Determinants of masticatory performance assessed by mixing ability tests.

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Acknowledgments

Two Spanish patents support both the platten design (ES2597839) and the computer-assisted method (ES2597237) used in this study. The study was conducted by the Research Group "Avances en Salud Oral" of the University of Salamanca, led by the first author.

CRediT author statement:

Javier Montero: Conceptualization, Methodology, Formal analysis, Writing-Original draft preparation. **Luis Leiva**: Software, Validation. **Inmaculada Martín-Quintero**: Data curation. **Rocío Barrios**: Investigation, Writing-Reviewing and editing.

JPD-19-881

CLINICAL RESEARCH

Determinants of masticatory performance assessed by mixing ability tests.

ABSTRACT

Statement of problem. Studies that determined the main predictors of masticatory performance by using mixing ability tests are sparse.

Purpose. The purpose of this clinical study was to analyze potential determinants of masticatory performance (MP) assessed by analyzing a patient's masticatory ability using bi-colored chewing gum and visual, quantitative, and interactive methods.

Material and methods. Non-dental participants attending health care centers were consecutively recruited in Granada, Spain. The inclusion criteria were over 18 years and residence in the coverage area of the reference health care centers during at least the previous 6 months. The participants were excluded if they had received dental treatment in the previous 6 months or they were unable to communicate. The MP was determined by using 2-colored chewing gum (Kiss 3 white & blue; Smint) that was masticated for a total of 20 strokes. The masticated gum was crushed between 2 transparent glass slides, creating a 1-mm-thick specimen that was subsequently scanned. The mixed-color area was calculated as a percentage by using Photoshop as described by Schimmel et al and designated as the gold standard method (GSM). In addition, all images made were analyzed by using the web application. the Chewing Performance Calculator (CPC). Additionally, the masticated bolus was inspected visually and mastication performance was classified as being poor, moderate, or good. Sociodemographic data, as well as data on behaviors, medical and nutritional status, health-related quality of life, saliva, and

general oral health, were collected for all participants in order to determine the main determinants of MP.

Results. One hundred and thirty-seven participants were enrolled. The MP values obtained using both methods (GSM and CPC) were significantly greater for well masticated gum ($P<.001$), which had been visually classified as being poorly (69.1% for GSM and 43.5 for CPC), moderately (89.7% for GSM and 67.3% for CPC), and well masticated (97.3% for GSM and 80.3% for CPC). The bivariate analyses revealed that MP was significantly higher in younger people (<65 years) ($P=.008$), who also had a higher basal salivary flow rate ($P<.001$), were non-denture users ($P=.002$), and had more standing teeth and occlusal units ($P<.001$). However, the multiple regression analyses showed that the number of occlusal units was the only significant predictor of MP. In addition, the mean MP (95% confidence interval: 47.7%-56.8%) was found to be greatly improved (by 1.2% to 2.2%), with each occlusal unit, according to the CPC and between 0.8 to 1.8% according to the GSM; the basal MP was calculated as 72.1-81.2% (95% confidence interval).

Conclusions. The number of occlusal units is one of the main predictors of masticatory performance when a 2-color bolus is used for testing mixing ability.

CLINICAL IMPLICATIONS

Clinicians should be aware that the number of occlusal units (natural or fixed prosthesis) are the main determinant when assessing food mixing ability. This fact should be taken into account when planning the prosthetic restoration of shortened dental arches and upon when delivering providing removable dentures.

INTRODUCTION

The Glossary of Prosthodontics Terms[1] defines mastication as the process of masticating food for swallowing and digestion. It is the first stage of the digestion process and is essential for good health. When mastication is deteriorated, food choice and nutritional intake become affected,[2] and there is evidence of a direct connection between mastication and systemic and cognitive functions.[3,4]

