objeto de estudo há vários anos. Por exemplo, são bem estabelecidos os papéis do consumo de açúcares fermentáveis na etiologia da cárie dental (JOHANSSON & BIRKHED, 1995; MOYNIHAN, 2000) e da carência de vitamina C no desenvolvimento de sangramento gengival (ARENS, 1999). Há também evidências de efeito protetor de vitamina A, frutas e verduras em relação a certos tipos de câncer bucal (INCA, 1996-1999; SALISBURY, 1997), e de efeito erosivo de ácidos alimentares nos tecidos dentários (ZERO, 1996). Além disso, algumas alterações bucais, como a palidez de mucosas e alteração das papilas linguais em certos casos de deficiências vitamínicas e anemia, podem ser indicativos precoces de doenças sistêmicas (ARENS, 1999).

O sentido contrário da relação saúde bucal – nutrição, entretanto, não é tão claro. A literatura é controversa sobre o impacto da saúde bucal na escolha e ingestão de alimentos. Diversos estudos transversais demonstraram que o consumo de determinados alimentos e nutrientes varia de acordo com as condições oclusais e tipo de prótese dental (WAYLER & CHAUNCEY, 1983; CHAUNCEY *et al.*, 1984; JOSHIPURA *et al.*, 1996, PAPAS *et al.*, 1998a,b; KRALL *et al.*, 1998; SHEIHAM *et al.*, 1999; SHEIHAM *et al.*, 2001). Outros estudos, contudo, não encontraram relação significativa entre condições bucais e dieta (ÖSTERBERG & STEEN, 1982; GREKSA *et al.*, 1995; GRIEP *et al.*, 1996; MOYNIHAN *et al.*, 2000).

Parte desses resultados contraditórios pode ser explicada pela utilização de diferentes metodologias, em diferentes populações. A multiplicidade de definições de variáveis, de instrumentos e de técnicas de medição impossibilita a comparação direta de estudos sobre função oral e dieta e dificulta o estabelecimento de intervenções que tenham respaldo em evidências científicas e não apenas no senso comum. A partir desta situação, derivam-se dois pontos básicos abordados neste trabalho: explorar questões ainda sem resposta definitiva e adotar uma metodologia padronizada, validada e com base em conceitos atuais em Odontologia e Nutrição.

Este trabalho, desenvolvido em três manuscritos, teve por objetivo estudar a relação entre função oral e qualidade de dieta, bem como seus fatores determinantes. Parte-se de um modelo conceitual da interação Condições bucais – Dieta, no qual estão organizados seqüencialmente a doença, a alteração anatômica, a alteração funcional e a alteração de comportamento (FIG. 1). Os três capítulos deste estudo se concentram nos três últimos níveis, ou seja, no relacionamento entre deficiência física bucal, limitação funcional e qualidade de dieta.

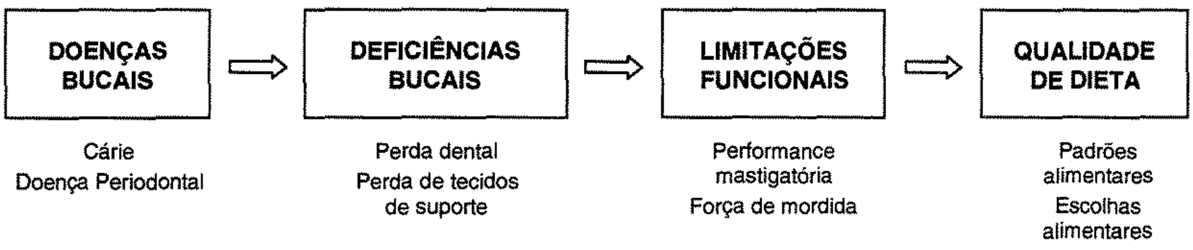

FIGURA 1. Modelo conceitual da interação Condições bucais – Dieta, com a organização dos níveis de doença, alteração anatômica, alteração funcional e alteração de comportamento.

Em relação às condições bucais, o nível de deficiência física foi caracterizado pelo número de unidades dentais funcionais posteriores, pela presença e tipo de prótese dental e pelas condições técnicas das próteses totais. O nível de limitação funcional incluiu as medições de performance mastigatória, força máxima de mordida bilateral, tempo de mastigação e número de ciclos mastigatórios. O índice de desordem têmporo-mandibular utilizado, o *"Craniomandibular Index"* (CMI) (FRICTON & SCHIFFMAN, 1986), também reflete comprometimento funcional do sistema estomatognático.

Na avaliação de qualidade de dieta, adotou-se um índice global, o *"Healthy Eating Index"* (HEI) (KENNEDY *et al.*, 1995) (ANEXO 1). O HEI é um índice desenvolvido com base nas *"Dietary Guidelines for Americans"* e na *"Food Guide Pyramid"* (ANEXO 2) e tem sido recomendado pelo governo americano para estudos epidemiológicos em Nutrição (BOWMAN *et al.*, 1998; VARIYAM *et al.*, 1998). O HEI permite a comparação direta de qualidade de dieta entre grupos e o acompanhamento longitudinal das populações estudadas pois os escores de consumo de alimentos são ajustados de acordo com o grupo de idade e o sexo do indivíduo. Os manuscritos que constituem este trabalho são os primeiros estudos em Odontologia a utilizar o HEI.

O primeiro capítulo, *"Oral function and diet quality in a community-based sample"*, avaliou a influência de variáveis mastigatórias (performance mastigatória, força de mordida, número de unidades dentais funcionais, desordens têmporo-mandibulares e condições oclusais) na qualidade de dieta de indivíduos dentados e edentados. O papel de fatores sócio-demográficos (idade, sexo, grupo étnico, nível de educação e renda familiar) foi analisado como fator determinante direto da qualidade de dieta e também como fator modulador das variáveis mastigatórias.

Um estudo mais aprofundado da qualidade de dieta em indivíduos edentados portadores de próteses totais foi realizado no segundo artigo, *"Dietary intake in edentulous subjects with good and poor quality complete dentures"*. Avaliou-se se a deficiência técnica de próteses totais em termos de retenção, estabilidade e desgaste de dentes artificiais está relacionada à diminuição da capacidade de performance mastigatória, à percepção de dificuldades em mastigar e à qualidade de dieta insatisfatória.

O terceiro capítulo, *"Masticatory performance is not associated with diet quality in Class II orthognathic surgery patients"*, abordou a relação entre função mastigatória (performance mastigatória, força de mordida, tempo de mastigação e número de ciclos mastigatórios), qualidade de dieta e problemas digestivos em pacientes de cirurgia ortognática.

Além dos capítulos que compõem o corpo deste trabalho, um quarto manuscrito, *"Determinants of masticatory performance in dentate adults"*, foi incluído em apêndice (APÊNDICE 1). Trata-se de uma análise multivariada de fatores demográficos, sistêmico e estomatognáticos para prever a capacidade de performance mastigatória em indivíduos adultos dentados, não-portadores de próteses removíveis. É um estudo sobre o aspecto bio-mecânico da mastigação e complementa o assunto desenvolvido neste trabalho.

CAPÍTULOS

Oral Function and Diet Quality in a Community-Based Sample

Journal of Dental Research, no prelo (APÊNDICE 2)

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Short title: Oral Function and Diet

KEY WORDS: mastication, diet, nutrition, Healthy Eating Index.

ABSTRACT

Overall diet quality indexes, such as the Healthy Eating Index (HEI), are preferred for epidemiological studies, yet studies in Dentistry have focused on isolated dietary components. This study investigated the influence of socio-demographic and masticatory variables (masticatory performance, bite force, number of posterior functional tooth units, TMJ disorder, and dentition status) on overall diet quality in a community-based sample (n = 731). Cross-sectional data were derived from clinical examinations, bite force recordings, masticatory performance measurements, and two 24-h dietary recalls. Females, European-Americans, and older subjects had better HEI scores than males, Mexican-Americans, and younger subjects, respectively. Income, education, and the masticatory variables were not related to diet quality. Analyses according to dentition status (good dentition, compromised dentition, partial denture, and complete dentures) showed no inter-group differences for HEI except for the age groups. The results suggest that the chewing-related factors evaluated in this sample are not predictors of overall diet quality across the socio-demographic groups.

INTRODUCTION

Masticatory impairment is believed to negatively impact general health by leading to restricted dietary selection and nutrient intake (Wayler and Chauncey, 1983; Joshipura *et al.*, 1996; Krall *et al.*, 1998). However, studies of the relationship between occlusal status, masticatory function and diet present contradictory and unclear results. For example, while some studies show that dental status affects food choices and dietary intake (Wayler and Chauncey, 1983; Chauncey *et al.*, 1984; Joshipura *et al.*, 1996, Papas *et al.*, 1998a,b; Krall *et al.*, 1998; Sheiham *et al.*, 1999), others show no significant change in dietary pattern with loss of teeth and use of prostheses (Österberg and Steen, 1982; Greksa *et al.*, 1995; Griep *et al.*, 1996). Similar dietary intakes were also found when comparing different types of prostheses among patients having similar dental conditions (Sebring *et al.*, 1995; Moynihan *et al.*, 2000). The relationship between compromised oral function and diet also remains obscure. Masticatory performance associated with tooth loss seems to alter food selection patterns in some situations (Wayler and Chauncey, 1983; Krall *et al.*, 1998). Insertion of new prostheses increases masticatory performance but not dietary intake (Gunne, 1985; Gunne and Wall, 1985; Garret *et al.*, 1997). Other functional and anatomical chewing-related variables have been scarcely studied regarding a possible impact on diet and nutrition.

All these previous investigations evaluated diet and nutrition in terms of isolated components of the diet, such as food choices and intake of specific nutrients. No attempt was made to assess the overall diet quality, which is preferred for screening and monitoring dietary changes for the population (Kennedy *et al.*, 1995; Variyam *et al.*, 1998; Haines *et al.*, 1999). Moreover, overall diet quality indexes are more strongly related to the risk of disease than are individual nutrients or foods (Kant, 1996). The Healthy Eating Index (HEI) is an overall diet quality index recently developed by the US Department of Agriculture to assess the dietary status of Americans, monitor changes in dietary patterns, and serve as a basis of nutrition promotion activities (Kennedy *et al.*, 1995). The HEI combines information on the amount and variety of foods in the diet and compliance with specific dietary recommendations (Kennedy *et al.*, 1995; Variyam *et al.*, 1998). It is based on several aspects of a healthful diet, controlling for adequacy, moderation, and variety.

Furthermore, in contrast to other dietary assessment methods applied in dental studies, the HEI score takes into account caloric intake, gender, and age.

This study investigated the influence of masticatory variables on overall diet quality in a sociodemographically diverse community-based sample. We hypothesized that oral functional limitation and compromised occlusal status would restrict food selection and nutrient intake. This would be reflected in alterations in diet quality and nutritional adequacy as measured by the HEI across the socio-demographic groups.

MATERIALS AND METHODS

Cross-sectional data were derived from the Oral Health: San Antonio Longitudinal Study of Aging (OH:SALSA), conducted in San Antonio, Texas, from July 1994 to May 1998. The OH:SALSA sample is a community-based cohort of Mexican-American and European-American, elderly and younger adults, and was established by sampling two subsets of the San Antonio Heart Study (SAHS) cohort (Hazuda *et al.*, 1998).

Subjects

This study sample comprised 731 participants, aged 37 to 81 years (mean: 60.1; s.d.: 11.3). OH:SALSA subjects who had incomplete data on the studied variables were excluded. Therefore, the sample is not representative of the parent OH:SALSA sample. Table 1 displays the socio-demographic characteristics of the sample.

Procedures

Calibrated examiners collected data during medical and dental examination sessions, which included a comprehensive review of oral, medical, and nutritional history, and physical and functional assessments. All subjects gave written informed consent for their participation, and the protocol was approved by the University's Institutional Review Board.

Masticatory Performance. Masticatory performance was measured with the modified Mastication Performance Index (Manly and Braley, 1950; Yurkstas and Manly, 1950). Subjects chewed 3 g of peanuts on one side of the mouth, using 20 strokes. This procedure was repeated three times on each chewing side. The mean percentage by weight of the combined left and right side dehydrated material passing through a sieve (mesh #10) constituted the masticatory performance score.

Bite Force. Bilateral maximum bite force was measured using a cross-arch beam and force transducer (Sensotec 13/2445-02, Columbus, OH) placed in the region of the first molar. Vertical jaw opening at the point of bite pad insertion was 14 mm. Force was digitized using a MacLab analog-to-digital converter. The procedures were explained to subjects, and they were allowed several test bites in order to build confidence in the procedure. The mean of the three highest trials of ten recordings was recorded as the maximum bite force.

Posterior Functional Tooth Units. Posterior functional tooth units were defined as pairs of occluding natural, restored or fixed prosthetic postcanine teeth (molars = two units; bicuspids = one unit), excluding third molars. Score range: 0 to 12.

Temporomandibular Joint Dysfunction (TMD). The number and severity of signs and symptoms of TMD were assessed using the Craniomandibular Index (CMI) (Fricton and Schiffman, 1986; 1987), which quantifies mandibular range of motion, TMJ noises, and tenderness of masticatory muscles and TMJ structures to manual palpation. The CMI produces separate scores of muscle and TMJ dysfunction, which constitute the Muscular Index (MI) and the Dysfunction Index (DI), respectively. Score range: 0 to 1.

Dentition Status. Subjects (n = 710; 21 subjects did not meet selection criteria for any of the dentition status groups and were excluded) were grouped into four categories according to the presence and number of functional tooth units, and presence, number and type of removable dentures: 1) Good Dentition Group (n = 369, eight or more posterior functional tooth units and no removable prosthesis); 2) Compromised Dentition Group (n = 143, one to seven functional tooth units and no removable prosthesis); 3) Partial Denture Group (n = 157, either upper or lower partial dentures, with or without any removable prosthesis in the other arch); and 4) Complete Denture Group (n = 41, both upper and lower complete dentures).

Dietary Assessment. Trained interviewers or registered dietitians collected diet data using the 24-hour dietary recall method (Thompson and Byers, 1994) on two nonconsecutive days (between sessions median: 22 days). Probing questions and recall aids (food models, measuring cups, and rulers) were used to assist subjects to recall types and amounts of foods consumed. The uses, limitations, reliability, and validity of this method were discussed and reported previously (Briefel and Sempos, 1992; Thompson and Byers, 1994). Dietary intake data were analyzed using First Data Bank Nutrient Computer Analysis Software (The Hearst Corporation, San Bruno, CA).

The primary outcome measure was the Healthy Eating Index (HEI), which is constructed based on the U.S. Department of Agriculture Food Guide Pyramid and Dietary Guidelines for Americans (Kennedy *et al.*, 1995; Bowman *et al.*, 1998). It comprises a 10-component system of five food groups (grains, vegetables, fruits, milk, and meat), plus total fat, saturated fat, cholesterol, sodium, and a measure of variety in food intake. Each component is scored ranging from 0 to 10. High scores indicate more compliance with recommended intake range or amount. The scoring takes into account the recommended number of food servings or intake according to the consumer's age and gender. The total HEI score ranges from 0 to 100. HEI scores were also grouped into three categories: Good (>80), Needs Improvement (51-80), and Poor (<51). In addition to the HEI, intake of 40 specific nutrients also was assessed. Because the emphasis of this study is on overall diet quality, we comment on these nutrients only to compare our results to previous studies.

Statistical Analysis. Spearman correlations, Kruskal-Wallis tests, and Pearson Chi-square tests were used to analyze the data. The overall HEI, which approximated a normal distribution, was analyzed with a 4 (dentition status) X 2 (sex) X 2 (age) X 2 (ethnicity) factorial ANOVA. Pairwise comparisons between dentition groups were made using Mann-Whitney U-tests with Bonferroni adjustment. Results were considered significant at $\alpha = 0.01$. The outcome variables were HEI and its components, plus selected nutrient and non-nutrient intakes. Explanatory variables were ethnicity (Mexican-Americans vs. European-Americans), sex, age (Younger group: < 65 yrs; Older group: 65 + yrs), income, level of education, dentition status, masticatory performance, bilateral bite force, number of posterior functional tooth units, MI score, and DI score.

RESULTS

Multifactorial ANOVA yielded statistically significant main effects for the factors representing age, sex, and ethnic group, but not for dentition status or any interactions. Females, European-Americans, and older subjects had higher HEI scores than their counterparts (Table 1). Separate ANOVA showed that the education level and income groups did not differ significantly on the HEI (Table 1).

Masticatory performance, bite force, and number of functional posterior tooth units were closely associated with sex, ethnic group, age, income, and education (Table 1). The four dentition status groups differed with respect to masticatory performance and bite force, but not DI, MI, or HEI (Table 2). The relationship between dentition status and HEI was constant across combinations of sex, ethnicity, and age (Figure 1). Masticatory variables were correlated to few of the ten HEI components (Table 3). Some nutrients, however, showed weak but statistically significant correlation coefficients with certain masticatory variables.

TABLE 1. Frequency of socio-demographic variables and mean and standard deviation (SD) of the HEI scores, masticatory performance, bite force, and number of functional tooth units (n = 731).

Socio-Demographic Variables	n	HEI Scores mean (SD)	Masticatory Performance (%) mean (SD)	Bite Force (N) mean (SD)	Number of Functional Tooth Units mean (SD)
Sex					
Female	397	72.1 (10.6) [a]	53.0 (22.6)	407.4 (199.3) [a]	7.0 (4.4)
Male	334	68.2 (12.1)	55.8 (24.9)	648.1 (312.7)	6.7 (4.6)
Ethnic Group					
Mexican-American	416	69.0 (11.5) [a]	52.0 (24.0) [a]	499.1 (282.4)	6.4 (4.4) [a]
European-American	315	72.1 (11.2)	57.2 (23.0)	541.3 (284.2)	7.3 (4.6)
Age					
Younger (< 65 yrs)	386	68.1 (11.3) [a]	59.3 (22.1) [a]	598.3 (281.6) [a]	8.3 (3.9) [a]
Older (65 + yrs)	345	72.8 (11.1)	48.6 (24.1)	427.0 (258.4)	5.2 (4.6)
Monthly Family Income					
$0 to 999	122	69.5 (12.0)	47.5 (25.5) [a]	431.2 (290.1) [a]	5.1 (4.5) [a]
$1,000 to 1999	170	70.6 (11.6)	47.1 (23.2)	447.7 (238.5)	5.7 (4.4)
$2000 t0 2999	149	70.4 (11.0)	53.0 (22.6)	516.2 (261.2)	6.2 (4.4)
$3,000+	289	70.5 (11.3)	61.8 (21.4)	597.6 (295.5)	8.5 (4.1)
Years of Education					
Less than 12	172	69.2 (11.7)	46.4 (22.9) [a]	404.5 (256.8) [a]	4.6 (4.3) [a]
12	210	69.9 (10.5)	50.7 (23.0)	493.1 (266.1)	6.4 (4.4)
13 to 15	185	70.6 (12.5)	55.1 (23.7)	535.3 (268.8)	7.2 (4.4)
16+	164	71.8 (11.1)	66.1 (20.6)	647.0 (297.3)	9.3 (3.6)

[a] Significantly different (p < 0.01).

