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Functional, esthetical, and periodontal determination of the dentition in 35- to 44-year-old Brazilian adults

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Abstract

Aims The aims of the present study were to evaluate oral health status among Brazilian adults aged 35 to 44 years with regard to functional dentition based on four different definitions and classify dentition configurations using a dental functional status classification system.

Methods The sample was composed of 9564 individuals who participated in the 2010 National Oral Health Survey. The definitions were "well-distributed teeth" concept (WDT), the World Health Organization functional dentition concept (FDWHO), functional dentition classified by esthetics and occlusion (FD_{Class5}), and functional dentition classified by esthetics, occlusion, and periodontal status (FD_{Class6}). Dentitions were classified on six sequential, accumulative levels (anyone reaching level VI necessarily met the criteria on all previous levels): I—≥one tooth in each arch; II—≥10 teeth in each arch (WDT) or ≥20 teeth present (FDWHO); III—all 12 anterior teeth present; IV—≥3 premolar posterior occluding pairs (POPs) present; V—≥one molar POP bilaterally (FD_{Class5}); VI—all sextants with Community Periodontal Index <3 and/or loss of attachment ≤1 (FD_{Class6}).

Results The prevalence rates of the different definitions of functional dentition ranged from 42.6 % (FD_{Class5}) and 40.3 % (FD_{Class6}) to 72.9 % (WDT) and 77.9 % (FDWHO).

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Conclusions The oral health status of Brazilian adults exhibited considerable variation due to the different definitions of functional dentition, and less than half of Brazilian adults met all the criteria of function.

Clinical relevance The indication and planning of prosthetic rehabilitation should not only be based on the absence of teeth but also the distribution and periodontal status of the teeth present.

Keywords Functional dentition · Tooth loss · Dental functional classification system · Oral health

Introduction

Functional dentition is a condition that ensures oral functions even when the dental arch is not complete. The concept of functional dentition adopted by the World Health Organization (WHO) [1] and widely employed in the literature [1–4] establishes 20 teeth as the minimum required. The WHO definition of functional dentition (FDWHO) is a quantitative concept, and it has been questioned recently, as each tooth group plays a different functional role [5]. Thus, the mere number of teeth seems to be a simplistic definition for the description of oral status in terms of functionality. According to an extensive review of the literature, there is some evidence that the teeth also need to be well distributed to ensure adequate oral function, with at least 10 teeth in each arch [6]. Thus, other configurations of shortened dentitions have been studied from the standpoint of adequate occlusion, functionality, and esthetics [5]. Despite the limitations of the FDWHO concept, it endorses the goal set by the WHO of 96 % of adults with functional dentition, which has not yet reached among Brazilian adults [2, 3, 7], although oral health status has improved in this population in recent years [8–10].

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The growing interest in different configurations of shortened dentitions stems from the possibility that there is no need of prosthetic replacement for all situations of teeth lost. Such alternative approaches are more viable in the public health realm in countries where the frequency of caries is high and both financial and human resources are limited [11]. Even in clinical terms, prosthetic replacement in individuals with shortened arches has not proven to be better than the non-replacement of lost molars (Shortened Dental Arch Concept) in relation to the need for posttreatment dental intervention [12], pain stemming from temporomandibular disorder [13], quality of life [14], and satisfaction with dentition [15]. Among Chinese adults, anterior regions that were "completed" by fixed dental prostheses (FDP) or premolar regions that were "altered" to "sufficient" by FDP were significantly associated with less chance of having impaired oral health-related quality of life (OHRQoL). However, when the association between OHRQoL and wearing prostheses was analyzed, regardless of the region replaced, subjects with FDP or removable dental prostheses had a significantly higher odds for impaired OHRQoL than their counterparts with similar dental conditions without these replacements [16].