The possible determinants of masticatory function have been assessed, with dental conditions, such as dry mouth, tooth decay, occlusal and muscle force, the number of functional teeth, and tooth loss, reported to be associated with masticatory performance (MP).[5-11] Thus, masticatory function is reduced in individual who have lost posterior teeth[12] and in those who wear removable dentures.[13] However, when missing teeth are restored with fixed prostheses, masticatory function substantially improves.[14] In addition, sociodemographic factors like age, income, and behavior such as smoking, are also factors related to mastication.[15,16] Although most studies have assessed masticatory function by using subjective methods,[7,15,16] objective methods have been reported to provide more precise measurements for masticatory performance and to be more useful in clinical practice.[17,18]

The combination of different methods to evaluate mastication has been suggested, especially considering the lack of agreement among the different procedures.[19] Mixing ability tests were created to measure the true mixing ability of food by assessing the changes in color of a 2-color material (usually gum or paraffin wax) either visually[20,21] or digitally, using a scanner.[22,23] Therefore, mastication can be evaluated in an integrated way.

Since the number of teeth present may overestimate the functional potential for mastication because this does not take into account the presence of opposing pairs of teeth, it was

hypothesized that the number of occlusal units may be one of the main predictors of masticatory performance. The purpose of the present clinical investigation was to analyze the most important determinants that influence the masticatory performance by using a mixing ability test and visual, quantitative, and digital methods.

MATERIAL AND METHODS

This clinical investigation was carried out from 3 public health care centers situated in the city of Granada (Spain) or in the surrounding region. Inclusion criteria were: over 18 years, and residence in the coverage area of the reference health care centers during at least the previous 6 months. The participants were excluded if they had received dental treatment in the previous 6 months or if they were unable to communicate.

The study design had been previously approved by the Bioethics Committee of the University of Granada and written consent was obtained from the participants once they had been informed of the purpose of the clinical investigation and the procedures. Masticatory performance (MP) was determined by using 2-colored chewing gum (Kiss 3 white & blue; Smint) that had been masticated for a total of 20 strokes. The masticated gum was taken from the participant and flattened between 2 transparent glass slides with 1 mm thick flanges (set up for this purpose), creating a 1-mm-thick bolus that was subsequently analyzed. The bolus was initially examined visually and the degree of mastication was classified as being poor, moderate, or good. Poor was selected when large parts of the chewing gum remain unmixed; moderate when the masticated bolus was somewhat mixed although there were streaks of unmixed original color; good was considered when the bolus is well mixed and there is no streaks of the original color.

Then, the gold standard method, described by Schimmel et al[23] was carried out, followed by the CPC interactive method.[24] The Schimmel et al method, which has been described in detail elsewhere,[23] is done in such a way that 1-mm wafers were scanned from both sides at a resolution of 500 dots per inch. This image was transferred to a fixed size of 1175×925 pixels and stored in the Adobe Photoshop format (psd). In addition, a scanned piece of unmixed gum was copied into each image to be used as a scale reference. The 'magic wand' tool was then used, with a tolerance (related to the range of colors accepted) of 20, to select the unmixed blue parts of the image. The number of selected pixels were recorded from the histogram and the ratio of unmixed pixels from the total number of pixels calculated. This ratio was then transformed into a estimating percentage of the mixing ability; that is to say, the higher the value the greater the MP.

Each masticated bolus was also analyzed by using the CPC,[24] a web application that takes as input the image of the masticated bolus enclosed in a custom platen. It allowed interactive selection of 3 parts of the image: the platen, the background, and the mixed color fraction. After a photograph was made without flash of the flattened bolus by using a mobile phone (Galaxy S7 SM-G930F; Samsung Electronics Co, Ltd) with a camera resolution of 12 megapixels, it was uploaded to the website: https://studio.chewing.app/

The custom-made plate was selected by clicking on it by using the mouse. An overlay automatically appeared on top of the plate to calibrate the size of the masticated bolus. Subsequently the background color was selected by clicking on it to delimit the total area of the masticated bolus. Finally, the mixed area was selected and the software automatically selected the area of the mixed color throughout the total area, with a tolerance of 15. Then, the tool "calculate" was selected to record the mixing ability, represented as a percentage.