TABLE 2. Mean and standard deviation values of masticatory variables and HEI scores according to dentition status groups (n = 710).

	Good Dentition (n=369)	Compromised Dentition (n=143)	Partial Denture (n=157)	Complete Denture (n=41)	*p*-value
Masticatory performance (%)	69.9 (15.8) [a]	35.8 (17.3) [b]	44.2 (18.7) [c]	31.5 (21.7) [b]	< 0.001
Bilateral bite force (N)	644.5 (280.2) [a]	451.5 (212.6) [b]	386.1 (233.1) [c]	239.3 (129.4) [d]	< 0.001
Functional tooth units (count)	10.7 (1.5) [a]	4.7 (1.7) [b]	2.4 (2.9) [c]	0 [d]	<0 .001
Muscular Index score	0.06 (0.11)	0.08 (0.15)	0.07 (0.10)	0.08 (0.10)	0.344
Dysfunction Index score	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)	0.08 (0.07)	0.284
Healthy Eating Index (HEI)	70.3 (11.4)	69.2 (10.9)	68.1 (13.0)	68.1 (13.0)	0.072

[a, b, c, d] Pairwise comparisons with Bonferroni correction. Pairs of values having different superscript letters are significantly different at $p < 0.01$

TABLE 3. Spearman correlation coefficients between masticatory and dietary variables for the overall sample (n = 731).

	Masticatory Performance	Bite Force	Posterior Functional Units
Healthy Eating Index (HEI)	0.00	-0.05	0.02
Grains (HEI score)	-0.07	-0.07	-0.05
Vegetables (HEI score)	0.09	0.06	0.09
Fruit (HEI score)	0.03	-0.07	0.01
Milk (HEI score)	0.00	0.01	0.02
Meat (HEI score)	-0.04	0.05	-0.07
Total fat (HEI score)	-0.03	-0.02	-0.01
Saturated fat (HEI score)	0.01	0.03	0.04
Total cholesterol (HEI score)	0.07	-0.01	0.07
Sodium (HEI score)	-0.10 [a]	-0.15 [a]	-0.07
Variety (HEI score)	0.08	0.09	0.12 [a]
Energy (kcal)	0.09	0.25 [a]	0.11 [a]
Vitamin A (RE)	0.08	0.06	0.08
Vitamin C (mg)	0.10 [a]	0.10 [a]	0.11 [a]
Protein (g)	0.01	0.18 [a]	0.05
Fiber (g)	0.11 [a]	0.14 [a]	0.10 [a]

[a] Statistically significant at $\alpha = 0.01$

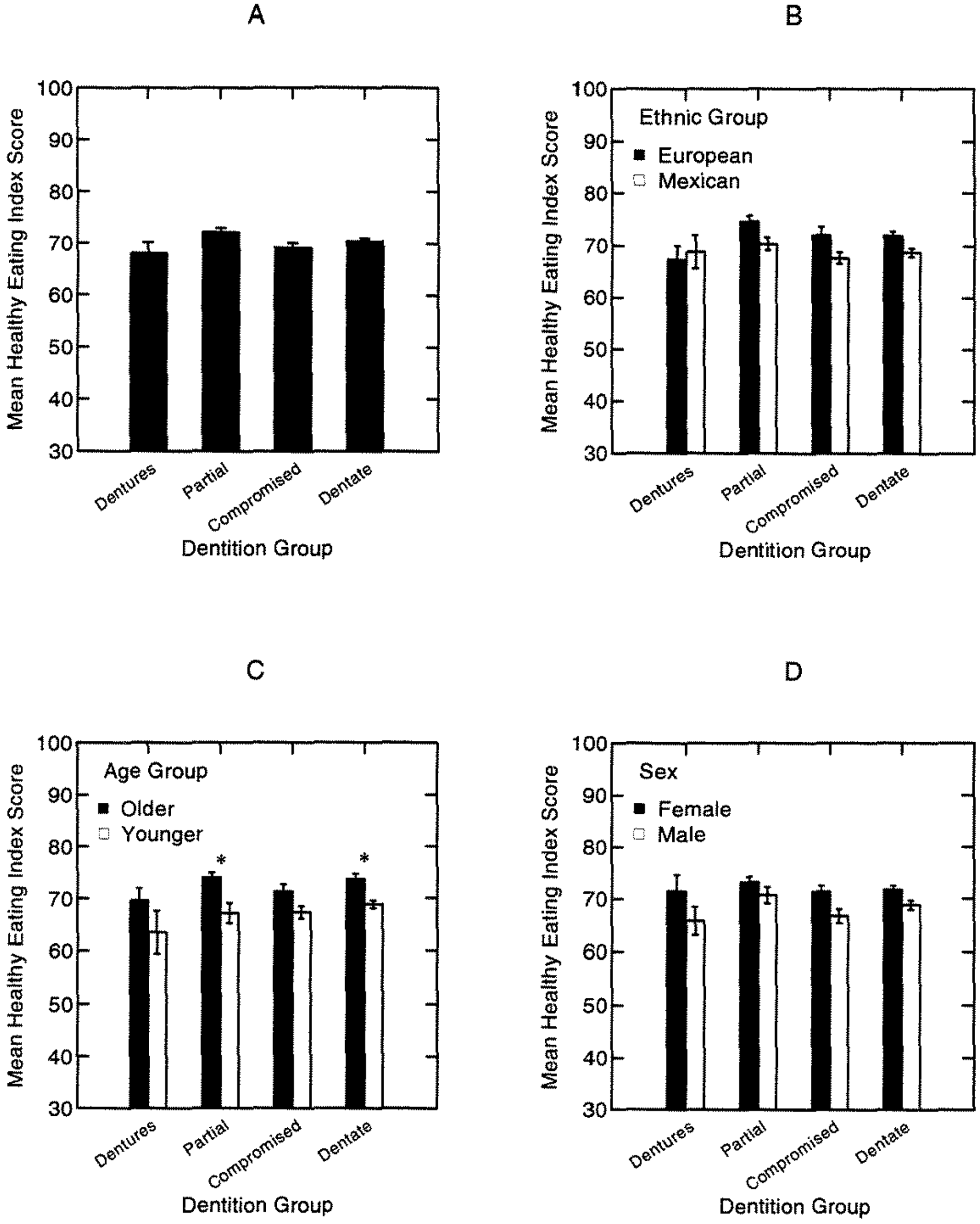

FIGURE 1. Mean and standard error values of Healthy Eating Index (HEI) scores by Dentition Group for (A) all subjects (n = 710), (B) European-American and Mexican-American groups, (C) Older and Younger groups, and (D) Female and Male groups. Main effects of ethnic group, age, and sex are statistically significant ($p < 0.01$), but main effect of dentition status and all 2-way interaction effects are not significant. * Pairwise differences are statistically significant ($p < 0.01$) by Bonferroni protected t-test.

DISCUSSION

Diet quality is a reflection of the combination of the variety of foods eaten, dietary patterns and preparation techniques (Variyam *et al.*, 1998). This is the first study to investigate the influence of masticatory variables on diet using an overall diet quality index, the Healthy Eating Index (HEI). The results demonstrated that diet quality varies as a function of sex, ethnicity, and age, but not income, level of education, or the functional, occlusal, muscular, and articular chewing-related factors evaluated in this sample.

Contrary to our hypothesis, masticatory variables cannot explain why females, European-Americans, and older subjects were eating better compared to males, Mexican-Americans, and younger subjects, respectively. Although the demographic groups showed significant differences for some of the masticatory variables, higher values of the latter did not translate into better diets. For example, the older group had the lowest values for all functional masticatory variables, but higher HEI scores than the younger group. We also found no influence of income or level of education on diet quality, although these variables clearly impact dentition and oral function. This further reinforces the conclusion that ability to comminute food, oral muscular strength, and TMD are not the primary determinants of the general diet quality or the intake of the recommended nutritional components. Likewise, occlusal impairment, as reflected by the four dentition status groups, is related to reduced oral function but not to quality of diet. Overall diet quality did not improve with better dentition conditions for any of the ethnicity, age, and sex groups studied.

As predicted, the poorer the dentition status, the worse the masticatory performance and bite force. While persons with compromised dentition may successfully compensate for their reduced masticatory function, persons with adequate dentition do not appear to eat a more healthful diet as we expected. Despite differences in masticatory variables, all four dentition groups consumed diets of similar quality, revealing a diet pattern that needs improvement. These results are consistent with a typical American diet as disclosed by the 1994-96 Continuing Survey of Food Intakes by Individuals (Bowman *et al.*, 1998), which showed that 70 % of the population were in the "needs improvement" range (HEI score between 51 and 80). The similar HEI scores for the four dentition groups, even the two extreme dentition conditions, suggests a better than expected diet quality in the poorer dentition groups. Complete denture wearers appear to eat the same quality diet as dentate people but perhaps in a more appropriate form. For instance, some coping strategies used by denture wearers to eat include: changing the resistance of the food to mastication by cooking it longer or otherwise softening it, cutting food into smaller pieces, and cutting meat and vegetables perpendicular to their fiber orientation (Ettinger, 1998; Obrez and Grussing, 1999). This possible explanation must be verified through analysis of food preparation techniques.

Although the masticatory variables did not associate with HEI, some weak associations with specific dietary components were found. These results are noteworthy because they corroborate in part the findings of previous studies. For instance, our results confirm the association between masticatory variables and intakes of vitamin C and fiber (Joshipura *et al.*, 1996, Papas *et al.*, 1998a,b; Krall *et al.*, 1998). Nevertheless, the other few associations were not consistent across the masticatory variables and did not follow a uniform pattern.

Two main reasons may account for the differences between our results and those of other studies. First, we employed a more conservative statistical analysis as the level of significance was 0.01 in contrast to others who used 0.05 or even 0.10. This approach aimed to detect strong associations and broad patterns and to limit identification of spurious associations because of the large number of dietary variables examined, which tend to be inter-related. Second, some studies evaluated convenience samples derived from dental schools or hospital settings in contrast to our community-based design. Even other community-based studies may not be comparable due to differences in the demographic characteristics of the sample and in the dietary assessment methods used. Though even small differences in diet would be detected due to the large statistical power afforded by our large sample, we were not able to find any strong relationships between masticatory and dietary variables. Thus, our findings point to a leading role for non-masticatory variables in determining the diet quality differences between Mexican-Americans and European-Americans, females and males, and older and younger subjects. It should be noted that, albeit statistically significant, the differences in diet quality related to ethnicity, sex, and age groups were small and may not be clinically relevant to target group-specific interventions.

Four broad categories of factors have been demonstrated to influence food consumption (Variyam *et al.*, 1998): consumer income, prices of food and other goods, consumer knowledge of health and nutrition, and tastes and preferences. In contrast to our results, level of education and income had a significant effect on diet choices and nutrition in other studies (Papas *et al.*, 1998b; Bowman *et al.*, 1998). However, these socioeconomic variables improve diet quality only if they lead to better acquisition and use of health information (Variyam *et al.*, 1998). Information and knowledge of nutrition play key roles in determining overall diet quality, even after controlling for income, education, age, gender, ethnicity, and body mass (Variyam *et al.*, 1998). It is important to keep this in mind when considering oral rehabilitation to improve diet because restoring occlusion and oral function without nutrition counseling is not sufficient to assure better diets. Therefore, nutritional information should be available to all patients, not only those less fortunate in terms of oral conditions, education or income, as the majority of the population needs improvement in diet quality.

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(ANEXO 3 — TABLE 4: Masticatory and dietary variables (mean and standard deviation) according to dentition status groups and for overall sample.)

Dietary Intake in Edentulous Subjects with Good and Poor Quality Complete Dentures

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ABSTRACT

Statement of the Problem: Previous studies in complete denture wearers evaluated the relationship between diet and measures of chewing, yet only isolated nutrient intake was considered. This makes the assessment of the overall diet quality and the planning of interventions difficult.

Purpose of study: This study investigated if poor quality of complete dentures is related to decreased masticatory performance, perceived difficulties in ability to chew, and poor diet quality as measured by the Healthy Eating Index (HEI), an overall diet quality index.

Methods: Subjects were 54 complete denture wearers. Data were obtained from clinical examinations, masticatory performance measurements, and two non-consecutive 24-hour dietary recalls. The outcome variables were the HEI and its components, plus selected nutrient and non-nutrient intake. Explanatory variables were quality of complete dentures, masticatory performance, and reported chewing ability. Data were analyzed with Kruskal-Wallis tests, Mann-Whitney U-tests, and Fisher Exact tests.

Results: Masticatory performance and perceived ability to chew were unrelated to diet quality. The Good Quality denture group had significantly better masticatory performance than the Medium and the Poor groups, but the median HEI scores and dietary intakes were not statistically different among these three groups. The milk, vegetables, fruits, and grain intake scores were mainly responsible for the low overall HEI scores.

Conclusion: Technical aspects of dentures, food comminution capacity, and perception of chewing ability in complete denture wearers were not related to diet quality. The majority of the denture wearers in this sample, regardless of technical quality of their dentures, had deficient diets.

INTRODUCTION

Improving health by restoring function is one of the main goals of oral rehabilitation of edentulous patients. Denture wearers have lower masticatory performance compared to dentate subjects[1-5], and decreased masticatory performance may restrict selection of foods that are difficult to chew.[2, 6] Poor masticatory performance in elderly denture wearers also is associated with more gastrointestinal disorders and increased intake of related drugs.[7]

It still is not clear if technically poor complete dentures can impact diet quality either through decreased ability to comminute food or perceived ability to chew. Studies in denture wearers show poor correlation between self-assessed chewing ability and objectively measured masticatory performance.[3, 8-10] Perceived chewing ability is closely related to comfort when chewing certain foods,[11,12] which may affect food selection patterns. On the other hand, it is widely accepted that optimal function with prostheses cannot be achieved without adequate technical characteristics. For instance, deficiencies in retention and stability are among the common complaints of denture wearers in relation to chewing,[12] and technical quality is one of the major factors influencing use of new dentures.[13] However, recent studies show that improvements in denture quality may have limited impact on ability to chew in patients with adequate denture-supporting tissues.[14] Similar dietary intake patterns also were found when comparing new conventional and implant-supported dentures.[15,16]

All these previous studies focusing on diet, chewing and quality of dentures evaluated food choices and intake of specific nutrients. Instead, we chose to use an overall diet quality index, the Healthy Eating Index (HEI), which combines information on the amount and variety of foods in the diet and compliance with specific dietary recommendations.[17-19] The assessment of overall diet quality reflects the variety of foods eaten, dietary patterns and preparation techniques, and not only intake of isolated nutrients.

This study aimed to investigate the relationship of technical quality of dentures, in terms of retention, stability, and tooth wear, with overall diet quality in complete denture wearers. We hypothesized that poor quality of complete dentures is related to decreased masticatory performance, perceived difficulties in ability to chew, and poor diet quality as measured by the HEI.

METHODS

Subjects were a subsample of the Oral Health: San Antonio Longitudinal Study of Aging (OH:SALSA), conducted in San Antonio, Texas, from July 1994 to May 1998. The OH:SALSA sample is a community-based cohort of elderly and younger adults, and was established by sampling two subsets of the San Antonio Heart Study (SAHS) cohort.[20] Our sample comprised 54 participants, 26 males and 28 females, aged 45 to 77 years (mean

67.8; s.d. 7.2). All subjects who had both upper and lower complete dentures and entire dietary intake data were included in the analysis.

Procedures

Calibrated examiners collected data during comprehensive medical and dental examination sessions. Assessments of denture quality, masticatory performance, and diet were completed by different examiners who were unaware of the subjects' performance on the other variables. All subjects gave written informed consent for their participation, and the University's Institutional Review Board approved the protocol.

Quality of Dentures. Three technical criteria, retention, stability, and tooth wear on posterior artificial teeth, were evaluated on a two-point scale (0 = no problem; 1 = problem) for the upper and the lower dentures. Lack of retention was recorded if the denture dislodged when the patient opened the mouth moderately wide without strain. Lack of stability was recorded when there was a displacement greater than 2 mm with unilateral and lateral force. Excessive tooth wear on posterior artificial teeth was recorded when at least half of the posterior artificial teeth lacked occlusal anatomy or were chipped. The retention, stability, and tooth wear scores for the upper and lower dentures were combined in a composite rating of denture quality ranging from 0 to 6. The subjects were classified according to this composite scale into three categories: "Good Quality" (scores 0-1), "Medium Quality" (scores 2-3), and "Poor Quality" (scores 4-6).

Masticatory Performance. The modified Mastication Performance Index was adopted.[21,22] Subjects were instructed to chew 3 g of peanuts on one side of the mouth, using 20 strokes, then rinse their mouth with water and expectorate into a container. A dentist inspected the oral cavity, collected any remaining particles, and added them to the sample. This procedure was repeated three times on each chewing side. The mean percentage by weight of the dehydrated material passing through a sieve (mesh #10, Market Grade Sieve Specifications, width of opening 1.91 mm) constituted the masticatory performance score. Left and right side samples were processed separately but averaged for this analysis.

Self-perceived Masticatory Ability: Subjective masticatory ability was assessed through three key questions about chewing: 1) I have trouble biting or chewing hard foods, such as apples, carrots, peanuts or hard breads (Yes or No); 2) I am careful about what I eat, because I have trouble biting, chewing or swallowing (Yes or No); and 3) Foods get caught underneath my dentures when I eat (Yes or No). For each question, subjects who responded "Yes" were compared to subjects who answered "No". Each question was analyzed separately.

Dietary and Nutritional Data. Trained interviewers or registered dietitians collected two non-consecutive 24-hour dietary recalls from each subject. Probing questions and recall aids (food models, measuring cups, and rulers) were used to assist subjects to recall types and amounts of foods consumed. The uses, limitations, reliability, and validity of this method were reported and discussed previously.[23,24] Foods consumed were converted to five major food groups (grains, vegetables, fruits, milk, and meat).[25] Data were analyzed using the First Data Bank Nutrient Computer Analysis Software (The Hearst Corporation, San Bruno, CA). This software analyzes diets for intakes of food groups as well as nutrients and non-nutrients.

The dietary data were converted to the Healthy Eating Index (HEI), our primary outcome measure. The HEI is based on the U.S. Department of Agriculture Food Guide Pyramid and Dietary Guidelines for Americans,[17,18] and was constructed according to a 10-component system comprised of five food groups (grains, vegetables, fruits, milk, and meat), four dietary variables (total fat, saturated fat, cholesterol, and sodium), and a measure of variety in food intake. The criteria for scoring the ten HEI components are described in Table 1. Each component is scored from 0 to 10. High scores indicate intake close to the recommended amounts; low scores indicate less compliance with the recommended amounts and dietary guidelines. Some components (fats, cholesterol, and sodium) adjust the scores for excessive intake. The scoring weights the recommended number of food servings or intake depending on a person's caloric requirement according to age and gender. The total HEI score ranges from 0 to 100.