A novel dental functional status classification system has recently been proposed and evaluated in populations in Europe and Southeast Asia [5, 15, 17]. This classification system is based on the knowledge that adequate oral function is not only associated with having a minimum of 20 teeth but also with having 9 or 10 opposing pairs of teeth, including those in the anterior region [6]. The fulfillment of the functionality criteria in this system (complete anterior region and sufficient premolar and molar regions) has a positive impact on chewing [18, 19] and leads to greater satisfaction with dentition [15] and better OHRQoL [16]. However, this system does not incorporate periodontal status in the definition of adequate functional dentition, which is a necessary aspect to consider. A reduced periodontal ligament due to periodontitis may affect the neural control of chewing actions due to degradation or changes in its sensory function signals from periodontal mechanoreceptors [20]. Studies conducted with Swedish [20] and Brazilian adults [21] found that the loss of periodontal support tissue due to periodontitis and reduced alveolar bone height led to a worse chewing performance. Although Okada et al. [22] evaluated older adults, it has been the only population-based study to evaluate the effect of periodontal status on chewing performance and found that the loss of periodontal support tissue exerts a negative impact on chewing function.

The designers of the dental functional status classification system have suggested its application in different populations [5], which was performed for the first time in America in the present study. Moreover, the incorporation of a new functionality item (i.e., periodontal status) to the system suggested by Nguyen et al. [5] is relevant to this investigation.

The aims of the present study were to evaluate oral health status among Brazilian adults aged 35 to 44 years with regard to functional dentition based on four different definitions and to determine agreement among the four definitions. It was hypothesized that the prevalence of functional dentition would be affected by the definition used, since agreement among the four definitions must be low. The definitions are explained in the "Material and Methods" section.

Material and methods

Data employed and sampling

The data employed in the present cross-sectional study were taken from the 2010 National Oral Health Survey (NOHS) conducted by the Brazilian Ministry of Health (BMH) in the five regions of the country. The division of Brazil into five large regions (north, northeast, central west, southeast, and south) was determined by the Brazilian Institute of Geography and Statistics and has been used in epidemiological studies with a national scope. Thus, these regions were adopted in the sampling project, along with the capitals of the 27 Brazilian states, including the Federal District, which totaled 32 domains formed by 177 municipalities (27 capitals and 30 municipalities in each region). The sample was obtained through the random selection of municipalities and census sectors, configuring multi-stage cluster sampling with probability proportional to size [23]. Detailed information on the method employed is found in other publications [2, 24].

For the 35- to 44-year-old age group used in the present study, the calculation of the sample size was based on the mean number of decayed, missing, and filled teeth (DMFT) in each domain based on data from a national survey conducted in 2003 [8]. The sample size was increased to compensate for a possible 20 % loss rate and a design effect of 2 [23].

Data collection

Data collection involved oral examinations to determine the prevalence and severity of the main adverse oral health conditions. The field teams were formed by an examiner (dentist) and annotator who had undergone 32 h of training workshops. Consensus calibration was adopted to calculate the level of agreement between each examiner and the results obtained by consensus of the team. Kappa coefficients were calculated for each examiner and condition studied, with 0.65 established as the minimum acceptable value [24].

The oral examinations were performed following the guidelines of the WHO manual for epidemiological studies [25], using the DMFT index, the Community Periodontal

Index (CPI), and loss of attachment (LA) for the determination of tooth status and periodontal status, respectively. Among all the oral data collected, only the DMFT index, number of teeth (including 3rd molars), tooth group, number of posterior occluding pairs (POPs), and CPI/LA codes of the sextants were considered in the present study. The total number of teeth was determined by the number of teeth present, excluding codes 4 and 5 (missing) and 8 (unerupted) of the DMFT index. A POP was defined as a pair of antagonist posterior teeth on each side of the mouth, such as the pairs formed by teeth 16 and 46 and teeth 26 and 36. Periodontal status was determined by the highest CPI and LA codes encountered among the sextants. Satisfactory periodontal status was defined as the presence of CPI ≤ 3 (pocket <6 mm) and/or LA ≤ 1 (loss of attachment <6 mm).