Information was obtained through an interview carried out by the same researcher (R.B.R.). The variables collected were sociodemographic data: age, sex, and social class; behavioral data: oral hygiene was evaluated by asking the question "How often do you clean your teeth, dentures or gums nowadays?" and the participants' answers were categorized as twice or more a day, once a day or less than once a day; the frequency of visits to the dentist was recorded as "regularly or occasionally" or "only when there is a problem or never"; and the participants were classified as being current smokers or non-smokers after responding to the question "Do you smoke cigarettes, pipe or cigars at all currently?"; medical data: any pathologies or medication that may reduce the flow of saliva; health-related quality of life: the participants were asked to fill in a short health survey[25] containing 12 items rated according to 3- or 5-point Likert scales. These items represented the dimensions of physical functioning, role physical, bodily pain, general health, vitality, social functioning, emotions, and mental health. Two summary scores, physical component summary and mental component summary, were calculated from these dimensions, which were compared with scores previously published for the Spanish population[26]; nutritional status using the Mini Nutritional Assessment (MNA)[27]: the participants were asked to fill in a short form consisting of 6 questions about weight loss or recent appetite, mobility, psychological stress or acute disease, neuropsychological problems, and body mass index (BMI). A score between 12 and 14 indicated satisfactory nutritional status, so the second part of the MNA was not applied. The second part had 12 additional questions with a maximum score of 16 points. Therefore the overall maximum MNA score was 30 points. The MNA score can be used to distinguish among 3 groups: those with adequate nutrition (score ≥ 24), or those that only needed to complete the short form (screening questionnaire); those at risk of malnutrition (scores between 17 and 23.5); and those with malnutrition (scores under 17);

salivary status: objective (unstimulated saliva) and subjective methods were used to assess dry mouth; and oral health variables: teeth status and dental treatment needs. The number of occlusal units were recorded by inspection at maximal intercuspal position by counting the number of occluding pairs of fixed teeth (either natural, restored, or fixed prosthetic units).[12,28] Prosthesis status was assessed according to Sato et al[29] for retention and stability.

The statistical analyses was carried out by using a statistical software package (IBM SPSS Statistics, v21; IBM Corp). For the bivariate analyses, the distribution of variables regarding the visually-determined mastication was assessed by either ANOVA test or chi square tests. The linear regression analyses was performed by using the backward step-wise method. The masticatory performance scores according to GSM and CPC were the dependent variables and the modulating factors found in the bivariate analyses as independent variables, after controlling the collinearity between them. The Spearman correlation coefficient (r_s) was calculated to assess the linear relation between the number of occlusal units and patient-centered outcomes variables (quality of life) (α=.05).

RESULTS

The present clinical investigation enrolled 137 non-dental participants. Sociodemographic, behavioral, nutritional, and clinical variables are described in Table 1. The mean ±standard deviation age of the participants was 66.7 ±13.4 years, 91 of them (66.4%) were men and most frequently (60.7%) of the low socioeconomic level . Twenty-four of the total sample (17.5%) smoked 14.7 ±11.9 cigarettes per day. Regarding the variables representing general health, 51.8% took medications that reduced saliva and had worse scores in all dimensions of health-related quality of life compared with the general population (reference norms) except in general

health. Most participants had a BMI greater than 23 kg/m^2 (87.6%), had a normal nutritional status (86.9%), and described their health as good (42.3%). The mean basal saliva flow rate was 0.2±0.1 mL/min with the 63.5% perceived episodic or permanent xerostomy.

Table 2 shows information regarding oral health status and masticatory function. The mean number of missing teeth was 16.1 ±10.6 and 70 of the participants (51.1%) did not use a prosthesis. Among the denture wearers, 38 (74.5%) had poor fit and 37 of them (72.5%) had poor retention. Regarding self-rated oral pain, 43 participants (31.4%) reported painful aching in the mouth in the previous year (results not shown in Tables). Most of the participants thought they did not require dental treatment (59.9%) and 82 of them (59.9%) had poor or moderate masticatory performance as determined by visual assessment. The mean mixing ability was 84.9 ±20.5 when using the Schimmel et al method and 63.6 ±21.0 with the CPC method. Mastication had an impact on the quality of life of the most of participants (64.2%).