In addition to the HEI, intake of 40 specific nutrients was assessed. Because the emphasis of this study is on overall diet quality, we comment on selected nutrients and non-nutrients intakes only to compare our results to previous studies.

Statistical Analysis. Data were analyzed with Kruskal-Wallis one-way analysis of variance, Mann-Whitney U-tests, and Fisher Exact tests, as implemented in Systat 8.03 (SPSS, Inc, Chicago, IL). Because a large number of dietary components were examined, results were considered significant at $\alpha = 0.01$. The outcome variables of interest were the Healthy Eating Index (HEI) and its components, plus selected nutrient and non-nutrient daily intakes. Explanatory variables were quality of dentures, masticatory performance, and reported chewing ability.

TABLE 1. Healthy Eating Index (HEI) components and scoring system (adapted from Kennedy *et al.*, 1995; Bowman *et al.*, 1998).[17,18]

HEI Component	Score [a]	Criteria for score of 10 [b]	Criteria for score of 0
Food groups [c]			
Grains	0 - 10	6 – 11 servings	0 servings
Vegetables	0 - 10	3 – 5 servings	0 servings
Fruits	0 - 10	2 – 4 servings	0 servings
Milk	0 - 10	2 – 3 servings	0 servings
Meat	0 - 10	2 – 3 servings	0 servings
Dietary guideline variables			
Total fat	0 - 10	30% or less total kcal from fat	45% or greater total kcal from fat
Saturated fat	0 - 10	Less than 10% total kcal from saturated fat	15% or greater total kcal from saturated fat
Cholesterol	0 - 10	Less than 300 mg per day	Greater than or equal to 450 mg per day
Sodium	0 - 10	Less than 2,400 mg per day	Greater than or equal to 4,800 mg per day
Variety	0 - 10	10 or more different food items per day [d]	3 or fewer different food items per day [e]

[a] Persons with component scores between the maximum and the minimum cutoff points are assigned scores proportionately.

[b] Numbers of servings of foods depend on recommended energy intake according to age and gender (Recommended Energy Allowance). Additional servings beyond the recommended number do not result in further credit or loss of points.

[c] Each food group is a good source of specific nutrients and non-nutrients: Grains are rich in B vitamins and fiber; Vegetables and Fruits are rich in vitamins A and C, folate, and fiber; Milk and Meat are rich in protein, calcium, phosphorus, and zinc. Meat also is a good source of iron.

[d] The original criterion was 16 different food items over a 3-day period.[17]

[e] The original criterion was 6 or fewer different food items over a 3-day period.[17]

RESULTS

The median daily HEI, HEI components, and selected nutrient and non-nutrient intakes for the three quality of dentures groups (Good, Medium, and Poor) and for the overall sample are shown in Table 2. In general, the diet data showed a large range of scores and skewed distribution. The median HEI scores for the three quality of dentures groups ranged from 60.5 to 72.0, and were not statistically different ($p > 0.01$). The milk, vegetables, fruits, and grains HEI component scores were mainly responsible for the low overall HEI scores. Intakes of meat, fats, cholesterol, and sodium approached or met dietary guidelines. Variety of food intake was adequate in this sample. When each technical characteristic (retention, stability, and tooth wear) was evaluated separately, no significant difference in diet quality, as measured by the HEI, was detected among groups with poor and technically adequate dentures ($p > 0.01$) (Figure 1). The ten HEI components and the other selected nutrients were not different when comparing subjects by good or poor quality of dentures.

TABLE 2. Median (standard deviation) daily dietary intake for complete denture subjects by quality of dentures categories and for the overall sample.

Dietary variables	*Quality of Dentures*			*Overall Sample*
HEI variables	**Good (n = 18)**	**Medium (n = 11)**	**Poor (n = 25)**	**(n = 54)**
Healthy Eating Index (HEI)	60.5 (11.2)	70.0 (14.3)	72.0 (13.3)	69.5 (13.0)
Grains (HEI score)	5.0 (2.2)	7.0 (2.1)	6.0 (2.4)	6.0 (2.3)
Vegetables (HEI score)	5.0 (2.9)	5.0 (3.6)	5.0 (2.6)	5.0 (2.9)
Fruit (HEI score)	5.5 (3.6)	5.0 (2.8)	5.0 (3.0)	5.0 (3.1)
Milk (HEI score) *	1.0 (2.7)	8.0 (3.8)	4.0 (3.6)	2.0 (3.7)
Meat (HEI score)	9.0 (1.7)	10.0 (2.4)	10.0 (2.7)	9.0 (2.3)
Total fat (HEI score)	7.0 (3.0)	8.0 (3.6)	9.0 (3.7)	7.5 (3.4)
Saturated fat (HEI score)	6.0 (3.6)	8.0 (3.9)	9.0 (3.7)	7.5 (3.7)
Total cholesterol (HEI score)	9.5 (3.9)	10.0 (2.5)	10.0 (2.9)	10.0 (3.2)
Sodium (HEI score)	9.0 (1.7)	7.0 (2.9)	9.0 (1.9)	9.0 (2.1)
Variety (HEI score)	10.0 (2.2)	10.0 (1.3)	10.0 (1.8)	10.0 (1.8)
Selected nutrient and non-nutrient variables				
Energy (kcal)	1672.0 (335.1)	1482.0 (591.3)	1612.0 (185.0)	1610.5 (345.2)
Protein (g)	60.7 (16.2)	62.5 (23.9)	65.7 (15.6)	64.5 (17.4)
Sugar (g)	48.3 (29.5)	49.6 (29.5)	56.6 (25.6)	49.5 (27.4)
Vitamin A (RE)	525.2 (1056.2)	945.2 (666.0)	696.5 (1226.7)	664.1 (1068.4)
Vitamin C (mg)	58.6 (60.0)	61.7 (88.5)	63.7 (49.1)	61.5 (61.2)
Folate (µg)	234.7 (91.7)	147.2 (147.8)	248.6 (157.5)	228.9 (139.6)
Iron (mg)	13.1 (4.0)	12.1 (11.3)	12.1 (20.4)	12.6 (15.0)
Dietary fiber (g)	10.0 (5.8)	10.3 (6.8)	13.3 (7.2)	10.7 (6.9)

All comparisons among the three categories of quality of dentures were not statistically significant at $\alpha = 0.01$.
The comparisons for the Milk HEI score was significant at $\alpha = 0.05$ (*).

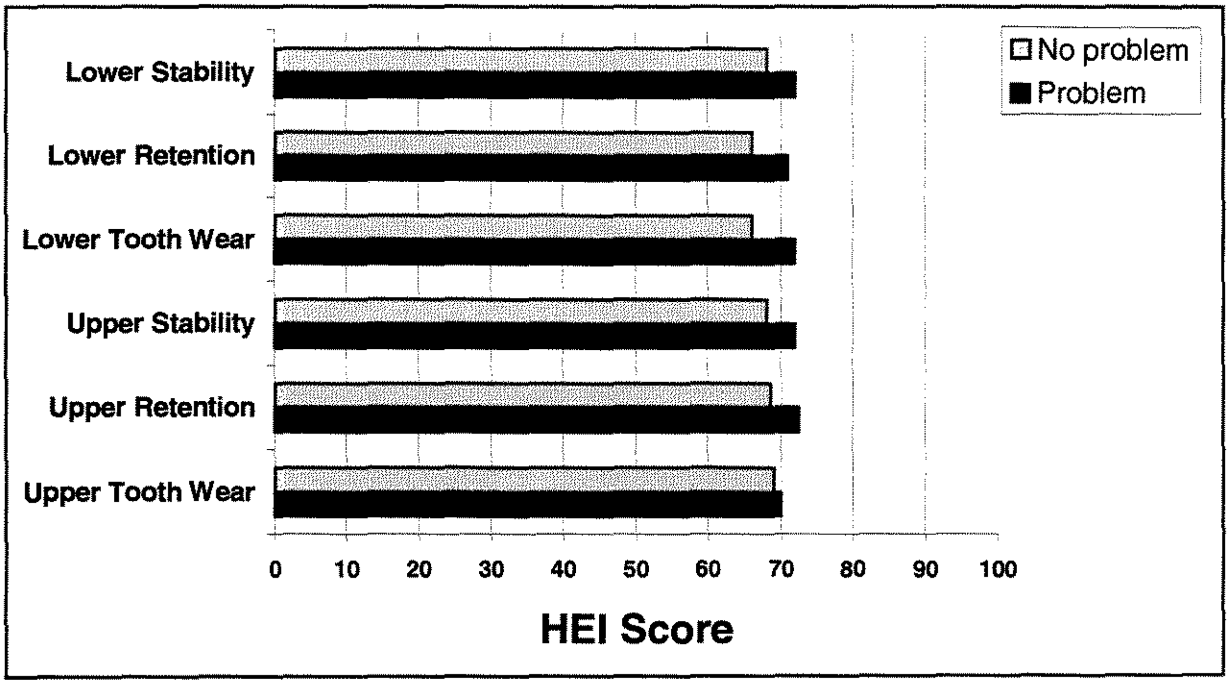

FIGURE 1. Median Healthy Eating Index (HEI) scores for subjects with acceptable or problem dentures (n = 54).

Mean masticatory performance as a function of composite quality of dentures ranged from 24.4 % to 43.5 % (Figure 2A). The Good Quality of Denture group had significant better masticatory performance than the Medium and the Poor groups ($p < 0.01$). The analysis of each separate technical characteristic (retention, stability, and tooth wear) revealed a general trend towards lower masticatory performance with poor quality of dentures (Figure 2B). However, masticatory performance was significantly different for stability of lower dentures only ($p = 0.008$).

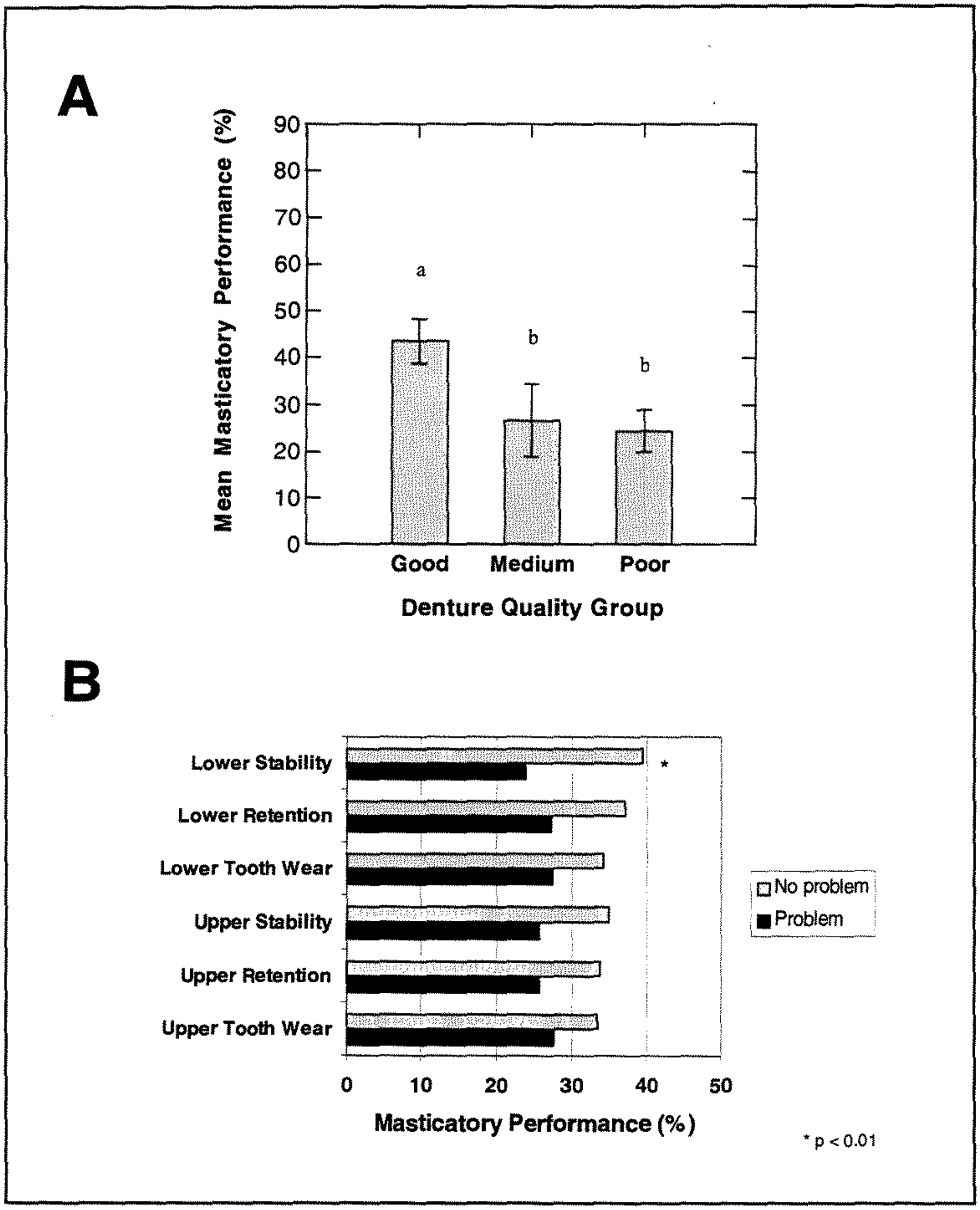

FIGURE 2. Mean Masticatory Performance as a function of quality of complete dentures (n = 45). A. Comparison of the three quality of dentures groups; bars labeled with different letters are significantly different at $p < 0.01$. B. Pairwise comparisons for each technical characteristic.

Figure 3 illustrates the distribution of the overall diet quality in relation to masticatory performance. HEI scores ranged from 40 to 90. Likewise, there was a large spectrum of masticatory performance values, but most of them were concentrated in the lower range (below 50%). No pattern could be distinguished in the relationship between HEI scores and masticatory performance. There was no difference in distribution of HEI scores according to gender (p = 0.33).

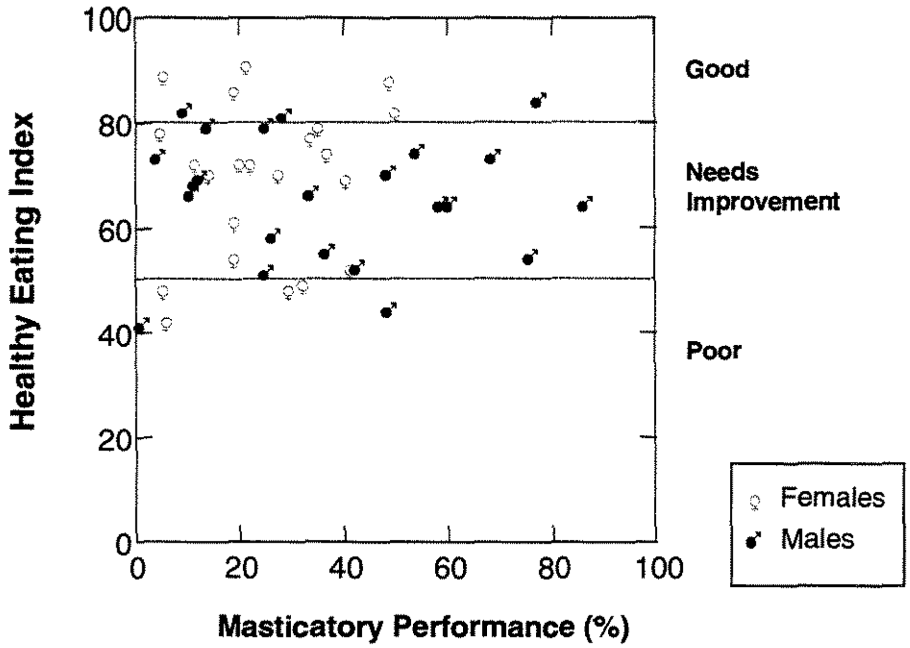

FIGURE 3. Distribution of the Healthy Eating Index (HEI) scores as a function of Masticatory Performance (n = 45). Horizontal dashed lines indicate the division of the HEI categories of diet quality (Good, Needs Improvement, and Poor). There was no significant difference in distribution of HEI scores according to gender (p = 0.33).

Perceived chewing ability was not significantly associated with masticatory performance or quality of dentures ($p > 0.01$) (Table 3). Additionally, diet quality was not associated with subjective chewing ability. Figure 4 shows the median HEI scores as a function of perceived chewing ability. Median HEI scores ranged from 63.5 to 73.5 and did not differ in subjects with or without self-reported problems when chewing. Comparisons between groups also showed no difference in the intake of the ten separate HEI components or the other selected nutrients ($p > 0.01$). For example, Figure 5 displays the median scores of the ten components of the HEI for the question "I have trouble biting or chewing hard foods, such as apples, carrots, peanuts or hard breads". Milk, vegetables, fruits, and grains were the HEI components with the lowest scores. No significant difference was found between the groups with and without self-reported problems, although the group with reported problems had lower absolute scores for some of the HEI components.

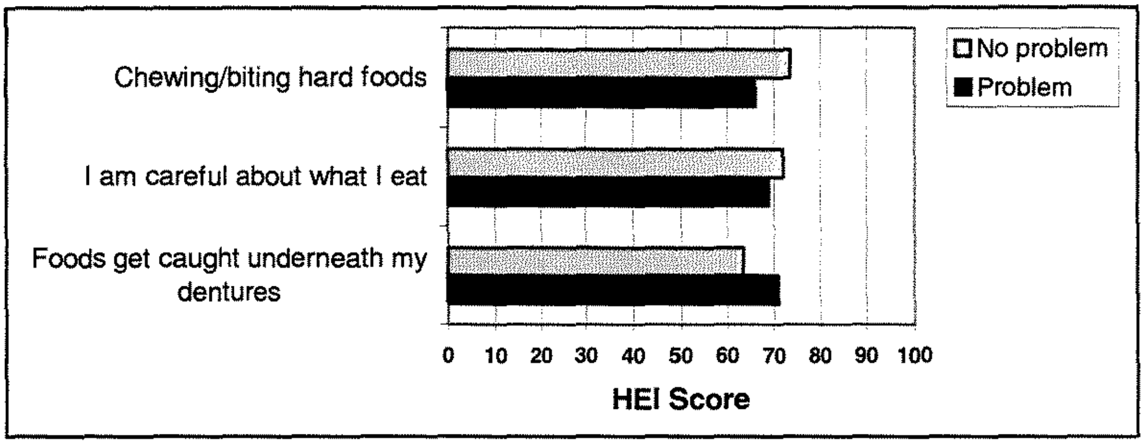

FIGURE 4. Median Healthy Eating Index (HEI) scores as a function of the self-reported chewing ability (n = 54).

TABLE 3. Mean (standard deviation) masticatory performance scores for the questions about perceived ability to chew and frequencies of responses by quality of dentures.