Functional dentition assessment

Four definitions that may correspond to a functional dentition were compared. The "well-distributed teeth" concept (WDT) corresponds to the presence of 10 teeth in each arch [5, 6]. The WHO functional dentition concept (FDWHO) was defined as the presence of 20 teeth in the mouth [1, 3]. Functional dentition classified by esthetics and occlusion (FD$_{Class5}$) corresponds to dentitions that sequentially exhibit at least one tooth in each arch, at least 10 teeth in each arch, all maxillary and mandibular anterior teeth, three or four premolar POPs, and at least one molar POP bilaterally. Functional dentition classified by esthetics, occlusion, and periodontal status (FD$_{Class6}$) corresponds to FD$_{Class5}$ with the addition of periodontal status of all sextants in the oral cavity with, at most, shallow pockets (<6 mm) and/or loss of attachment of 5 mm (CPI ≤ 3 and/or LA ≤ 1).

Dental functional status classification system

Nguyen et al. [5] developed a dental functional status classification system based on criteria that reflect the function of different groups of teeth and other requirements to ensure adequate oral function, such as the number of natural teeth and number of POPs. In the present study, adapted versions of this system were used to classify the dentition of the participants, which include the periodontal status of the teeth. Dentitions were classified based on a dichotomized six-level, step-by-step, branching hierarchy (Table 1). Level I (dentition level) separates individuals who are edentulous in the maxilla and/or mandible (cutoff, $\geq$one tooth in each arch). Level II (arch level) is based on the "20 well-distributed teeth" concept and the assumption that, for adequate oral function, including being satisfied with dental esthetics and chewing function [15], adequate distribution of at least 10 teeth in each arch is required to allow nine to ten opposing pairs of teeth [6] (cutoff, $\geq$10 teeth in each arch (WDT)). Level III (anterior level) is based on the strong association between the anterior teeth and

satisfaction with dental esthetics [15] as well as the importance of the anterior teeth to chewing foods such as apples [18, 19] and carrots [19] (cutoff, 12 anterior teeth). Levels IV (cutoff, 3 or 4 premolar POPs) and V (cutoff, $\geq$one molar POP bilaterally) are based on findings that having premolar and molar regions with sufficient occlusal support (i.e., 3 or 4 pairs of premolars and at least 1 occluding pair of molars bilaterally) diminishes the odds of having chewing problems with fibrous and pasty foods [18, 19]. Moreover, posterior occlusal support is associated with general satisfaction with dentition, dental esthetics, and chewing function, independently of the uniform distribution of 10 teeth in each arch, complete anterior region, and prosthetic tooth replacement [15]. Level VI (created through the adapted version of the system) (cutoff, all sextants with CPI ≤ 3 and/or LA ≤ 1) is based on the knowledge that the loss of periodontal tissue support exerts a negative impact on chewing function [22]. Periodontal status was included as another level in the classification system based on the fact that the consequences of advanced periodontal disease (gingival inflammation, tooth mobility, and the increase in interproximal spaces) can exert a negative impact on comfort, occlusion, and esthetics, which are necessary aspects of a functional dentition. For this level, the criteria of all sextants in the oral cavity with, at most, shallow pockets (<6 mm) and/or loss of attachment of 5 mm (CPI ≤ 3 and/or LA ≤ 1) was considered to define satisfactory periodontal status.

Data analysis

Graphs were constructed to visualize tooth retention patterns according to tooth group for each sex separately. The proportions of adults with WDT, FDWHO, FD$_{Class5}$, and FD$_{Class6}$ were calculated with respective confidence intervals (95 % CIs). The proportions of individuals who sequentially met the cutoff points for the criteria of the dental functional status classification system were calculated for the overall sample and the group of dentate individuals with WDT and FDWHO. As the Mann-Whitney test revealed a significant difference between sexes ($p < 0.001$), the mean number of teeth and mean number of POPs were determined separately for men and women. The results of the dentition configurations based on the dental functional status classification system were presented in bar charts (percentage of men and women above and below the cutoff points for each level) and line charts (number of teeth and number of POPs). Based on the dental functional status classification system, maxillary and/or mandibular edentulous individuals were excluded from the analysis on level I. From level II, the proportions of dentate men and women who reached the cutoff points were calculated. For the comparison of WDT and FDWHO of functional dentition in relation to meeting the other criteria of the dental functional status classification system, another version was tested replacing WDT with FDWHO on level II.