The bivariate analysis of the comparison among different sociodemographic and clinical variables, based on the visual examination of the masticated gum, is presented in Table 3. The participants with poor mastication were significantly older (mean: 71.6 ±11.3 years (P=.002), took medications that reduced salivary flow (76.9%) (P<.001) and qualified as poor or regular their health in higher proportion (46.2%) (P=.01) than participants with moderate or good mastication. There was a linear relationship between masticatory function and quality of life, where significantly worse scores with regard to physical function (P<.001), role physical (P<.001), pain (P=.03), general health (P=.002), vitality (P<.001), and physical health (P<.001) were associated with poor masticatory performance. Salivary status and dental variables were also significantly associated: participants with good mastication had normal salivation more frequently (50.9%) (P=.04), the 58.2% did not wear prosthesis (P=.02), had higher mean of

natural and healthy teeth (*P*=.01), and lower mean of teeth prosthetically restored. Also, differences were found among the MP groups (poor-moderate-good) using both the Schimmel et al method (69.1%-89.7%-97.3%) and the CPC (43.5%-67.3%-80.3%) method (both *P*=.001).

A stepwise linear regression analyses, carried out to predict masticatory performance after including all of the significant causal variables (Table 3) showed that occlusal units significantly predicted MP when assessed by using both the GSM and the CPC methods (Table 4). Specifically, it was shown that the mean MP, according to the CPC (95% confidence interval: 47.7%-56.8%), significantly improved by 1.2% to 2.2% with each occlusal unit (*P*<.001). Similarly, the mean MP determined by using the GSM (95% confidence interval: 72.1%-81.2%) significantly increased by 0.8% to 1.8% with each occlusal unit (*P*<.001). In addition, the predictive ability of this single predictor was found to be greater for the CPC (R^2=0.29) than for the Schimmel et al method (R^2=0.15).

Furthermore, a significant linear correlation was found between the number of occlusal units and patient-centered measures such as self-rated general health (r_s=0.30; *P*<.001), oral health-related quality of life (r_s=0.19; *P*<.05), and most of the SF-12 domains, physical function (r_s=0.44; *P*<.001); role physical (r_s=0.34; *P*<.001); pain (r_s=0.36; *P*<.001); general health (r_s=0.28; *P*<.001); vitality (r_s=0.30; *P*<.001); and physical health (r_s=0.33; *P*<.001).

DISCUSSION

The objective of the present clinical investigation was to determine the main predictors of masticatory performance by using qualitative (visual assessments) and quantitative tests (Schimmel et al[23] and CPC interactive method[24]). As it was hypothesized, the results suggest that the number of occlusal units is a key determinant of mastication regardless of the methods used

to assess it.

Mastication is a complex function in which good oral health plays an important role. Since 1992, the World Health Organization adopted as a goal for oral health "the conservation throughout life of a natural, aesthetic and functional dentition of no less than 20 teeth".[30] However, different studies have shown that the number of functional teeth is a superior predictive factor for masticating ability than the number of remaining natural teeth.[8-10] Similarly, the results of this study revealed that the number of occlusal units is the main predictor of masticatory ability, which is consistent with the findings of previously published reports.[9,10] This is an important finding because occlusal units was also significantly associated with relevant patient-centered outcomes such as quality of life or self-rated health. Like other authors,[31,32] prosthetic reconstruction (fixed or removable) was found to be a variable also associated with worse masticatory performance however it influence disappears in the multivariate analysis. It shows that it is more determinant the presence of the restored teeth in occlusal units than its number in terms of masticating efficacy. In view of these results, the oral health WHO goal of 20 teeth present could be discussed, to take into account other considerations as its distribution in addition to its quantity.

The age of the participants was a variable associated with masticatory performance but, as reported by other studies,[33,34] this association was not found in the adjusted analysis. It could be due to the fact that age is related to the number of functional occlusal units, where older people have less one than younger. Therefore, a decrease in masticatory performance in older people should not be accepted as a natural process of aging because it does not have an impact on mastication itself.[35] Taking into account that the functional units teeth was counted without removable prosthesis, oral health professional should guide the treatments to maintain natural or

fixed functional units teeth.