	I have trouble biting or chewing hard foods, such as apples, carrots, peanuts or hard breads		I am careful about what I eat, because I have trouble biting, chewing or swallowing		Foods get caught underneath my dentures when I eat	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Masticatory performance score (%) (n = 45)	28.4 (21.7)	32.7 (21.7)	25.4 (19.6)	37.4 (22.4)	28.2 (20.4)	34.9 (23.4)
Quality of Dentures						
Good (n = 18)	11 (61%)	7 (39%)	11 (61%)	7 (39%)	10 (56%)	8 (44%)
Medium (n = 11)	4 (36%)	7 (64%)	6 (55%)	5 (45%)	7 (64%)	4 (36%)
Poor (n = 25)	17 (68%)	8 (32%)	18 (72%)	7 (28%)	19 (76%)	6 (24%)

All comparisons between the Yes and No responders for each of the three questions were not statistically significant at $\alpha = 0.01$.

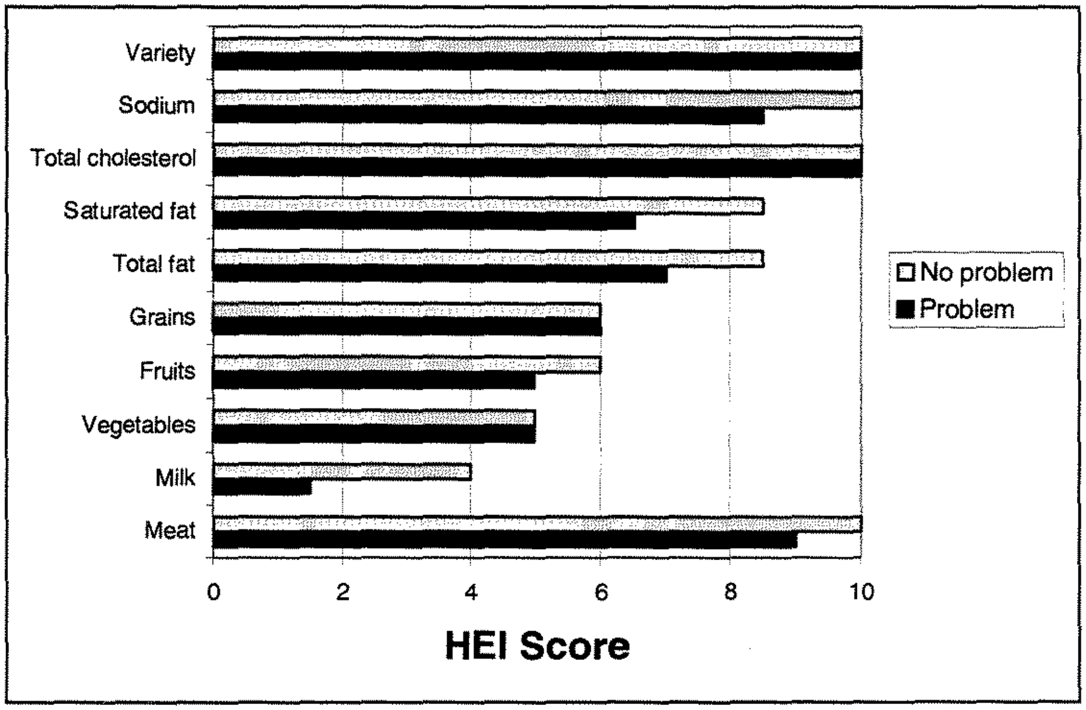

FIGURE 5. Median scores of the components of the Healthy Eating Index (HEI) as a function of the self-reported chewing ability assessed by the question "I have trouble biting or chewing hard foods, such as apples, carrots, peanuts or hard breads" (n = 54).

DISCUSSION

Chewing and diet are both complex. Chewing depends upon several anatomical structures of the stomatognathic system, sensorimotor control, perception, and food characteristics. Diet, in turn, reflects all the factors that lead to food choices and intake, including personal preferences and resource availability. It has been suggested that impaired chewing because of wearing complete dentures may restrict dietary selection and nutrient intake.[2, 26-28] A logical extension of this is that dentures of good quality would be less restricting than dentures of poor technical quality. The results of our study, however, do not support this assumption. Technical aspects of dentures, food comminution capacity, and perception of chewing ability in complete denture wearers were not related to overall diet quality.

The assessment of overall diet quality in relation to oral function is a new approach. Previous studies concentrated exclusively on intake of isolated nutrients, most often measured as percentages of Recommended Dietary Allowances (RDA). The use of RDAs has two major limitations.[29] First, RDAs are not requirements below which deficiency diseases are apt to develop. Second, RDAs are recommendations for healthy individuals, for which the nutritional requirements may be different from those of ill subjects. Moreover, when nutrient variables are examined independently, large samples are required, and analyses may lead to interpretation errors because of the common synergistic relationship among variables. Dietary analyses based on isolated nutrients also are more difficult to translate into diet interventions due to collinearity of nutrients in the foods ingested by the patient. To overcome these problems we used the Healthy Eating Index. The HEI is an overall diet quality index developed by the US Department of Agriculture to assess the dietary status of Americans, monitor changes in dietary patterns, and serve as a basis of nutrition promotion activities.[17-19] It is based on several aspects of a healthful diet, incorporating requirements for adequacy, moderation, and variety, and controlling for age and gender. Therefore, the HEI is designed to present a composite of multiple nutrient and non-nutrient intakes as well as eating behaviors.

In this investigation of complete denture wearers, overall diet quality (HEI) was not related to quality of dentures so far as lack of retention, stability or wear of artificial teeth are concerned. The consumption of the HEI components and other selected nutrients and non-nutrients, such as energy, protein, and dietary fiber, also were not statistically different in subjects with good and compromised dentures. This corroborates the findings of Neill & Phillips, who did not find differences in the intake of calories, carbohydrates, fat, and protein with different degrees of retention and stability of dentures.[30] Likewise, replacement of old poor fitting dentures with new conventional complete dentures improves masticatory performance but not dietary intake.[31] Recent studies indicate that improvements in retention and stability provide no improvement in masticatory function and nutrient intake in conventional denture patients treated with new conventional or implant-retained overdentures. [14,16]

It is interesting to note that neither people with good nor poor complete dentures are eating well. The HEI scores can be grouped into three categories – Good (>80), Needs Improvement (51-80), and Poor (<51).[18] The majority of the complete denture wearers in this sample, regardless of the technical quality of their dentures, fall into the intermediate category (Needs Improvement). Milk, vegetable, fruit, and grain intakes were the diet components far below the HEI guidelines. Specific nutritional recommendations for these food groups should be given to all denture patients, which reinforces the role of the dentist as a comprehensive health care provider. Nutritional counseling and education should be incorporated into the dental treatment plan provided to denture patients.

Masticatory performance was higher for subjects with good quality dentures in comparison with subjects in the medium and poor quality groups. Isolated technical problems with the dentures, however, were not related to low oral function in terms of ability to comminute food, except for stability of lower dentures. It is possible that the stability of the mandibular denture by itself may not be the reason for diminished masticatory performance, but the significant difference in comminution ability would be the result of interactions of poor stability and the other variables. This issue is also controversial in the literature. For example, in our study neither worn teeth nor lack of retention were good indicators of masticatory performance. This parallels previous studies showing that improvements in retention, stability, and occlusion of poor complete dentures do not impact masticatory performance.[32,33] Another population-based study also found low predictive values of retention and stability of dentures for masticatory performance.[34] On the other hand, in elderly denture wearers objective masticatory performance was predicted by denture stability but not by occlusal form of artificial teeth.[35] A common finding, however, is the large variability of masticatory performance in denture wearers, which may reflect different degrees of functional adaptation. Indeed, psychological, behavioral, and oral neuromuscular factors may be more important than technical denture factors in relation to chewing.[10,32]

Self-perceived chewing ability also did not differ in subjects with Good, Medium, and Poor quality dentures. Lack of retention, stability and artificial tooth wear were not related to reported difficulties in chewing certain foods, or concerns about comfort. This supports the interpretation that many subjects are well adapted to poor quality dentures. Moreover, the expected relationship between perceived chewing ability and overall diet quality or specific foods consumption was not confirmed. This is contrary to previous studies on intake of particular nutrients[36] and on selection of foods.[37] Self-assessed chewing difficulty was independent of selection of easy- or difficult-to-chew foods[38] and of dietary intake in another population-based study.[39]

Distinction has to be made between food choices and quality of diet. Complete denture wearers who express dissatisfaction with their ability to eat difficult-to-chew foods may adopt coping mechanisms, such as choosing new forms of food preparation, that permit intake of the same food. It is also possible that they eat other foods with the same nutrient content as substitutes for the more difficult-to-chew foods. As a result, a nutritious diet still could be consumed. Another point to be considered is that quality of diet may not directly relate to quality of life. For instance, although not statistically significant, we observed that subjects with Poor or Medium quality dentures consumed higher quantities of milk than subjects with Good quality dentures. This suggests that these people may have chosen a diet with more liquid content to supply intake of protein and vitamins. In so doing, they might achieve an equivalent diet in terms of nutrient content and variety compared to subjects with good dentures, but may still suffer restriction in their food choices. Such coping strategies for chewing were addressed previously.[12,40-42] Additional studies would be necessary to confirm this as the reason for our results in terms of the similarity in overall diet quality of subjects with good and poor quality dentures.

CONCLUSIONS

This study does not support significant differences in diet quality when comparing subjects with dentures of good and poor technical quality. This does not mean that oral rehabilitation is not important for improving chewing or allowing the complete denture wearer to eat certain types of food. However, people with good quality dentures are not necessarily more likely to consume better diets compared to people with poorly fitting or worn dentures.

CLINICAL IMPLICATIONS

Provision of technically perfect dentures does not seem to be of primary importance to diet quality as people with good quality dentures do not consume better diets. This is important to keep in mind because it will help to target and prioritize interventions. For instance, when facing a case of a mal-nourished patient who has old complete dentures, with worn teeth and lack of retention and stability, careful diagnosis and treatment planning should include individualized nutritional assessment and counseling to improve diet quality. An interdisciplinary approach with referrals to a nutritionist and/or physician should be considered.

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(ANEXO 4 — TABLE 4: Median (standard deviation) daily dietary intake for complete denture subjects by quality of dentures categories and for the overall sample.)

Masticatory Performance Is Not Associated with Diet Quality in Class II Orthognathic Surgery Patients

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The International Journal of Adult Orthodontics and Orthognathic Surgery

(no prelo) (APÊNDICE 4)

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ABSTRACT

This study evaluated the association between masticatory function, diet, and digestive system problems in 59 Class II patients five years after bilateral sagittal split osteotomy (BSSO). Dietary intake data were recorded on 4-day diet diaries and analyzed for overall diet quality (Healthy Eating Index) and selected dietary components. Masticatory function was assessed through measurements of masticatory performance, maximum bilateral bite force, and time of chewing and number of chewing strokes until the subject felt that the bolus was ready to swallow. Self-reported frequency of digestive system problems was recorded with a 7-point Likert scale questionnaire. Masticatory function was not associated with diet quality or gastrointestinal problems. There was weak association between intake of foods that require chewing (*e.g.*, fiber, protein, meat, and vegetables) and masticatory variables. Fourteen subjects (24%) had a Poor diet, and 45 subjects (76%) had a diet that Needs Improvement according to the diet quality index. Self-reported constipation was the only digestive system problem significantly associated with masticatory performance.

INTRODUCTION

The prevalence of Class II malocclusion in the United States has been recently disclosed in the National Health and Nutrition Examination Survey III data.[1] These data revealed that about 4% of the population has an overjet greater than 7 mm. Many subjects with such severe malocclusions are treated with combined orthodontic and surgical care. Most of these patients are seeking improved facial esthetics, improved oral function, and other health benefits.[2, 3] The esthetic benefits of orthognathic surgery are highly subjective and essentially undisputed. The functional consequences of malocclusion correction and the health-related benefits of orthognathic surgery are less evident.

Patients scheduled to undergo orthognathic surgery have restricted masticatory performance compared to subjects with normal occlusion.[4–6] However, cross-sectional[4] and prospective studies[6, 7] demonstrate rather disappointing improvements in masticatory function following orthognathic surgery.

Regarding the impact of masticatory function on general health and dietary habits, poor masticatory performance is associated with lower intakes of high fiber foods and with increased prevalence of gastrointestinal disorders in edentulous elderly.[8, 9] This raises the question of whether oral functional limitations due to malocclusion translate into restricted dietary intake or increased risk for gastrointestinal disorders.

This analysis was conducted to assess the association between masticatory function, diet, and digestive system problems in a group of patients five years after they received bilateral sagittal split osteotomy (BSSO) to correct a severe Class II malocclusion. The *a priori* hypothesis was that following correction of malocclusion with orthognathic surgery, good masticatory function would be associated with good diet quality

MATERIALS AND METHODS

Subjects and Treatment

Participants included 44 female and 15 male patients referred by their orthodontists for surgical correction of a Class II malocclusion. Subjects were enrolled in a multi-site randomized clinical trial designed to compare the benefits and risks of wire osteosynthesis and rigid internal fixation. This analysis includes all subjects from the San Antonio site who completed a dietary assessment at five years post-surgery. Thirty-six subjects received rigid internal fixation and 23 received wire osteosynthesis. Subject characteristics are displayed in Table 1. All subjects gave informed consent for the procedures, and the University's Institutional Review Board approved the research protocol.

Measures

Masticatory Performance. Masticatory performance was assessed using the Masticatory Performance Index described by Manly and Braley (1950)[10] and modified by Yurkstas and Manly (1950).[11] This index was calculated as the percentage of a masticated test food bolus that passes through a #10 mesh screen. This index has been found effective in quantifying the reduction in masticatory ability in subjects with malocclusion,[12] during orthodontic treatment,[13] and with missing teeth.[14] Three trials were given on each chewing side using 3 g samples of peanuts and 20 chewing strokes per trial. The mean of all left and right side trials was used as the masticatory performance score.

Maximum Bite Force. Maximum bilateral bite force was assessed using a cross-arch-bilateral bite element equipped with a Sensotec model 13/2445-02 strain gauge. The bilateral bite pads were placed in the region of the first molar. Vertical jaw opening for the bite pads was 14 mm. The bite pads were covered with a polyvinyl chloride sleeve to protect the teeth and with cellophane sheets for infection control. The force values were digitized with a MacLab (Analog Digital Instruments, Castle Hill, NSW, Australia) analog-to-digital converter. Subjects were allowed to practice biting on the bite element in order to build confidence in the stability of the transducer. The experimental procedure was completed by measuring 10 maximum force clenches on the bite element for 1-2 seconds each. Subjects were exhorted by the examiner to bite "as hard as possible". The mean of the three highest bite force trials was taken as the maximum bite force score.

Time of Chewing and Number of Strokes. Subjects were instructed to chew 3g of peanuts unilaterally until they felt that the bolus was ready to swallow (swallowing threshold). A jaw-tracking device was used to measure jaw movements while chewing. This device captures changes in small magnetic fields produced by a magnet positioned on the lower incisors. The electromagnetic sensors are mounted in a headgear that rests on the bridge of the nose and ears, like a pair of eyeglasses. As the jaw moves, the trajectory and velocity of jaw movements are digitized electronically and stored on the microcomputer using the MacLab system (Analog Digital Instruments, Castle Hill, NSW, Australia). The mean of the left and right sides trials was used to obtain the time of chewing and the number of strokes (chewing cycles).

Self-Reported Digestive System Problems. Subjects completed a 7-point Likert-type scale (1 = "Never", 7 = "All the time") questionnaire designed to measure self-reported frequency of digestive system problems that may be related to diet or ability to properly chew food. The questions asked to the patients were: "How often do you experience the following: heartburn / constipation / diarrhea / stomach aches / burping / gas ?"

Dietary Intake. After receiving verbal instructions and watching an instructional videotape, subjects kept a detailed written record of everything they consumed for four nonconsecutive 24-hour periods. Dietary supplements and details including brand names and serving sizes were included. A dietary technician analyzed the diet histories for 75 nutrient and non-nutrient components using the First Data Bank Nutrient computer analysis software (The Hearst Corporation, San Bruno, CA).

In addition to assessment of specific nutrients, the Healthy Eating Index (HEI), a measure of overall diet quality, was calculated. The HEI was developed by the U.S. Department of Agriculture's (USDA) Center for Nutrition Policy and Promotion to assess and monitor the dietary status of Americans.[15, 16] The HEI score is an aggregate of 10 component scores, each of which quantifies one aspect of a healthful diet. Scores are scaled to reflect recommended intakes for age and gender groups. The first five components quantify the degree to which a diet conforms to the USDA's daily serving recommendations for the five food groups (grains, vegetables, fruits, milk, and meat). The sixth and seventh components quantify total fat and saturated fat consumption as a percentage of total energy intake. The last three components quantify total cholesterol and sodium intake and dietary variety, respectively. The overall HEI score can range from 0 to 100, with each component score contributing a maximum of 10 points. An HEI total score below 51 implies a "Poor" diet, a score between 51 and 80 implies a diet that "Needs Improvement", and a score over 80 implies a "Good" diet. Because of the importance of dietary sugars to dental health, we calculated the percentage of total energy intake from sugars. All dietary variables were expressed as the average daily intake over the four days.

Statistical Analysis

Associations of masticatory variables with dietary intake and gastrointestinal problems were assessed with Spearman rank order correlations. Bi-directional significance levels were evaluated at the $\alpha = 0.01$ level.

RESULTS

Subjects treated with wire osteosynthesis and internal rigid fixation were not significantly different in terms of their HEI scores. Therefore, these two groups were combined for subsequent analyses.

Table 1 displays the descriptive data for the masticatory variables. Spearman rank order correlations among masticatory variables are shown in Table 2. Significant correlations were found between time of chewing and number of strokes, and between masticatory performance and bite force, number of strokes, and time of chewing.

Few significant associations were found between HEI scores and masticatory variables (Table 3). Some HEI components and selected nutrients and non-nutrients showed weak but significant correlations with specific masticatory variables. The primary measure of masticatory performance used in this study was the mean of left and right-sided chewing. Subjects were asked whether they typically chew their food on a preferred side or bilaterally. The correlations with HEI components and nutrient intake were re-calculated using two alternative measures of masticatory performance. First, the chewing side having the greater masticatory performance score was used. Second, if the subject stated a preferred chewing side, then the masticatory performance score corresponding to that side was used. Otherwise, if the subject stated that he chews bilaterally then the mean of the left and right sides was used. The results of these secondary analyses (data not shown) did not depart remarkably from those displayed in Table 3.

TABLE 1. Characteristics of the Subject Sample (n = 59).

Characteristic	Mean	SD
Age (years)	36.4	10.8
Body Mass Index (BMI) [a]	25	5
Pre-surgical Overjet (mm)	7.7	3.5
Masticatory Performance (%)	65.7	18.3
Bilateral Maximum Bite Force (N) (n = 46)	494.7	174.1
Time of Chewing (s) (n = 56)	25.3	14.0
Number of Strokes (n = 56)	31.9	18.8

[a] Body Mass Index is a relationship between weight and height (BMI = wt / ht^2). For 18 years or older, BMI 18-24 normal, 25-29 overweight, ≥ 30 obese.