Table 1 Levels and criteria for dichotomization of the step-by-step branching hierarchy[a]

Level	Yes	No	Dichotomy
I—Dentition level	≥one tooth in each arch	Edentulous arch(es)	≥1 tooth vs no teeth
II—Arch level (WDT)	≥10 teeth in each arch	<10 teeth in each arch	≥10 teeth vs <10 teeth
II—Arch level (FDWHO)	≥20 teeth present	<20 teeth present	≥20 teeth vs <20 teeth
III—Anterior level	All 12 anterior teeth present	<12 anterior teeth	Complete vs incomplete
IV—Premolar level	3 or 4 POPs of premolars	≤2 POPs of premolars	Sufficient vs insufficient
V—Molar level (FD$_{Class5}$)	≥one POP of molars bilaterally	No POP of molars bilaterally	Sufficient vs insufficient
VI—Periodontal level (FD$_{Class6}$)	All sextants with CPI ≤3 and/or LA ≤1	≥one sextant with: CPI = 4 or excluded sextant and LA ≥2 or excluded sextant	Satisfactory vs unsatisfactory

WDT well-distributed teeth concept, *FDWHO* World Health Organization functional dentition concept, *FD$_{Class5}$* functional dentition classified by esthetics and occlusion, *FD$_{Class6}$* functional dentition classified by esthetics, occlusion, and periodontal status, *POP* posterior occluding pairs, *CPI* community periodontal index, *LA* loss of attachment.

Adapted from Nguyen et al. [9] with permission of Quintessence Publishing Company Inc. Chicago

All descriptive analyses were weighted by the sample weight due to the design effect of complex sampling using the *Complex Samples* command of the SPSS program. Observed and expected agreement and kappa coefficients were calculated to determine the level of agreement among the four definitions of functional dentition. All statistical analyses were performed using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA) and graphs generated on Microsoft® Excel® 2013.

Results

The initial sample identified for participation in the survey consisted of 9779 adults, but examinations were not performed on 215, resulting in a final sample of 9564 adults. The predominant teeth present were incisors, canines, and premolars in both arches in men and women (Fig. 1). Molars were the least frequent teeth in both sexes. The mandibular first molars were present in 57.1 % of the men and 56.2 % of the women.

Among the total sample (9564 subjects), 1039 (10.1 %; 95 % CI 8.5–12.0 %) were edentulous in the maxilla and/or mandible. The prevalence rates of the different definitions of functional dentition in the total sample ranged from 42.6 % (95 % CI 40.0–45.2 %) (FD$_{Class5}$) and 40.3 % (95 % CI 37.7–43.0 %) (FD$_{Class6}$) to 72.9 % (95 % CI 70.1–75.4 %) (WDT) and 77.9 % (95 % CI 75.4–80.2 %) (FDWHO). Considering only dentate individuals, the prevalence rates of WDT and FDWHO were 81.1 and 86.6 %, respectively. Table 2 displays the percentage of adults with WDT and FDWHO who reached the cutoff points sequentially on levels II to VI. Among the 6541 adults with WDT, 86.2 % (95 % CI 84.1–88.0 %) had a complete anterior region, but this figure diminished as the cutoff points of the following levels were considered. The same occurred in dentate individuals with FDWHO (*n* = 7153), among whom the vast

majority (93.6 %) had ≥10 teeth in each arch (WDT). Although the proportion of individuals with WDT above the cutoff points on the subsequent levels was greater than the proportion of individuals with FDWHO, this difference did not achieve statistical significance due to the overlap of the 95 % CIs. About half of the dentate individuals in both groups met all functionality criteria. Figure 2 displays the prevalence rate of adults who met or failed to meet the criteria on each level of the dental functional status classification system in relation to the total sample. Among those who failed to meet the level II criterion (right side of Fig. 2), the vast majority also failed to meet the criteria on the subsequent levels.