In dental practice time is valuable, and it is important to find efficient methods that can be used on a daily basis. For its easy detection, the identification of functional occlusal units (fixed opposing teeth in contact relation at the intercuspal position)[1] as the most important predictor of masticatory function is promising. The results of this clinical investigation showed that the CPC method is better at predicting masticatory performance than the Schimmel et al method.[23] Furthermore, the GSM suffers from a "ceiling effect" (Table 3) because several of the participants exhibiting good masticatory performance reached the maximum score (100%). This implies that this method would be unable to detect improvements in mastication after intervention for this group of participants with good masticating ability. With the web application, the analysis of masticatory performance using the CPC method is both straightforward and rapid.

Some of the potential limitations of the present clinical investigation include: a causal relationship could not be determined due to the cross-sectional nature of the study. Second, although potential variables related to mastication have been taking into account, variables such as orofacial pain, occlusal forces, or the role of other buccal elements like the tongue or cheeks were not analyzed.[6,36] Third, this clinical investigation failed in differentiating functional units of each side because it was considered we collected this data considering full mouth. By last, certain groups of individual, such as those with uncontrolled diabetes mellitus, autoimmune diseases, infections, lupus erythematosus, among others, were not represented in this study. These pathologies may influence masticatory function and therefore should be analyzed in future studies.

CONCLUSIONS

The number of occlusal units is one of the major predictors of the masticatory performance when a 2-colored bolus is used for testing the mixing ability.

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TABLES

Table 1. Description of sociodemographic, behavioral, nutritional, and clinical variables of participants (N=137)

SOCIODEMOGRAPHIC VARIABLES	Mean±sd
Mean age in years	66.7±13.4
Age Interval	N(%)
≤50 years	19(13.9)
51-64 years	45(32.8)
≥65 years	73(53.3)
Sex	
Women	46(33.6)
Men	91(66.4)
Socio-occupational Level	
High	15(10.1)
Medium	40(29.2)
Low	82(60.7)
BEHAVIORAL VARIABLES	
Smoking habit	
Currently smoking regularly	24(17.5)
	Mean±sd
Mean cigarretes per day	14.7±11.9
MEDICAL VARIABLES	N(%)
Hypertension	56(40.9)
Diabetes	20(14.6)
Coronary heart diseases	15(10.9)
Respiratory diseases	14(10.2)
Participants taking medications that reduces salivary flow	71(51.8)
QUALITY OF LIFE according to SF-12	Mean±sd
Physical function	43.1±11.8
Role physical	44.5±11.9
Pain	50.0±7.1
General health	46.3±7.4
Vitality	46.9±8.3
Physical health	45.8±10.1
Emotions	47.0±10.6
Mental health	45.2±8.0
NUTRITIONAL VARIABLES	
BODY MASS INDEX (BMI)	N(%)
19<BMI<21	5(3.6)
21<BMI<23	12(8.8)
BMI>23	120(87.6)
NUTRITIONAL STATE ASSESSMENT	N(%)
Normal nutrition	119(86.9)
Malnutrition risk	18(13.1)
SELF-RATED GENERAL HEALTH	N(%)
Excelent	5(3.6)
Very good	31(22.6)
Good	58(42.3)
Regular	38(27.7)
Poor	5(3.6)
SALIVARY STATUS	Mean±sd
Basal salivary flow rate (mL/min)	0.2±0.1
Self-perceived salivary status	N(%)
Normal salivation	50(36.5)
Episodic xerostomy	59(43.1)
Permanent xerostomy	28(20.4)

Table 2. Description of the oral health status and the masticatory function (assessed by visual method) of the participants (N= 137)