TABLE 2. Spearman Rank Order Correlations among Masticatory Variables (n = 46).

	Bite Force	Number of Strokes	Time of Chewing	Masticatory Performance
Bite Force	1.00			
Number of Strokes	-0.25	1.00		
Time of Chewing	-.024	0.91 *	1.00	
Masticatory Performance	0.40 *	-0.46 *	-0.46 *	1.00

* Significant at $\alpha = 0.01$

The mean HEI overall score of 59.2 falls at the low end of the Needs Improvement category, according to the USDA standards (Table 3). None of these subjects had a diet that could be classified as Good, 14 subjects (24%) had a Poor diet, and 45 subjects (76%) had a diet that Needs Improvement (Figure 1). There was no difference on HEI scores due to gender (p = 0.82), and there was no significant association between HEI and age ($r_s = -0.062$).

TABLE 3. Spearman Rank Order Correlation of Average Scores on the Healthy Eating Index Components and Average Daily Dietary Intake of Selected Nutrient and Non-Nutrient Components with Masticatory Variables.9

Dietary Variables	Mean (SD) (n = 59)	Correlation with Masticatory Performance (n = 59)	Correlation with Bite Force (n = 46)	Correlation with Time of Chewing (n = 56)	Correlation with Number of Strokes (n = 56)
Total HEI Score §	59.2 (10.2)	-0.01	-0.10	-0.17	-0.09
Milk †	5.4 (3.8)	0.26	0.32	-0.12	-0.05
Meat †	7.5 (2.6)	-0.12	0.20	0.29	0.24
Vegetables †	4.8 (2.5)	-0.23	-0.28	0.31	0.37 *
Fruit †	2.7 (2.6)	0.03	-0.18	0.00	0.03
Grains †	6.7 (2.2)	0.19	0.34	0.06	-0.04
Total Fat Percent †	6.2 (3.1)	0.17	-0.07	-0.22	-0.15
Saturated Fat Percent †	5.9 (3.7)	0.07	0.03	-0.23	-0.22
Total Cholesterol †	7.6 (3.6)	0.05	-0.23	-0.29	-0.19
Sodium †	6.2 (3.2)	-0.26	-0.42 *	-0.08	-0.15
Variety †	6.4 (2.9)	-0.33	-0.09	0.13	0.21
Selected Nutrients					
Sugar (% of total intake)	20.5 (8.9)	0.06	0.13	-0.31	-0.23
Total Energy (kc)	2010.4 (680.4)	0.27	0.53 *	0.04	0.04
Protein (g)	75.5 (28.5)	0.19	0.40 *	0.12	0.14
Vitamin A (RE)	781.6 (481.4)	-0.02	-0.16	0.16	0.16
Vitamin C (mg)	72.4 (50.2)	-0.13	0.02	-0.08	-0.04
Dietary Fiber (g)	13.6 (6.3)	-0.03	0.13	0.24	0.22

§ Score range: 0 – 100. † Score range: 0 – 10. * Significant at $\alpha = 0.01$

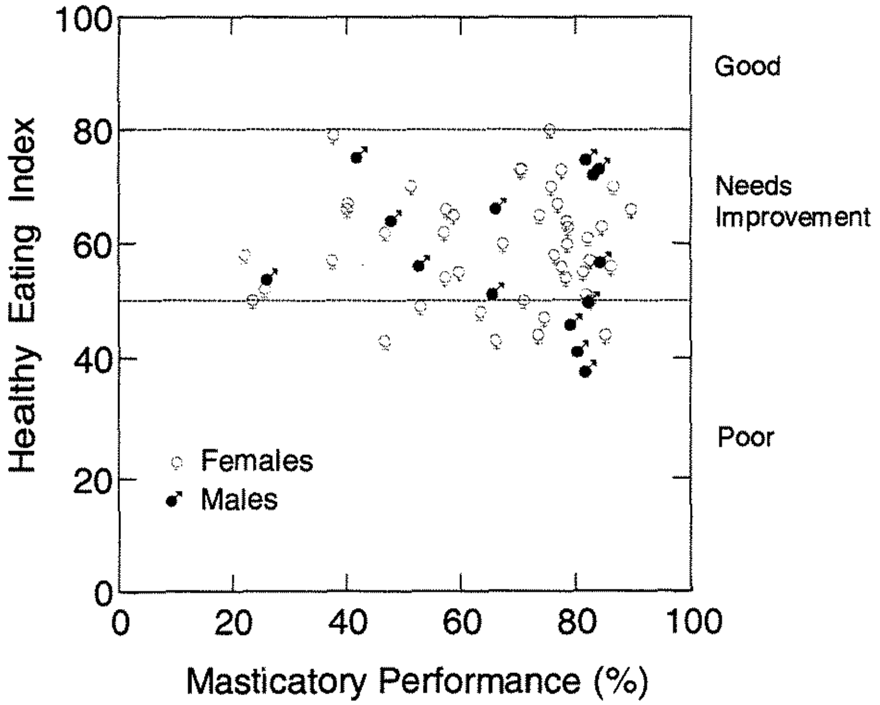

FIGURE 1. Distribution of the Healthy Eating Index (HEI) scores as a function of Masticatory Performance. Horizontal dashed lines indicate the division of the HEI categories of diet quality (Good, Needs Improvement, and Poor). There was no difference in distribution of HEI scores according to gender (p = 0.82).

The correlations between the self-reported digestive system problems and the masticatory variables are displayed in Table 4. The only reported problem that was associated with chewing was constipation ($r_s = -0.35$).

TABLE 4. Spearman Rank Order Correlations between Self-Reported Digestive System Problems[a] and Masticatory Variables.

Digestive System Problem	Mean (n = 59)	SD	Correlation with Masticatory Performance (n = 59)	Correlation with Bite Force (n = 46)	Correlation with Time of Chewing (n = 56)	Correlation with Number of Strokes (n = 56)
Heartburn	2.1	1.2	-0.16	-0.24	0.24	0.30
Constipation	2.3	1.7	-0.35 *	-0.12	0.25	0.19
Diarrhea	1.7	0.8	-0.05	0.04	0.07	0.11
Stomachaches	1.9	1.2	-0.13	0.03	0.28	0.22
Burping	2.8	1.6	0.08	0.05	0.05	0.05
Gas	2.8	1.5	-0.07	-0.01	0.08	0.05

[a] Scale from 1 to 7 (1 = "Never", 7 = "All the time"). * Significant at $\alpha = 0.01$

DISCUSSION

In this study, we evaluated masticatory function using masticatory performance, bite force, and time of chewing and number of strokes until the subject felt the bolus was ready to swallow. The correlations among some of the four measures of mastication were statistically significant but of moderate magnitude. This suggests that these measures reflected different aspects of masticatory function. We assumed that masticatory performance and bite force had reached stable values five years after surgery, as bite force seems to reach normal values within 2 to 3 years after orthognathic surgery.[17, 18]

The masticatory performance scores for these patients were not very high. A high score, however, does not necessarily imply that the subject will chew properly. The masticatory performance score denotes that the subject has a certain potential to break the food into small particles, but other factors (*e.g.*, habitual chewing pattern) may influence the final result of chewing. Our results showed significant correlations among masticatory performance, time of chewing, and number of strokes. Higher masticatory performance was associated with shorter chewing time and fewer chewing strokes before reaching the swallowing threshold.

In relation to diet quality, the hypothesis that good oral function would be associated with good diet quality could not be sustained. Subjects were eating poorly independent of masticatory function. Although some subjects demonstrated a considerable difference between left and right side masticatory performance, re-analysis of data by best chewing side or preferred chewing side did not reveal an association between chewing ability and diet quality. Only weak associations were found between consumption of foods that require chewing (*e.g.*, fiber, protein, meat, and vegetables) and masticatory performance, bite force, time of chewing and number of strokes. Although these subjects had very poor intake scores for fruit and vegetables, scores for meat and grains were better. Therefore, some chewy foods have been consumed while others have not. Unfortunately, no dietary data were available before surgery to permit a prospective analysis. As no patient had a diet classified as good, our results suggest that competent masticatory function is not sufficient to assure an adequate diet. This finding parallels some rehabilitation study results where insertion of new prostheses improved masticatory performance, but dietary intake did not change.[19, 20]

Overall diet quality was disappointingly low. Three quarters of the subjects had a diet in the Needs Improvement category as specified by the USDA standards, and one quarter had poor diet quality. These patients had a diet quality that was poorer than comparable cohorts analyzed in our facilities. In a study comprising different dentition groups (good dentition, compromised dentition, removable partial dentures, and complete dentures), the HEI means ranged from 68.1 to 70.3,[21] which is approximately ten points above the HEI mean for this sample of orthognathic surgery patients. The patients in this study are dentate and achieved good occlusal conditions after treatment. As the quality of the diet was poor, it may be more closely associated with life-time eating habits than with oral function or occlusal conditions. It should be noted that no nutritional counseling was provided before the collection of the dietary data or at the time of surgery. Individualized dietary counseling was shown to improve fiber intake in elderly women after poor dentures were relined.[22] Moreover, information and knowledge of nutrition play key roles in determining diet quality.[23] Additional studies concerning the influence of nutrition information, education and counseling on diet quality improvement for orthognathic patients would help to clarify this issue.

The impact of masticatory function on digestive symptoms was not clear. Overall, these problems were reported at relatively low levels. Because of the low consumption of fiber from vegetables and fruit, one would expect a higher prevalence of gastrointestinal disorders based on studies with elderly edentulous women.[8, 9] However, constipation was the only symptom experienced by subjects with poor masticatory performance. Burping and gas were reported more often than constipation but were not significantly associated with masticatory variables. Future studies should examine these variables longitudinally and explore the interactions among dietary intake and digestive problems.

In conclusion, this study did not support the hypothesis that good masticatory function is associated with good diet quality or less gastrointestinal problems. Prospective controlled studies are necessary to probe the determinants of diet quality and food consumption before and after orthognathic surgery. As no patient had good diet quality and overall diet quality was independent of masticatory function, individualized nutritional assessment, diet counseling and follow-up should be beneficial for all orthognathic surgery patients.

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CONCLUSÕES GERAIS

Os resultados deste trabalho permitem concluir que:

1. A qualidade de dieta medida pelo índice HEI não foi determinada pelas condições oclusais ou pelo grau de função oral. Nível de escolaridade, renda e percepção de capacidade mastigatória e de conforto na mastigação também não influíram na qualidade de dieta. Fatores demográficos, como idade, sexo e grupo étnico, apresentaram diferenças em qualidade de dieta; contudo, estas diferenças foram de pequena magnitude e podem não ser clinicamente relevantes.

2. Quanto pior as condições oclusais, pior é a eficiência de função oral em termos de performance mastigatória e força de mordida. Em relação a próteses totais, próteses com qualidade técnica adequada permitiram um desempenho funcional superior às próteses com deficiências técnicas em retenção, estabilidade e desgaste de dentes artificiais. Entretanto, não há reflexo na percepção de capacidade mastigatória ou na qualidade de dieta e adequação nutricional.

3. Independentemente das condições oclusais, da qualidade técnica das próteses totais ou do grau de função oral, a maioria dos indivíduos apresentou qualidade de dieta deficiente. Portanto, o cirurgião-dentista deve estar consciente de que o tratamento odontológico por si só não basta para garantir uma qualidade de dieta adequada. A análise de dieta, o aconselhamento nutricional individualizado e o acompanhamento do paciente devem ser considerados para a melhoria da qualidade de dieta durante e

após o tratamento odontológico reabilitador. Isto implica num desafio educacional: a inserção mais ativa da odontologia no cuidado primário de saúde e com participação efetiva em equipes interdisciplinares. Assim, o trabalho em conjunto com outras áreas profissionais pode otimizar os resultados do tratamento odontológico para fornecer atenção integral à saúde.

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ANEXOS

ANEXO 1

Healthy Eating Index (HEI)

(KENNEDY, E.T., OHLS, J., CARLSON, S., FLEMING, K. The Healthy Eating Index: Design and applications. *J Am Diet Assoc*, Chicago, v.95, n.10, p.1103-1108, Oct. 1995.) (Tradução das páginas 1104-1106)

(...)

Estrutura Geral do *Healthy Eating Index*

O HEI tem 10 componentes, os quais são baseados em diferentes aspectos de uma dieta saudável. Para cada componente, os indivíduos receberam escores variando de 0 a 10. Assim, o índice geral tem uma amplitude de 0 a 100. Os componentes são definidos a seguir e descritos mais completamente na TABELA 1. Os componentes de 1 a 5 medem o grau de adequação da dieta de um indivíduo de acordo com as recomendações da *USDA (United States Department of Agriculture) Food Guide Pyramid* para os cinco principais grupos de alimentos: grãos, vegetais, frutas, leite e carne. O componente 6 se baseia no consumo global de gordura como uma porcentagem da ingestão calórica (de energia) alimentar total. O componente 7 é baseado no consumo de gordura saturada como uma porcentagem da ingestão calórica alimentar total. O componente 8 baseia-se na ingestão de colesterol. O componente 9 é baseado na ingestão de sódio. O componente 10 é basedo na quantidade de variedade na dieta do indivíduo.

TABELA 1. Componentes do HEI

Componente	Escore	Critérios para escore 10[a]	Critérios para escore 0
Grupo de alimento			
Grãos	0 - 10	6 – 11 porções [b]	0 porções
Vegetais	0 - 10	3 – 5 porções [b]	0 porções
Frutas	0 - 10	2 – 4 porções [b]	0 porções
Leite	0 - 10	2 – 3 porções [bc]	0 porções
Carne	0 - 10	2 – 3 porções [b]	0 porções
Orientações de Dieta			
Gordura total	0 - 10	30% ou menos de energia a partir de gordura	45% ou mais de energia a partir de gordura
Gordura saturada	0 - 10	Menos de 10% de energia a partir de gordura saturada	15% ou mais a partir de gordura saturada
Colesterol	0 - 10	Menos de 300 mg	Mais de ou igual a 450 mg
Sódio	0 - 10	Menos de 2400 mg	Mais de ou igual a 4800 mg
Variedade	0 - 10	16 tipos diferentes de alimentos num período de 3 dias	6 ou menos alimentos diferentes num período de 3 dias

[a] Pessoas com escores de componentes entre os pontos de corte máximo e mínimo receberam escores proporcionalmente. Por exemplo, se uma pessoa precisava de 8 porções de grãos e consumiu 4, ele/ela teria um escore 5 na categoria grão.

[b] Depende da ingestão de energia recomendada – ver Tabela 2.

[c] O número recomendado de porções no grupo leite é 3 para mulheres gestantes e lactantes e para adolescentes e jovens adultos até 24 anos de idade.

Sistema de Escore para os Componentes 1 a 5

O escore exato que uma pessoa recebe em quaisquer categorias de grupo de alimento é determinado pelo número apropriado de porções para um determinado nível de ingestão calórica (Tabela 2). Por exemplo, a RDA (*Recommended Dietary Allowance*) de energia alimentar para uma mulher de 40 anos de idade é 2200 kcal e o manual da *USDA Food Guide Pyramid* indica que neste nível de energia são recomendadas quatro porções de vegetais por dia. Para uma mulher de 40 anos de idade obter um escore máximo de 10 pontos na categoria vegetais, ela necessita comer quatro porções de vegetais por dia.

TABELA 2. Número de porções diárias recomendadas aos níveis de energia discutidos no manual da *Food Guide Pyramid*.

	Porções				
Energia (kcal)	**Grãos**	**Vegetais**	**Frutas**	**Leite [a]**	**Carne**
1600	6	3	2	2	2
2200	9	4	3	2	2,4
2800	11	5	4	2	2,8

[a] Três porções de leite são necessárias para mulheres gestantes ou lactantes e para adolescentes e jovens adultos até 24 anos de idade.

Anexo 1

Uma pessoa que consome o número recomendado de porções em um dos grupos de alimento receberia um escore 10 para aquele grupo; por outro lado, uma pessoa que não consumisse nenhuma porção de um grupo de alimento receberia escore 0. Entre 0 e 10, o escore é calculado proporcionalmente; por exemplo, uma pessoa que consumiu três porções da categoria grãos mas precisava de seis porções, receberia um escore 5. Se quatro porções fossem consumidas, o escore seria 6,6. As quantidades das porções de alimentos foram calculadas a partir dos dados de consumo alimentar usando fatores derivados dos pressupostos de tamanho de porções na *Food Guide Pyramid.* O método para determinar o tamanho de porções de alimentos específicos é discutido mais adiante neste artigo.

As recomendações publicadas de porções de alimentos são para níveis de energia entre 1600 e 2800 kcal. O manual da *USDA Food Guide Pyramid* afirma que crianças pré-escolares necessitam a mesma variedade de alimentos que os familiares mais velhos, mas podem precisar de menos de 1600 kcal. Assim, para crianças com RDAs de energia alimentar abaixo de 1600 kcal, o número mínimo de porções foi mantido (*e.g.*, 6 para o grupo de grãos) mas os tamanhos das porções foram diminuídos proporcionalmente de acordo com a RDA para energia.

Um caso semelhante surgiu na extremidade alta da distribuição de energia. Para homens de 15 anos ou mais que têm uma necessidade energética maior que 2800 kcal, o número de porções de alimentos foi truncado no máximo especificado na *Food Guide Pyramid* sem ajustar o tamanho das porções. O texto da *Food Guide Pyramid* não fornece orientação sobre o número de porções ou o tamanho de porções para acomodar níveis de energia superiores a 2800 kcal. Ao invés de exceder o tamanho recomendado de porções, nós decidimos que o número de porções de alimentos seria truncado na quantidade máxima mostrada na *Food Guide Pyramid*. Da mesma forma, o tamanho de porção para grupos específicos de alimentos não foram aumentados. Nenhum dos resultados aqui relatados para o HEI seria afetado significativamente usando-se a especificação alternativa de aumentar o tamanho das porções proporcionalmente ao requerimento de energia.

O cálculo dos escores para os grupos de alimentos seguiu um procedimento semelhante. As porções reais foram comparadas com as porções recomendadas de acordo com a *Food Guide Pyramid*. Entretanto, um fator adicional envolvendo legumes foi considerado. A *Food Guide Pyramid* contabiliza os legumes como carne ou vegetal. No cálculo do HEI, os legumes foram designados para o grupo carne até o ponto necessário para alcançar o escore máximo para a categoria carne; qualquer legume adicional além daquele ponto foi designado para o grupo vegetal. A única exceção foi a de produtos de soja, os quais são geralmente usados como substitutos de carne e, portanto, foram sempre designados para o grupo carne.

Em cada grupo, quando o número ótimo de porções foi alcançado, nenhum crédito extra foi dado para porções adicionais, nem foram deduzidos pontos por estar além de certo número de porções.

Sistema de Escore para os Componentes 6 a 10

Os componentes de 6 a 10 foram avaliados diferentemente. Para o componente 6, um escore 10 foi dado se a ingestão total de gordura de um indivíduo, como uma proporção do consumo de energia, fosse 30% ou menos. O escore diminuiu para 0 quando esta proporção alcançou 45%. Entre estes dois pontos, os escores diminuíram proporcionalmente.

O escore para gordura saturada (componente 7) foi calculado de forma análoga ao da gordura total. Um escore máximo foi alcançado quando a ingestão de gordura saturada total foi menor que 10% da ingestão calórica, e o escore foi 0 quando a razão foi 15% ou mais.

Os escores para colesterol e sódio foram baseados em miligramas consumidos. Os pontos de corte para um escore perfeito 10 foram determinados a 300 mg para colesterol e 2400 mg para sódio. Os correspondentes pontos de corte 0 foram 450 mg para colesterol e 4800 mg para sódio, respectivamente. Pesquisas anteriores forneceram pouca orientação sobre como os limites para um escore 0 para gordura total, gordura saturada, colesterol e sódio deveriam ser determinados. Os limites superiores para determinar o escore 0 foram baseados em consultoria a pesquisadores em Nutrição e análise das distribuições de consumo destes componentes usando dados dos levantamentos *Continuing Survey of Food Intake by Individuals* (CSFII) de 1989 e 1990.

A *USDA Food Guide Pyramid* assim como o relatório de dieta e saúde da *National Academy of Science* enfatizam a importância da variedade na dieta. Apesar da concordância geral de que variedade na dieta é importante, é surpreendente o pequeno número de estudos que quantificaram variedade como parte de um índice de dieta. Para analisar a variedade na dieta, o HEI contou o número total de diferentes alimentos ingeridos por uma pessoa e que contribuiu substancialmente para preencher um ou mais requisitos para os cinco grupos de alimento. Os alimentos foram contados somente se fossem consumidos em quantidades suficientes para contribuir ao menos com metade de uma porção em quaisquer dos grupos de alimento. Itens de alimentos idênticos ingeridos em ocasiões diferentes foram agregados antes de se considerar o ponto de corte de meia-porção. Por exemplo, se uma pessoa tomou um terço de porção de leite no café-da-manhã e outro um terço de porção no almoço, o leite seria contado para o índice de variedade, porque a soma das porções de leite excedeu o padrão mínimo de meia-porção.

Alimentos que são similares, tais como dois tipos diferentes de batata ou duas formas diferentes de pão branco, foram contados apenas uma vez na categoria variedade. Misturas foram divididas em suas partes constituintes de forma que um item único pudesse contribuir para dois ou mais pontos para o índice de variedade. Por exemplo, lasanha poderia contribuir para ambos os grupos grãos e carne.

Na categoria variedade, foi concedido um escore 10 a uma pessoa se 16 ou mais diferentes alimentos foram consumidos em um período de estudo de 3 dias. Um escore 0 foi dado se 6 ou menos diferentes alimentos foram ingeridos no período de 3 dias. Havia pouca orientação para sugerir os limites superior e inferior para analisar variedade; portanto, também aqui os limites para variedade foram derivados do estudo de dados de consumo e da consultoria a pesquisadores.

Determinação do Tamanho de Porção

Os métodos para determinar os tamanhos de porções e designar misturas para grupos individuais de alimento foram críticos para o desenvolvimento do HEI. Os tamanhos de porções para itens nos cinco grupos de alimento (categorias 1 a 5) foram baseados nas quantidades de porção especificadas pelo manual da *USDA Food Guide Pyramid*. Por exemplo, uma fatia de pão, meia xícara de pasta cozida, uma maçã média inteira, uma xícara de leite e 2,5 oz de carne magra foram todos descritos como uma porção única. Para estes e alimentos similares, as quantidades correspondentes de tamanho de porção foram usadas no cálculo do HEI.

A base de dados USDA de nutrientes tem atualmente mais de 4000 diferentes alimentos codificados por um sistema de sete dígitos. Nossa abordagem geral na determinação de tamanho de porção para o cálculo dos escores do HEI objetivou alcançar consistência entre os vários alimentos em um grupo através do foco na quantidade de elementos-chave. Assim, porções de pães e baguetes foram determinados de acordo com uma abordagem de "equivalência em farinha". De acordo com a informação dos arquivos de receitas USDA usados no desenvolvimento da base de dados de nutrição para a CSFII, o pão mais comumente consumido (pão branco) pesa 26 g por fatia média e contém 15,2 g de farinha por fatia. Portanto, a *Food Guide Pyramid* designa uma fatia de pão como uma porção, e qualquer outra forma de pão foi convertida para porções com base no número de gramas de farinha que ele contém.

Uma abordagem similar foi usado para pasta. Conversões em grama das porções de pasta da *Food Guide Pyramid* foram baseadas na quantidade de grãos em meia xícara de pasta de trigo, 25 g. Este fator 25 g foi determinado a partir da mesma fonte USDA citada, com base na quantidade média de grão em vários tipos diferentes de pasta de trigo, incluindo macarrão, lasanha, ziti, rotini, conchas, espaguete, lingüini e outros tipos de pasta.

Os mesmos procedimentos foram usados para outros grupos de alimento. Alimentos foram convertidos em seus equivalentes vegetal, fruta, e assim por diante, com base no padrão de tamanho de porção especificado para um determinado grupo de alimento.

(...)

ANEXO 2

Dietary Guidelines for Americans, 2000

As "Dietary Guidelines for Americans" são recomendações desenvolvidas pelo Departamento de Agricultura (U.S. Department of Agriculture Center for Nutrition Policy and Promotion) e pelo Departamento de Saúde e Serviços Humanos dos Estados Unidos. São recomendações de dieta geral e de atividades físicas para orientar a população, crianças a partir de dois anos e adultos de todas as idades, a alcançar e manter um padrão de alimentação saudável e boa saúde geral. As "Dietary Guidelines" são atualizadas a cada cinco anos e incluem aconselhamento sobre escolha de alimentos que promovam saúde e diminuam risco de doenças crônicas, tais como doenças cardíacas, certos tipos de câncer, diabetes e osteoporose.

As "Dietary Guidelines for Americans, 2000" englobam dez recomendações gerais, as quais são divididas em três grupos temáticos:

1. Tenha como meta a boa forma ("Aim for fitness")

2. Construa uma base saudável ("Buid a healthy base")

3. Escolha com sensatez ("Choose sensibly")

Anexo 2

1. **Tenha como Meta a Boa Forma**

    a. Tenha como meta um peso saudável

    b. Seja fisicamente ativo diariamente

2. **Construa uma Base Saudável**

    a. Deixe que a Pirâmide guie suas escolhas de alimentos

    b. Escolha uma variedade de grãos diariamente, principalmente grãos integrais

    c. Escolha uma variedade de frutas e vegetais diariamente

    d. Mantenha o alimento seguro para ser ingerido

3. **Escolha com Sensatez**

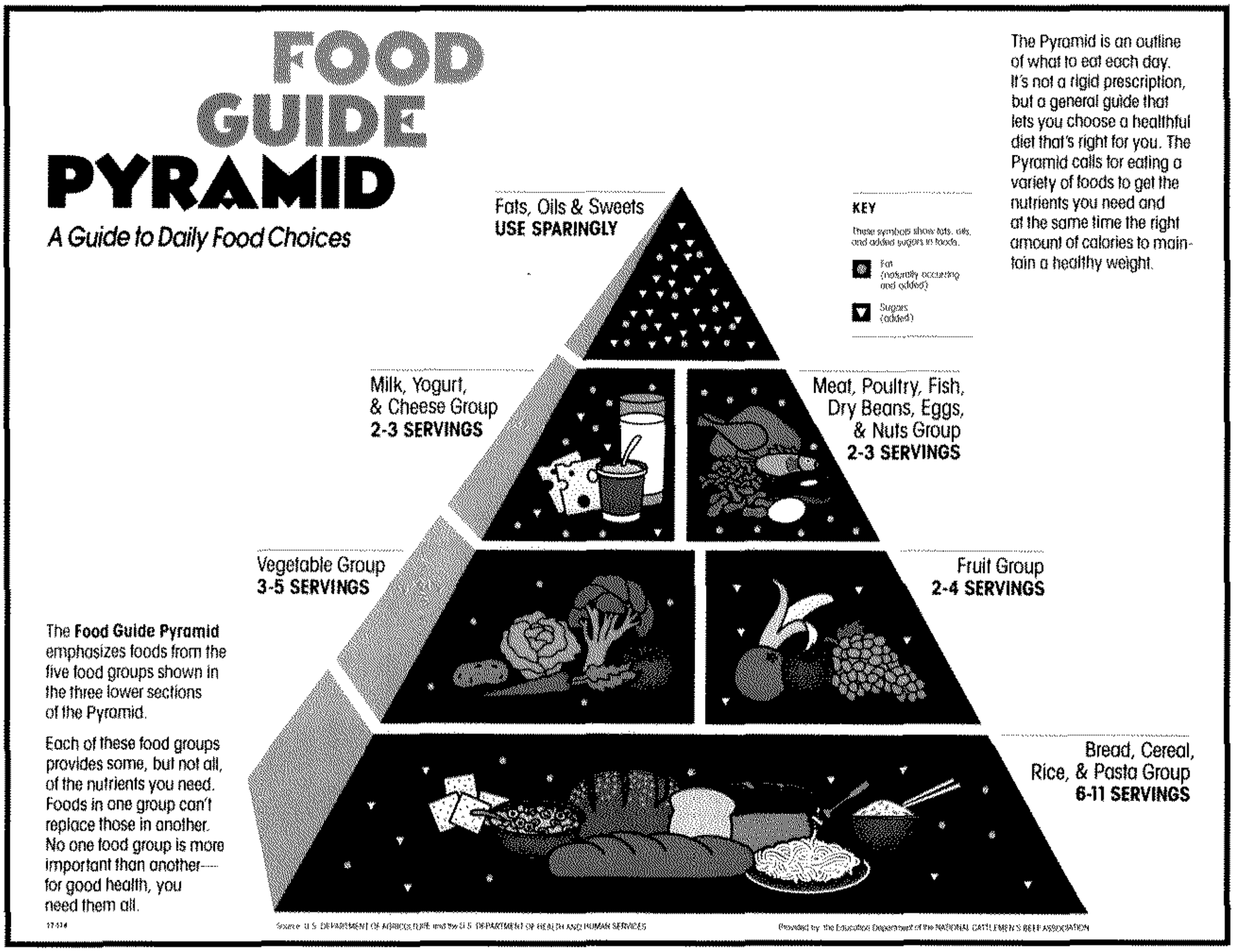
    a. Escolha uma dieta que tenha baixa quantidade de gordura saturada e colesterol e moderada quantidade de gordura total

    b. Escolha bebidas e alimentos para moderar a ingestão de açúcares

    c. Escolha e prepare alimentos com menos sal

    d. Se você ingerir bebidas alcoólicas, faça-o com moderação

USDA Food Guide Pyramid



ANEXO 3

Oral Function and Diet Quality in a Community-Based Sample

TABLE 4. Dietary variables (mean and standard deviation) according to dentition status groups and for the overall sample.

	Good Dentition (n=369)	Comprom. Dentition (n=143)	Partial Denture (n=157)	Complete Denture (n=41)	*p*-value *	Overall sample (n=731)
Healthy Eating Index (HEI)	70.34 (11.39)	69.17 (10.91)	68.07 (13.04)	68.07 (13.03)	0.0527	70.32 (11.44)
Grains (HEI score)	6.36 (2.15)	6.65 (2.16)	6.53 (2.17)	6.27 (2.27)	0.4900	6.48 (2.16)
Vegetables (HEI score)	5.93 (2.80)	5.29 (2.61)	5.54 (2.25)	5.17 (2.78)	0.0768	5.66 (2.79)
Fruit (HEI score)	5.49 (3.60)	4.73 (3.67)	6.27 (3.44)	5.10 (3.30)	0.0022	5.48 (3.58)
Milk (HEI score)	4.16 (3.79)	3.59 (3.70)	4.08 (3.77)	4.54 (3.76)	0.2707	4.04 (3.77)
Meat (HEI score)	7.77 (2.46)	7.76 (2.51)	8.00 (2.12)	8.20 (2.35)	0.7342	7.88 (2.38)
Total fat (HEI score)	7.37 (3.04)	7.80 (2.75)	7.87 (2.76)	6.88 (3.50)	0.2249	7.52 (2.96)
Saturated fat (HEI score)	7.67 (3.30)	7.92 (3.19)	7.87 (3.16)	6.32 (3.68)	0.0513	7.66 (3.29)
Total cholesterol (HEI score)	8.27 (3.41)	7.96 (3.49)	8.25 (3.34)	8.54 (2.51)	0.6215	8.18 (3.41)
Sodium (HEI score)	7.66 (2.89)	8.01 (2.63)	8.26 (2.68)	7.95 (2.29)	0.0193	7.88 (2.76)
Variety (HEI score)	9.68 (0.98)	9.45 (1.14)	9.44 (1.20)	9.12 (1.71)	0.0044	9.56 (1.11)

Anexo 3

Energy (kcal)	1848.02 (483.58)	1832.60 (470.20)	1732.71 (463.22)	1635.29 (368.99)	0.0032	1810.85 (472.94)
Vitamin A (RE)	1245.04 (1032.87)	971.51 (800.90)	1220.07 (1049.54)	1018.56 (1122.72)	0.0020	1183.05 (1052.19)
Vitamin C (mg)	122.98 (84.44)	99.47 (70.15)	119.24 (81.35)	76.24 (59.46)	0.0000	114.24 (80.47)
Iron (mg)	17.40 (13.40)	16.54 (13.30)	17.06 (13.76)	17.51 (16.86)	0.3348	17.24 (13.76)
Sugar (g)	66.21 (40.49)	66.19 (44.96)	67.93 (42.79)	54.05 (25.87)	0.3384	65.52 (41.29)
Folate (µg)	275.77 (147.61)	267.82 (137.55)	287.03 (175.25)	254.63 (138.48)	0.7812	275.99 (150.67)
Protein (g)	76.10 (22.96)	76.00 (22.34)	73.70 (23.39)	66.88 (18.29)	0.0664	75.44 (23.01)
Fiber (g)	13.94 (7.28)	12.20 (7.19)	13.43 (7.57)	13.67 (7.06)	0.0470	13.45 (7.32)

* Kruskal-Wallis One-Way Analysis of Variance comparing the four dentition status groups (n = 710).

ANEXO 4

Dietary Intake in Edentulous Subjects with Good and Poor Quality Complete Dentures

Table 4. Median (standard deviation) daily dietary intake for complete denture subjects by quality of dentures categories and for the overall sample.

Dietary variables	*Quality of Dentures*			*Overall Sample*
	Good (n = 18)	**Medium (n = 11)**	**Poor (n = 25)**	**(n = 54)**
HEI variables				
Healthy Eating Index (HEI)	60.5 (11.2)	70.0 (14.3)	72.0 (13.3)	69.5 (13.0)
Grains (HEI score)	5.0 (2.2)	7.0 (2.1)	6.0 (2.4)	6.0 (2.3)
Vegetables (HEI score)	5.0 (2.9)	5.0 (3.6)	5.0 (2.6)	5.0 (2.9)
Fruit (HEI score)	5.5 (3.6)	5.0 (2.8)	5.0 (3.0)	5.0 (3.1)
Milk (HEI score) *	1.0 (2.7)	8.0 (3.8)	4.0 (3.6)	2.0 (3.7)
Meat (HEI score)	9.0 (1.7)	10.0 (2.4)	10.0 (2.7)	9.0 (2.3)
Total fat (HEI score)	7.0 (3.0)	8.0 (3.6)	9.0 (3.7)	7.5 (3.4)
Saturated fat (HEI score)	6.0 (3.6)	8.0 (3.9)	9.0 (3.7)	7.5 (3.7)
Total cholesterol (HEI score)	9.5 (3.9)	10.0 (2.5)	10.0 (2.9)	10.0 (3.2)
Sodium (HEI score)	9.0 (1.7)	7.0 (2.9)	9.0 (1.9)	9.0 (2.1)
Variety (HEI score)	10.0 (2.2)	10.0 (1.3)	10.0 (1.8)	10.0 (1.8)

<u>*Anexo 4*</u>

Selected nutrients and non-nutrients				
Energy (kcal)	1672.0 (335.1)	1482.0 (591.3)	1612.0 (185.0)	1610.5 (345.2)
Fat (g)	63.9 (17.6)	44.9 (30.5)	63.2 (20.5)	62.9 (21.6)
Saturated fat (g)	20.3 (6.4)	16.9 (11.7)	20.5 (6.7)	19.9 (7.7)
Monounsaturated fat (g)	20.3 (7.2)	16.0 (10.3)	20.4 (7.7)	20.3 (8.0)
Polyunsaturated fat (g)	10.9 (4.2)	8.3 (5.5)	11.2 (5.5)	10.7 (5.0)
Cholesterol (g)	186.0 (49.0)	173.7 (77.7)	227.6 (50.2)	199.2 (56.7)
Cholesterol (mg)	316.9 (190.6)	204.1 (103.6)	197.1 (146.0)	207.3 (157.0)
Vitamin A (RE)	525.2 (1056.2)	945.2 (666.0)	696.5 (1226.7)	664.1 (1068.4)
Vitamin B1 (mg)	1.1 (0.5)	1.1 (0.6)	1.3 (0.5)	1.2 (0.5)
Vitamin B2 (mg)	1.4 (0.6)	1.6 (0.9)	1.6 (0.6)	1.5 (0.6)
B3 (mg)	16.3 (5.9)	17.6 (6.5)	17.3 (7.5)	17.4 (6.7)
B6 (mg)	1.3 (0.4)	1.1 (0.9)	1.5 (0.8)	1.3 (0.7)
Vitamin B12 (µg)	3.2 (7.7)	2.7 (3.0)	3.4 (5.7)	3.2 (6.0)
Vitamin C (mg)	58.6 (60.0)	61.7 (88.5)	63.7 (49.1)	61.5 (61.2)
Vitamin D (µg)	1.6 (1.4)	3.3 (3.3)	2.6 (1.5)	2.4 (2.1)
Vitamin E (mg)	5.1 (3.6)	5.1 (9.1)	5.4 (6.7)	5.3 (6.4)
Alpha Tocopherol (mg)	4.2 (1.9)	3.4 (2.4)	4.7 (5.0)	4.5 (3.9)
Beta carotene (µg)	67.2 (129.0)	112.5 (387.2)	105.6 (657.9)	100.0 (495.2)
Folate (µg)	234.7 (91.7)	147.2 (147.8)	248.6 (157.5)	228.9 (139.6)
Calcium (mg)	538.7 (172.7)	790.2 (318.3)	611.7 (229.7)	604.9 (241.5)
Iron (mg)	13.1 (4.0)	12.1 (11.3)	12.1 (20.4)	12.6 (15.0)
Magnesium (mg)	230.4 (63.5)	186.1 (100.2)	249.9 (75.7)	230.4 (78.8)
Phosphorus (mg)	965.9 (235.5)	917.5 (491.2)	1004.0 (251.9)	985.7 (306.5)
Potassium (mg)	2224.0 (520.2)	2033.0 (967.5)	2579.0 (716.6)	2253.0 (721.5)

Sodium (mg)	2564.0 (976.9)	3070.0 (1072.8)	2679.0 (963.3)	2728.0 (977.5)
Zinc (mg)	9.0 (3.0)	6.0 (6.0)	8.5 (3.4)	8.5 (3.9)
Sugar (g)	48.3 (29.5)	49.6 (29.5)	56.6 (25.6)	49.5 (27.4)
Fructose (g)	11.3 (11.1)	10.7 (6.9)	10.3 (11.4)	10.9 (10.4)
Galactose (g)	0.0 (0.0)	0.0 (0.4)	0.0 (0.0)	0.0 (0.2)
Glucose (g)	10.2 (11.8)	9.8 (7.4)	8.7 (10.7)	10.0 (10.4)
Lactose (g) *	5.2 (4.1)	10.7 (8.3)	6.2 (6.9)	6.1 (6.8)
Sucrose (g)	10.1 (11.7)	11.6 (7.6)	13.1 (11.5)	11.7 (10.8)
Alcohol (g)	0.0 (7.9)	0.0 (0.0)	0.0 (13.1)	0.0 (10.0)
Caffeine (mg) *	207.3 (133.9)	154.6 (102.6)	114.8 (167.7)	152.8 (146.8)
Fiber (g)	10.0 (5.8)	10.3 (6.8)	13.3 (7.2)	10.7 (6.9)
Protein (g)	60.7 (16.2)	62.5 (23.9)	65.7 (15.6)	64.5 (17.4)
Cholesterol (percent)	47.5 (7.3)	53.0 (7.7)	51.0 (10.3)	49.5 (8.9)
Fat (percent)	35.5 (5.4)	29.0 (7.8)	32.0 (10.6)	33.0 (8.6)
Protein (percent)	17.0 (3.3)	18.0 (3.2)	16.0 (3.8)	17.0 (3.5)
Sugar (percent)	16.4 (8.8)	18.9 (6.2)	20.1 (7.7)	18.4 (7.7)

All comparisons among the three categories of quality of dentures were not statistically significant at $\alpha = 0.01$.
Some dietary variables were significant at $\alpha = 0.05$ (*).