CLINICAL VARIABLES	Mean±sd
Natural standing teeth	14.1±10.2
Healthy teeth	13.6±10.4
Missing teeth	16.1±10.6
Occlusal units	6.5±6.4
Teeth prosthetically restored with removable dentures	7.5±11.2
Teeth prosthetically restorable	8.6±7.7
Prosthodontic status	N(%)
Without prosthesis	70(51.1)
Fixed Prosthesis	16(11.7)
Partial Removable Denture	19(13.9)
Removable Complete dentures	32(23.4)
Denture Fit among removable denture wearers (n=51)	
Poor	38(74.5)
Regular	13(25.5)
Denture retention/stability among removable denture wearers (n=51)	
Poor	37(72.5)
Regular	14(27.5)
Mucosal Denture-related lesions beneath removable dentures (n=51)	
Prevalence	4(8.0)
Perceived Dental Treatment Needs	N(%)
No Perceived	82(59.9)
Perceived	55(40.1)
Normative Dental Treatment Needs	Mean±sd
Number of teeth needing fillings	1.0± 1.7
Number of teeth needing endodontic treatments	0.02± 0.13
Number of teeth needing exodoncy	0.4± 1.1
MASTICATORY PERFORMANCE ASSESSED BY DISTINCT METHODS	
by visual assessment of the Mixing Ability (Traditional)	N(%)
Poor masticatory performance	52(38.0)
Moderate masticatory performance	30(21.9)
Good masticatory performance	55(40.1)
	Mean±sd
by quantitative assessment of the Mixing Ability (GSM) ^	84.9±20.5
by interactive assessment of the Mixing Ability (CPC) *	63.6±21.0
Self-reported masticatory impact on quality of life	N(%)
Yes	88(64.2)
No	49(35.8)
Total Impact	Mean±sd
Percentual score based on frequency and severity of the impact	20.3±21.6

^GSM=gold standard method proposed by Schimmel et al[23]

*CPC=Chewing Performance Calculator[24], the experimental method used in this study

Table 3. Significant comparison by bivariate analyses (ANOVA test and Chi^2) of variables according to the masticatory performance assessed by visual estimation of the mixing ability test within participants (N=137)

	Masticatory Performance			Comparison
SOCIODEMOGRAPHIC VARIABLES	Poor (n=52)	Moderate (n=30)	Good (n=55)	Test; (*P*-value)
Age Interval	N(%)	N(%)	N(%)	
≤50 years	2(3.8)	3(10.0)	14(25.5)	Chi^2=13.8; (*P*=.008)
51-64 years	15(28.8)	13(43.3)	17(30.9)	
≥65 years	35(67.3)	14(46.7)	24(43.6)	
	Mean(sd)	Mean(sd)	Mean(sd)	
Age (years)	71.6(11.3) [A]	66.0(10.5) [A, B]	62.4(15.2) [B]	F=6.8; (*P*=.002)
MEDICAL VARIABLES				
Consumption of medicaments that reduces salivary flow	N(%)	N(%)	N(%)	
No	12(23.1)	15(50.0)	39(70.9)	Chi^2=24.6; (*P*<.001)
Yes (antihypertensive, benzodiazepines…)	40(76.9)	15(50.0)	16(29.1)	
Self-rated General Health	N(%)	N(%)	N(%)	
Poor or regular	24(46.2)	8(26.7)	11(20.0)	Chi^2=8.9; (*P*=.01)
Good or excelent	28(53.8)	22(73.3)	44(80.0)	
QUALITY OF LIFE according to SF-12	Mean± sd	Mean± sd	Mean±sd	
Physical function	37.3±11.5 [A]	44.9±10.9 [B]	47.6±10.4 [B]	F=12.4; (*P*<.001)
Role physical	38.6±11.8 [A]	46.9±11.4 [B]	48.9±10.0 [B]	F=12.5; (*P*<.001)
Pain	48.0±8.0 [A]	50.2±5.8 [A,B]	51.7±6.6 [B]	F=3.8; (*P*=.03)
General health	43.7±6.4 [A]	46.5±6.7 [A, B]	48.7±8.0 [B]	F=6.6; (*P*=.002)
Vitality	43.6±8.8 [A]	48.3±7.5 [B]	49.4±7.3 [B]	F=7.8; (*P*=.001)
Physical health	41.2±11.0 [A]	47.4±8.5 [B]	49.4±8.1 [B]	F=10.9; (*P*<.001)
Emotions	44.6±12.4	47.8± 9.2	48.9±9.1	F=2.3; (*P*=.1)
Mental health	44.2±8.9	45.6± 8.0	45.8±7.3	F=0.5; (*P*=.6)
SALIVARY STATUS	Mean(sd)	Mean(sd)	Mean(sd)	