APÊNDICES

Determinants of Masticatory Performance in Dentate Adults

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ABSTRACT

Masticatory performance results from a complex interplay of direct and indirect effects, yet most studies employ univariate models. This study tested a multivariate model of masticatory performance for dentate subjects. Explanatory variables included number of functional tooth units, bite force, sex, age, masseter cross-sectional area, TMD, and presence of *diabetes mellitus*. The population-based sample consisted of 631 dentate subjects aged 37 to 80 years. Covariance structure analysis showed that 68% of the variability in masticatory performance could be explained by the combined effects of the explanatory variables. Age and sex did not show a strong effect on masticatory performance, either directly or indirectly through masseter cross-sectional area, TMD, and bite force. Number of functional tooth units and bite force were confirmed as the key determinants of masticatory performance, which suggests that their maintenance may be of major importance for promoting healthful functional status.

Key words: mastication, masticatory performance, dentate, structural equation modeling.

INTRODUCTION

Factors believed to affect masticatory performance include loss and restoration of postcanine teeth (Helkimo et al., 1978; Akeel et al., 1992; Van der Bilt et al., 1993; Van der Bilt et al., 1994; Yamashita et al., 2000), bite force (Wilding, 1993; Boretti et al., 1995; Fontijn-Tekamp et al., 2000), severity of malocclusion (Omar et al., 1987), tactile sensitivity

(Kapur et al., 1990), occlusal contact area and body size (Julien et al., 1996), and oral motor function (Koshino et al., 1997). With a few exceptions, the factors affecting mastication have been studied one at a time in a piecemeal fashion. This approach may provide only limited insight regarding the complex interplay of factors that jointly determine masticatory performance. While not every potentially relevant variable can be studied in any single investigation, key sets of variables can be identified and studied within a multivariate research design.

The purpose of this study was to focus on two key variables thought to be implicated in the aging-related loss of masticatory performance in adults – loss of postcanine functional tooth units and loss of bite force. Both variables were selected as main factors because they represent local measures of occlusion and oral strength, which have been consistently shown to influence chewing. Previous studies demonstrate that age *per se* is not necessarily associated with a loss of masticatory performance (Wayler & Chauncey, 1983; Carlsson, 1984; Fontijn-Tekamp et al., 2000). Therefore, it is necessary to look to other factors that may be linked to the aging process. We hypothesized that age-related local or systemic diseases, which lead to loss of tooth structure, masticatory muscle pathology, or pain, are largely responsible for age-related decline of masticatory function. In this study, signs and symptoms of temporomandibular disorders (TMD) represented a local disease process, and a diagnosis of *diabetes mellitus* represented a systemic disease process.

To test this hypothesis a cross-sectional, population-based study was conducted. A theoretical multivariate model of masticatory performance was constructed and tested using a statistical modeling procedure known as covariance structure modeling, linear structural equation modeling, or causal modeling (Blaylock, 1971). The name causal modeling does not imply that causal pathways are being proven. Rather the researcher develops *a priori* an explicit model based on hypothesized causal pathways. Data are then collected and analyzed to determine how consistent they are with the model.

MATERIALS AND METHODS

Subjects

Subjects were 283 men and 348 women, Mexican-American and European-American, between the ages of 37 and 80 years (mean = 58.5, sd = 11.1), who were participants in the Oral Health: San Antonio Longitudinal Study on Aging (OH:SALSA), conducted in San Antonio, Texas, from 1994 to 1998. OH:SALSA participants were selected by a stratified random selection procedure that sampled three socio-economically distinct neighborhoods in San Antonio, Texas: a low income "barrio" neighborhood, a middle income "transitional" neighborhood, and an upper income "suburban" neighborhood. Socio-demographic and medical-dental characteristics are displayed in Tables 1 and 2, respectively. Exclusion criteria comprised pregnancy, impossibility of classification as Mexican-American or European-American, and presence of any removable full or partial denture. Subjects were selected without regard to their dental treatment status.

TABLE 1. Socio-demographic characteristics of subjects (n = 631).

Socio-demographic Characteristic	*Count*	*Percent*
Sex		
Female	348	55.2
Male	283	44.8
Ethnic Group		
Mexican-American	368	58.3
European-American	263	41.7
Neighborhood		
Barrio	157	24.9
Transitional	222	35.2
Suburban	252	39.9

TABLE 2. Medical-dental characteristics of subjects (n = 631).

Medical-dental characteristic	Mean	SD
Functional tooth units (count)	8.37	3.76
Bilateral bite force (newtons)	583.49	281.11
Masticatory Performance (percent)	59.46	24.98
Craniomandibular Index score	0.064	0.082
Masseter cross-sectional area (cm^2) (n=216)	4.6	1.5
Age (years)	58.5	11.1
Diabetes mellitus	**Count**	**Percent**
Diabetic	128	20.4
Non-diabetic	501	79.6

Procedures

Data were collected during a medical and dental examination, which included a comprehensive dental and periodontal assessment, evaluation of masticatory performance, TMJ exam, and registration of bite force, number of functional tooth units, and masseter cross-sectional area. In addition, a complete review of medical history, medications, and physical and functional assessments were accomplished. All subjects gave written informed consent for their participation, and the protocol was approved by the University's Institutional Review Board.

Masticatory Performance. The modified Mastication Performance Index was adopted (Manly & Braley, 1950; Yurkstas & Manly, 1950). This index quantifies the percentage by weight of a masticated test food bolus that will pass through a standard screen sieve after a set number of masticatory strokes. Peanuts served as the test food for unilateral chewing, with three 20-stroke trials per side. The mean of the six trials administered by a calibrated examiner composed the bilateral Mastication Performance Index score. The inter-rater reliability of the masticatory performance test assessed using the intra-class correlation coefficient was equal to 0.78. This sieving method has been used for many years by different research groups and is particularly suitable for large samples studies (Demers et al., 1996; Kapur et al., 1997; Garrett et al., 1998; Krall et al., 1998).

Temporomandibular Joint Disorders (TMD). The number and severity of signs and symptoms of TMD were assessed using the Craniomandibular Index (CMI) administered by a calibrated examiner with the subject seated in a dental chair (Fricton & Schiffman, 1986; 1987). The overall aggregate CMI score was used.

Bite Force. Bilateral maximum bite force was measured using a cross-arch force transducer (Sensotec 13/2445-02, Columbus, OH) placed in the region of the first molar. Vertical jaw opening at the point of bite pad insertion was 14 mm. Force was digitized using an analog-to-digital converter, registered in pounds, and converted to newtons. The procedures were explained to subjects, and they then were allowed several test bites on the bite element in order to build confidence in its stability. The mean of the three highest trials of ten recordings was recorded as the maximum bite force. Except for the use of a bilateral bite element the procedures were similar to those used in previous studies (Van Spronsen et al., 1989; Bakke et al., 1990).

Functional Tooth Units. Functional tooth units were defined as pairs of occluding natural, restored or fixed prosthetic postcanine teeth (molars = two units; bicuspids = one unit).

Diabetes mellitus. Classification into the diabetic or non-diabetic group was according to the American Diabetes Association criteria (American Diabetes Association, 1999) or occasionally according to self-reported diabetic status.

Masseter Muscle Cross-Sectional Area. Masseter cross-sectional area was measured indirectly using high frequency ultrasound (Bakke et al., 1992; Alanen et al., 1994). Real-time imaging of the masseter muscles was performed bilaterally using a fingertip probe connected to an ultrasound scanner (Advanced Technology Laboratories, HDI 3000). Three recordings on each side were performed, with the subjects in an upright position and gently biting on a custom-made occlusal plane. Measurements of masseter cross-sectional area were made using the scanner's electronic cursors by tracing the muscle outline on the screen. Areas of both sides were computed for each subject and averaged.

Data Analysis. Analysis used the Reticular Action Model (McArdle & McDonald, 1984) as implemented in Systat 8.0 (SPSS, Inc, Chicago, IL). The outcome variable was masticatory performance. Explanatory variables included bilateral bite force, number of functional tooth units, sex (dummy coded 1 = Male; 2 = Female), age, CMI score, and *diabetes mellitus* (dummy coded 0 = not diabetic; 1 = diabetic). The CMI score was square root transformed to more closely approximate normality.

The hypothesized model is depicted in Figure 1. Variables represented by rectangles were considered manifest, *i.e.*, they were assumed to be directly observable and measurable. The latent or unobservable variables represent residual unexplained variance and measurement error (represented by circles in Figures 1 and 2). Input data were in the form of a Pearson correlation matrix estimated using a maximum likelihood expectation maximization procedure. The variances of all latent variables were fixed at a value of 1.0. Goodness of fit between the model and the data was assessed using the Steigler-Lind root mean square error of approximation statistic, a measure of significance that is adjusted for model complexity.

RESULTS

The matrix of bivariate correlations among the input variables is displayed in Table 3. Bartlett's statistic ($X^2 = 1102.4$, $p < 0.001$) indicated that the variables were globally associated. Results of the primary analysis are displayed in Figure 1. Only direct path coefficients are shown next to arrows. Indirect effects can be calculated by multiplying component path coefficients, and total effects by summing direct and indirect effects. We hypothesized direct causal pathways from functional tooth units, age, and bite force to masticatory performance. We predicted that the effect of age would be small relative to the effects of functional tooth units and bite force. We further hypothesized that the impact, if any, of diabetes on masticatory performance would be exerted through its effect on functional tooth units, and that the effects of TMD on masticatory performance would be exerted through its effect on bite force. Standardized estimates of path coefficients are displayed adjacent to arrows representing pathways. The multiple R^2 for each structural equation is displayed above the upper right-hand corner of rectangles representing endogenous variables. The double-headed curved arrows connecting diabetes with age and diabetes with sex represent unanalyzed relationships. The Steiger-Lind statistic was equal to 0.030 (90% confidence interval 0.000, 0.060), indicating an excellent fit between the model and the data. The R^2 value of 0.71 (Figure 1) demonstrates that the model accounts for a 71% of the variance observed in masticatory performance. The coefficient representing unexplained residual variance in masticatory performance (represented by the circle labeled U in Figures 1 and 2) demonstrates that variables not represented in the model remain to be identified. The residual variances associated with bite force, TMD, and functional tooth units (represented by circles labeled W, X, and Y, respectively) are relatively large because only a small number of their determinants were included in the model. Explanation of more of the variance in these variables would not necessarily yield a more complete explanation of masticatory performance.

As predicted, the direct effect of age on masticatory performance was slight. The direct effects of age on functional tooth units and bite force also were relatively small. In contrast, the direct effects of the identified key variables, *i.e.*, post-canine functional tooth units and bite force, were much larger. Bite force, in turn, was shown to be influenced primarily by sex and number of functional tooth units. The representative local disease process, TMD, appeared to exert only a small influence on bite force. The representative systemic disease, *diabetes mellitus*, did show the predicted influence on the number of remaining functional tooth units. In summary, the primary analysis demonstrated that the data were highly consistent with the hypothesized causal model.

The effects of masseter cross-sectional area were assessed by adding this variable to the model and testing on a sub-sample of 216 subjects for whom muscle scanning data were available. The path diagram corresponding to this modified sub-model is shown in Figure 2. This model yielded a Steiger-Lind statistic equal to 0.041 (90% confidence interval 0.000, 0.093), once again indicating a very good fit of the data to the model. The R^2 value of 0.68 (Figure 2) demonstrates that the modified model accounts for a 68% of the variance observed in masticatory performance.

As can be seen from Figure 2, the path coefficient corresponding to the pathway from diabetes to muscle cross-sectional area was very small and statistically not significant. In this sample, age and sex were stronger determinants of muscle cross-sectional area than was diabetes. The coefficient linking muscle cross-sectional area to bite force was statistically significant.

TABLE 3. Correlation Coefficients Among Variables Used in the Model (n = 631)†

	1	2	3	4	5	6	7
1. TMD							
2. Sex	.29***						
3. Functional Tooth Units	-.01	.01					
4. Age	.02	.02	-.22***				
5. Bite Force	-.24***	-.48***	.45***	-.27***			
6. Diabetes	-.12**	-.08*	-.27***	.13**	-.06		
7. Masticatory Performance	-.06	-.08	.82***	-.19***	.55***	-.19***	
8. Masseter Cross-Sectional Area†	-.13	-.25***	.15*	-.22***	.41***	-.04	.25***

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p<0.001$

†Sample size for correlations involving masseter cross-sectional area is 216, and displayed p-values are correct for this sample size.

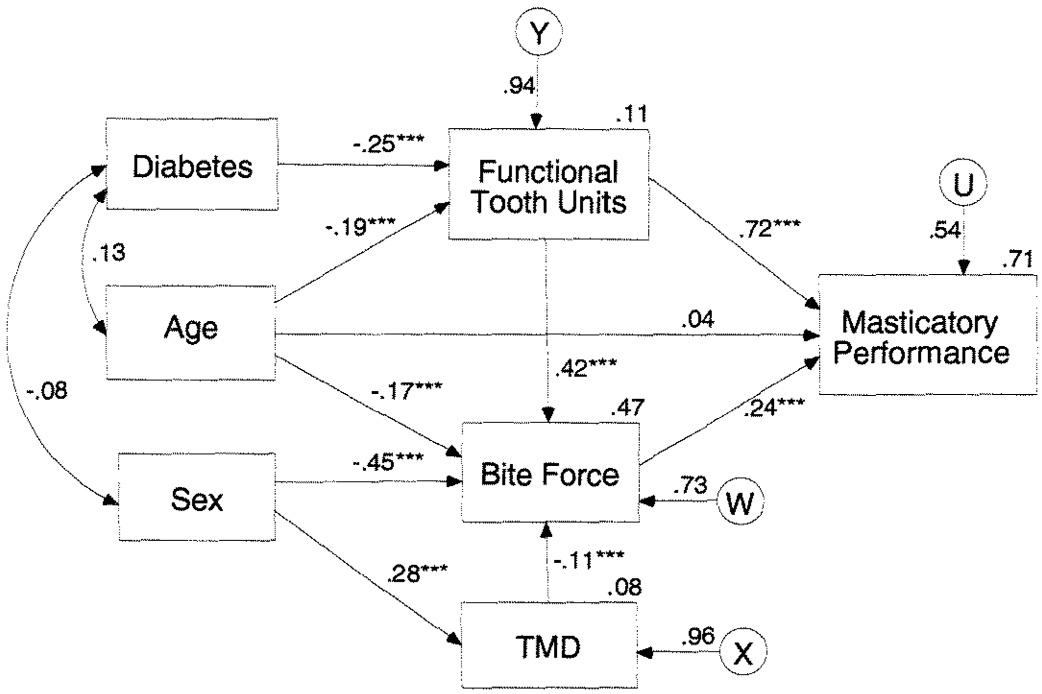

FIGURE 1. Path diagram depicting the covariance structure model of masticatory performance (sample size n = 631). Rectangles represent manifest (measured) variables. Circles (labeled W, U, X, Y, and Z) represent latent (unobservable) variables, *i.e.*, measurement error. Single-headed arrows represent proposed causal pathways. Double-headed curved arrows represent unanalyzed relationships. Numbers adjacent to arrows are standardized path coefficients. Numbers immediately above the upper right-hand corner of rectangles represent the R^2 associated with each structural equation. Variables on the left are assumed to be causally prior to those on the right. Indirect effects are computed by multiplying component path coefficients. Total effects are calculated by summing direct and indirect effects. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p<0.001$

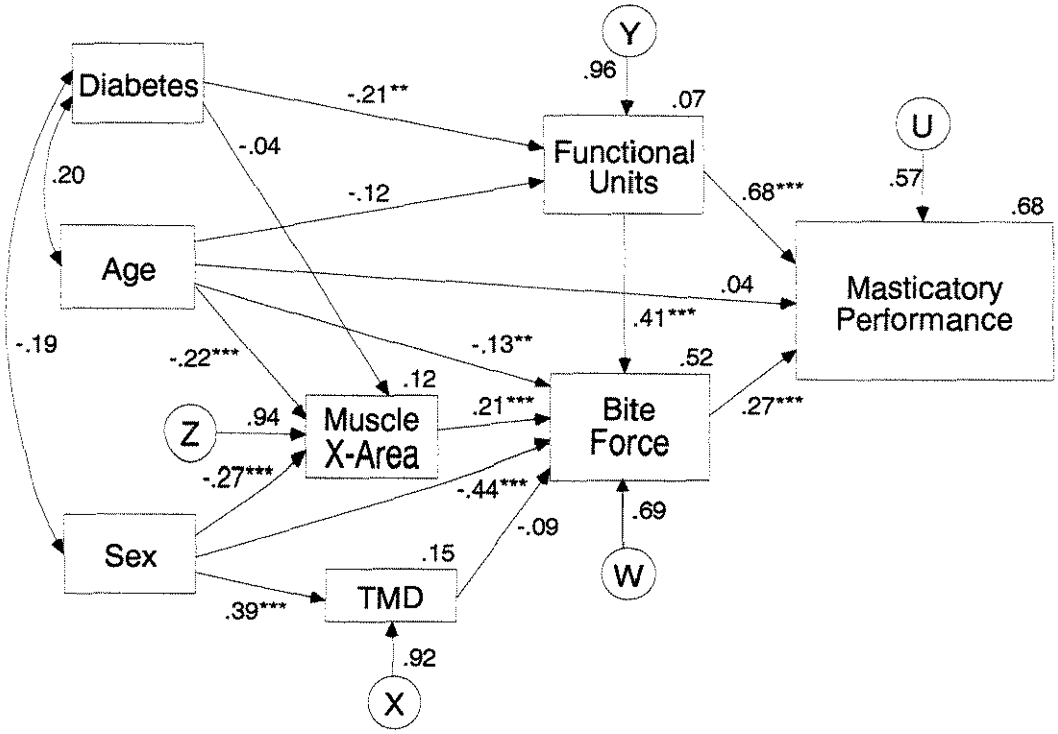

FIGURE 2. Path diagram depicting the covariance structure model of masticatory performance involving masseter cross-sectional area (sample size n = 216). *p < 0.05; **p < 0.01; ***p<0.001

DISCUSSION

A conceptual model of mastication for dentate subjects was constructed with causal assumptions based on existing literature, and tested in a large, stratified random sample derived from the San Antonio, Texas population. This study supports the hypothesis that masticatory performance is the outcome of complex simultaneous interrelationships among physiological and contextual variables. The proposed model showed that the combined effects of the explanatory variables explain 68% of the variability in masticatory performance (see Figure 2). Number of functional tooth units and bite force were confirmed as key predictors, which suggests that maintenance of these factors may be of primary importance for promoting healthful functional status.

The single best predictor of masticatory performance was the number of postcanine functional tooth units. This corroborates that the comminution capacity depends on the number of occluding pairs of teeth (Helkimo et al., 1978; Omar et al., 1987; Akeel et al., 1992; Van der Bilt et al., 1993). Our community-based results add evidence that primary interventions to maintain or improve masticatory performance in dentate subjects should be aimed at the preservation and/or restoration of posterior functional teeth. However, the increased number of posterior occlusal units seems to improve chewing performance only when the predominant chewing side arch is restored (Van der Bilt et al., 1994). Thus the distribution of functional tooth units, and not only their number, might be a relevant factor affecting masticatory performance. Influence of occlusal contact area on chewing efficiency was also previously evaluated, but contradictory results were found (Wilding, 1993; Julien et al., 1996).

Diabetes and age were considered modifiers of the number of functional tooth units. Loss of teeth is the endpoint of many local oral diseases, such as caries and periodontal disease, which can be influenced by systemic diseases and the aging process. However, in this random sample, diabetes and age together accounted for only 7% of the variability in the number of functional tooth units (see Figure 2). Diabetic subjects had fewer functional units than non-diabetic subjects, but the clarification of diabetes as a cause of tooth loss should be assessed through longitudinal studies.

Number of functional tooth units also showed an important influence on bite force, which, in turn, affects masticatory performance. Considering the model depicted in Figure 2, the indirect impact of functional tooth units on mastication was approximately six-fold lower than the direct effect[2], and is explained by the moderate effects of functional tooth units on bite force and of bite force on masticatory performance.

Bite force was the other key predictor in our model, but its impact on masticatory performance was not as strong as that of number of functional units. Indeed, the effect of bite force was lower than expected from the literature. This probably occurred because other studies investigated this relationship in samples of subjects with more heterogeneous dental status, *i.e.*, dentate, edentulous, and prosthesis wearers (Heath, 1982; Fontijn-Tekamp et al., 2000).

In addition, we tested the hypothesis that bite force mediates the effects of several other physiologic and demographic variables. The combined effects of sex, number of functional postcanine tooth units, masseter cross-sectional area, age, and presence of

---

[2] The direct effect of posterior functional tooth units on masticatory performance is 0.68. The indirect effect is calculated by multiplying the components' beta path coefficients 0.41 x 0.27 = 0.10.

TMD explained 52% of the variance in bite force. However, 48% of the variation in bite force may be explained by variables not included in this model. For example, other factors believed to affect bite force are psychological factors (Orchardson & Cadden, 1998), craniofacial morphology (Raadsheer et al., 1999), and body size (Julien et al., 1996). Current dental treatment status also could have an effect on bite force, but this variable was not explored in this study.

Sex was the most important factor influencing bite force, basically through the direct path. Females tended to have lower maximum bite force values compared to males, which could be explained by a difference of mass in the masticatory muscles (Newton et al., 1993). Masseter muscle cross-sectional area and thickness is related to craniofacial morphology (Weijs and Hillen, 1986; Bakke et al., 1992; Raadsheer et al., 1996; Raadsheer et al., 1999), body size (Raadsheer et al., 1996; Shiau et al., 1999), and bite force (Van Spronsen et al., 1989; Bakke et al., 1992; Raadsheer et al., 1999) Our data showed a significant association between masseter cross-sectional area and bite force (bivariate $r = 0.41$). The strength of this association, however, was attenuated in the multivariate analysis after controlling for other variables affecting bite force (compare Table 3 and Figure 2). Although masseter muscle thickness was shown to be the major contributing factor of bite force in adults (Raadsheer et al., 1999), the association between sex and masseter cross-sectional area was not strong enough to explain the sex differences in bite force in this study.

Another indirect effect of sex on bite force was assessed through the TMD path. The expected association of sex with TMD was confirmed, but a strong influence of TMD as a local factor causing restriction of jaw mobility and pain, and thus limiting bite force

(Svensson et al., 1998), could not be demonstrated. One explanation for this result may be the low prevalence of TMD (CMI mean = 0.064, on a scale of 0 to 1) in our non-clinical sample in contrast to studies that included patients with more severe TMD (Sato et al., 1999; Tortopidis et al., 1999).

Finally, as predicted, age did not exert a strong effect on masticatory performance, either directly or indirectly through maintenance of tooth structure or bite force. In fact, the direct path from age to masticatory performance could not be sustained. This suggests that masticatory performance need not decline with age if teeth are retained and masticatory muscle strength is maintained. Age may affect oral function through the cumulative effect of a multitude of minor influences. The influence of age is currently viewed as the result of an accumulation of insults to orofacial structures (Ship et al., 1996). Such an indirect effect of age on masticatory performance was assessed in the model via pathways involving dental and muscular tissues. However, these pathways were shown to be relatively weak.

Although ability to chew involves sociopsychologic aspects, masticatory performance is considered an objective indicator of masticatory function (Boretti et al., 1995; Yamashita et al., 1999). On the whole, a general prediction about masticatory performance in dentate subjects can be made using the proposed multivariate model. Nevertheless, moderate to high coefficients for the residual variables indicate the presence of unknown factors associated with the outcome measures. These may include biological, behavioral, and/or social variables not assessed here. Because of the population-based design of this study, we focused on selected variables and pathways to limit the complexity of the analysis (Scheultz & Poulsen, 1999). In future studies we will test the generalizability of this model on other populations, such as edentulous subjects and removable prostheses wearers. It also will be necessary to conduct longitudinal studies to confirm causal relationships and refine the model.

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May 2, 2001.

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26 March 2001

Dr. Rosemary S. A. Shinkai
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Re: Manuscript #14987

Dear Dr. Shinkai:

Thank you for submitting manuscript #14987, entitled "Dietary intake in edentulous subjects with good and poor quality complete dentures." Your manuscript was forwarded to an assistant editor and two reviewers. They recommend that you **revise** the manuscript and **resubmit** it for a second review.

Please revise your manuscript and return it **within 6 weeks** of the date of this letter (or as soon as possible) so that we can proceed with the publishing process. **A cover letter must accompany the revision and respond, one by one, to the preceding list of comments**. Failure to respond to these comments in the cover letter will result in the return of the manuscript to you for the inclusion of a letter that addresses each recommendation.

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Yours truly,

Glen P. McGivney, DDS

Editor

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The International Journal of Adult Orthodontics & Orthognathic Surgery

June 5, 2001

Dr John P. Hatch
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7703 Floyd Curl Drive
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Dear Dr Hatch:

Congratulations on the acceptance of your article, "Masticatory performance is not associated with diet quality in Class II orthognathic surgery patients." It has been scheduled for publication in the Fall issue of *The International Journal of Adult Orthodontics and Orthognathic Surgery*, to be published in September.

Page proofs will be mailed to the above address in July. If you will be unavailable at that time, please contact me as soon as possible, and we will make other arrangements.

I look forward to working with you.

Sincerely,

Jennifer Ballinger
Jennifer Ballinger
Managing Editor

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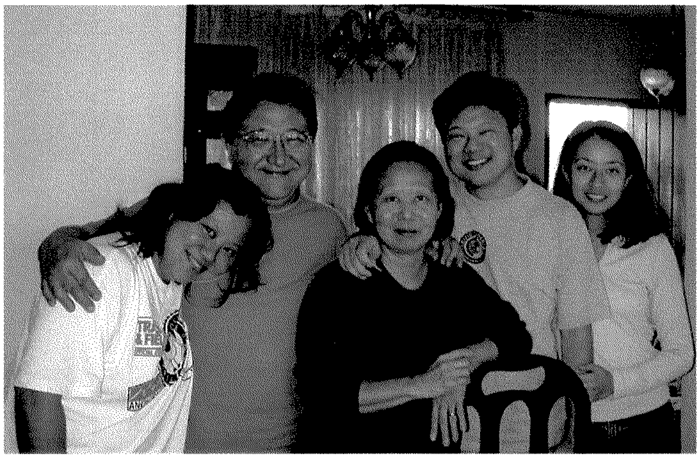
Um dos muitos e-mails que recebi

quando eu achava que estava muito longe

"Existem pessoas em nossas vidas que nos deixam felizes pelo simples fato de terem cruzado o nosso caminho. Algumas seguem ao nosso lado, vendo muitas luas passarem; outras apenas vemos entre um passo e outro. A todas elas chamamos de amigo.

Há muitos tipos de amigos. Talvez cada folha de uma árvore caracterize um deles.

O primeiro que nasce do broto é a amiga mãe e o amigo pai. Mostram o que é ter vida. Depois vem o amigo irmão, com quem dividimos o nosso espaço para que ele floresça como nós. Passamos a conhecer toda a família de folhas, a qual respeitamos e desejamos o bem.





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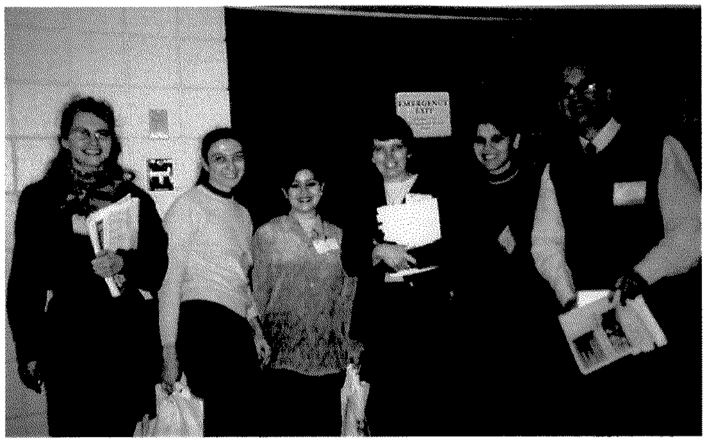
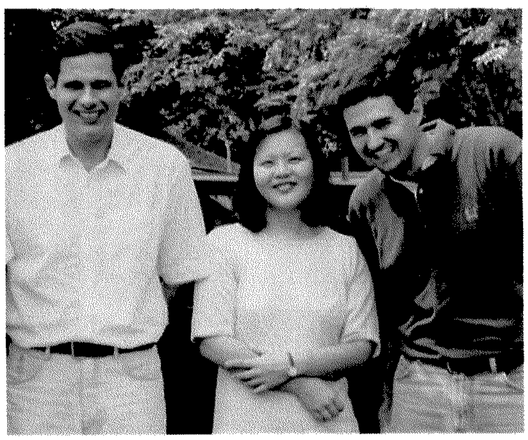
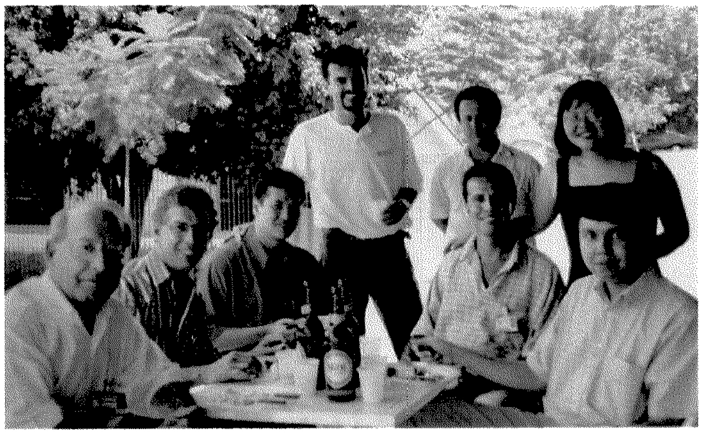
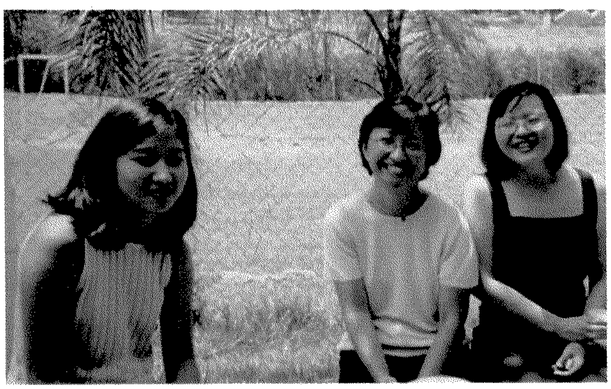




Mas o destino nos apresenta a outros amigos, os quais não sabíamos que iriam cruzar o nosso caminho. Muitos destes são amigos do peito, do coração. São sinceros, são verdadeiros, sabem quando não estamos bem, sabem o que nos faz feliz... Às vezes, um desses amigos do peito estala o nosso coração e então é chamado de amigo namorado. Este dá brilho aos nossos olhos, música aos nossos lábios, pulos aos nossos pés.



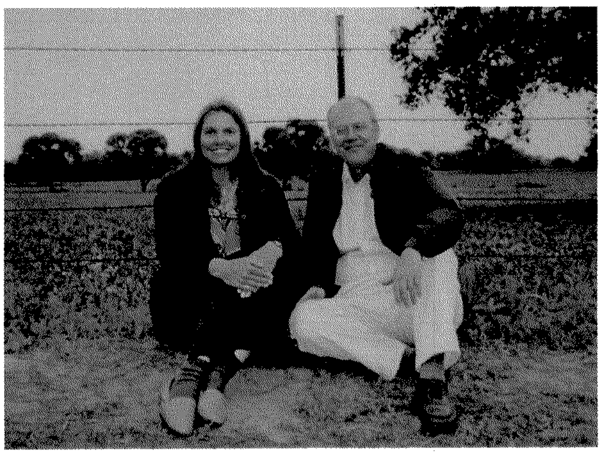



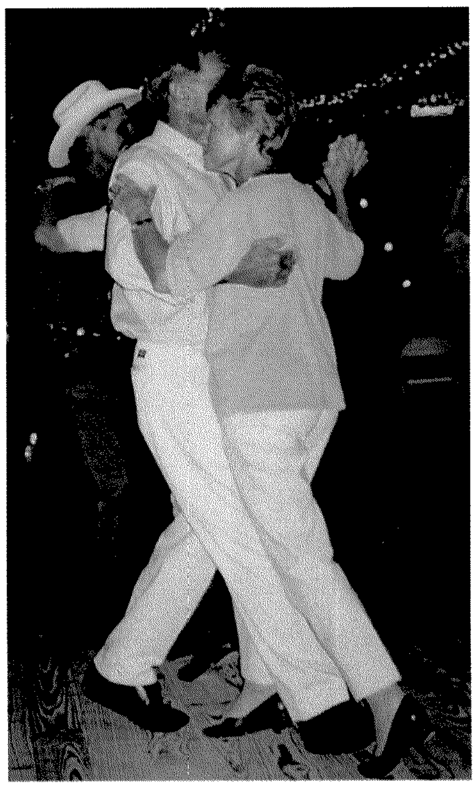





Há também aqueles amigos por um tempo mais ligeiro, talvez umas férias ou mesmo um dia ou uma hora. Eles costumam colocar muitos sorrisos na nossa face durante o tempo que estão por perto. Não podemos nos esquecer dos amigos distantes, que ficam nas pontas dos galhos, mas que quando o vento sopra, aparecem novamente entre uma folha e outra.

O tempo passa, o verão se vai, o outono se aproxima, e perdemos algumas de nossas folhas. Algumas nascem num outro verão e outras permanecem por muitas estações. Mas o que nos deixa mais feliz é que as que caíram continuam por perto, continuam aumentando a nossa raiz com alegria. Lembranças de momentos maravilhosos enquanto cruzavam o nosso caminho.





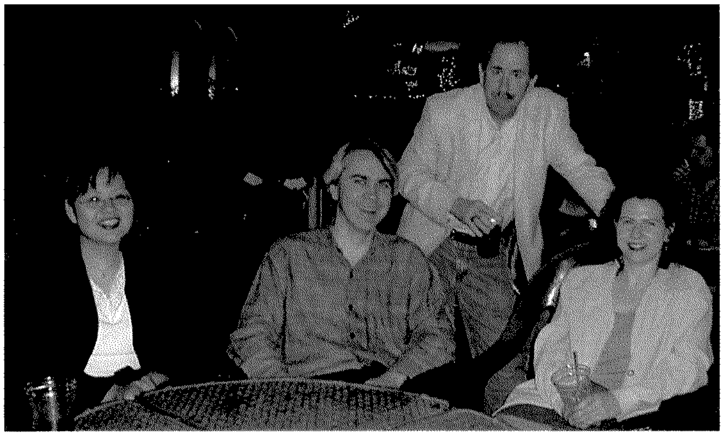
Desejo a você, folha da minha árvore,

Paz, Amor, Saúde, Sucesso, Prosperidade...

Hoje e Sempre...

Simplesmente porque: Cada pessoa que passa em nossa vida é única. Sempre deixa um pouco de si e leva um pouco de nós. Há os que levaram muito, mas não há os que não deixaram nada. Esta é a maior responsabilidade de nossa vida e a prova evidente de que duas almas não se encontram por acaso."

Muito obrigada por tudo!

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