Basal Salivary Flow Rate (mL/min)	0.11(0.08) [A]	0.15(0.08) [A, B]	0.19(0.16) [B]	F=5.3; (*P*=.006)
Self-perceived salivary status	N(%)	N(%)	N(%)	
Normal salivation	14(26.9)	8(26.7)	28(50.9)	Chi^2=8.6; (*P*=.04)
Episodic xerostomy	25(48.1)	15(50.0)	19(34.5)	
Permanent xerostomy	13(25.0)	7(23.3)	8(14.5)	
DENTAL STATUS				
Prosthetic Status	N(%)	N(%)	N(%)	
Without prosthesis	25(48.1)	13(43.3)	32(58.2)	Chi^2=14.8; (*P*=.02)
Fixed Prosthesis	2(3.8)	3(10.0)	11(20.0)	
Partial Removable Denture	7(13.5)	6(20.0)	6(10.9)	
Removable complete dentures	18(34.6)	8(26.7)	6(10.9)	
Dental Variables				
Natural standing teeth	8.1(8.0) [A]	12.2(8.5) [A]	20.9(8.7) [B]	F=31.8; (*P*<.001)
Healthy teeth	7.2(7.9) [A]	11.8(9.2) [A]	20.5(8.9) [B]	F=32.8; (*P*<.001)
Missing teeth	22.7(8.3) [A]	17.8(9.6) [A]	9.0(8.6) [B]	F=33.3; (*P*<.001)
Occlusal units	2.4(3.7) [A]	5.1(5.3) [A]	11.1(6.1) [B]	F=40.1; (*P*<.001)
Teeth prosthetically restored with dentures	10.4(12.5) [A]	9.3(12.1) [A]	3.7(8.2) [B]	F=5.7; (*P*=.004)
Teeth prosthetically restorable	12.2(9.5) [A]	8.5(6.7) [A,B]	5.3(4.2) [B]	F=12.5; (*P*<.001)
Quantitative Masticatory Performance	Mean(sd)	Mean(sd)	Mean(sd)	
By Schimmel method^	69.1(24.2) [A]	89.7(12.5) [B]	97.3(3.8) [B]	F=42.2; (*P*<.001)
By CPC method*	43.5(19.1) [A]	67.3(8.8) [B]	80.3(7.6) [C]	F=92.8; (*P*<.001)

[A,B,C] Distinct letters in the columns mean significant differences between groups after ANOVA with Post Hoc Bonferroni correction among

^GSM=gold standard method proposed by Schimmel et al[23]

*CPC=Chewing Performance Calculator[24], the experimental method used in this study

Table 4. Backward Step-wise Linear Regression Models for predicting the masticatory performance with both the GSM^ and the CPC* in the investigation sample (N=137) after including all the significant modulating variables found in Table 3 (age, salivary flow rate, and all the variables regarding dental status)

					95% confidence interval for β	
Parameters	β	S.E.	Standardized β	*P*-value	Lower	Upper
MASTICATORY PERFORMANCE ACORDING TO GSM [A]						
Constant	76.7	2.3		<.001	72.1	81.2
Occlusal units	1.3	0.3	0.40	<.001	0.8	1.8
MASTICATORY PERFORMANCE ACORDING TO CPC [B]						
Parameters						
Constant	52.3	2.3		<.001	47.7	56.9
Occlusal units	1.7	0.3	0.53	<.001	1.2	2.2

[A]ANOVA F= 25.64; *P*<.001; Corrected R^2=0.15

[B]ANOVA F= 46.88; *P*<.001; Corrected R^2=0.29

^GSM=gold standard method proposed by Schimmel et al[23]

*CPC=Chewing Performance Calculator[24], the experimental method used in this study