In the group with WDT (left side of Fig. 2), the proportion of men whose dentition configuration met the criteria of functionality was greater than the proportion of women on all levels, except level III. These differences were statistically significant for the presence and absence of the cutoff point on level I and the absence of the cutoff point on level III. On the latter level, the proportion of men without a complete anterior region (14.6 %; 95 % CI 11.6–18.2 %) was greater than the proportion of women (9.2 %; 95 % CI 7.8–10.7 %). Moreover, an accentuated decrease in the percentage of subjects that met higher levels of functionality was found for both sexes. The inclusion of periodontal status proposed herein to the original system proposed by Nguyen et al. [5] did not result in a significant reduction in the proportion of adults who met all criteria. Although 42.6 % of the adults reached the cutoff points through level V and this figure diminished to 40.3 % with the inclusion of level VI, the 95 % CIs overlapped (data not shown). Likewise, the reduction found when the sexes were analyzed separately also did not achieve statistical significance. Similar patterns were found when FDWHO replaced WDT on level II, especially on levels V and VI, on which the number of adults who met the criteria was equal (Online Resource 1).
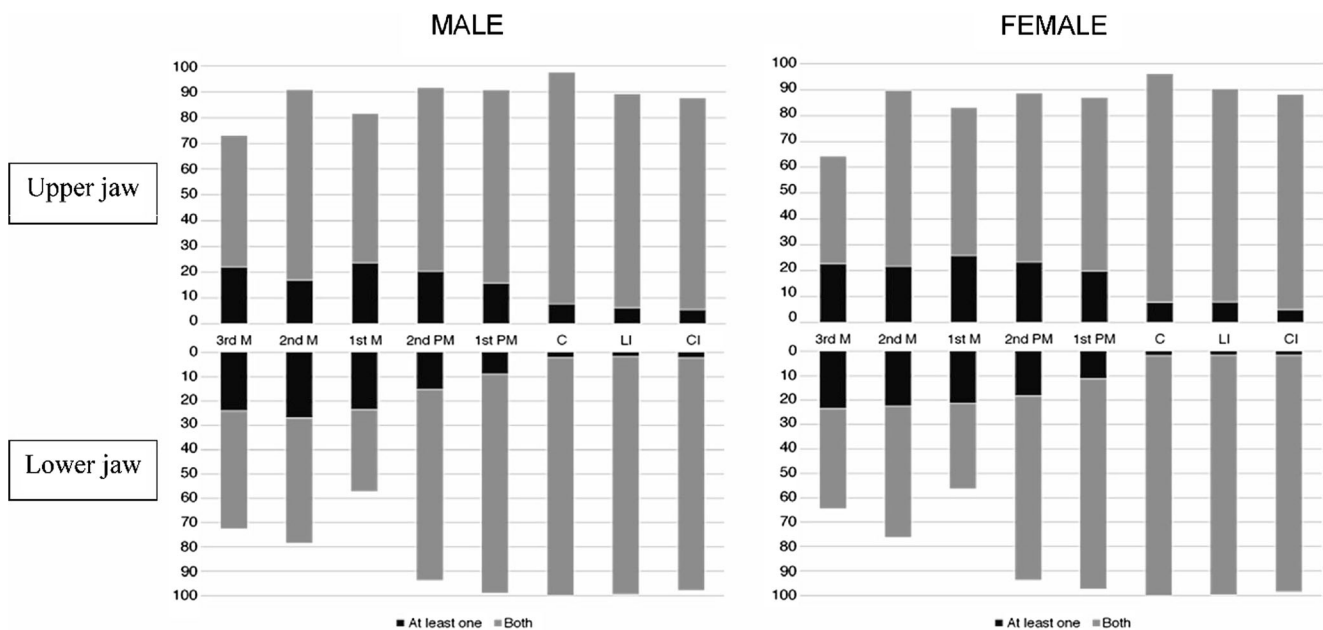
Fig. 1 Percentage of adults with retention of at least one or both maxillary and mandibular teeth according to type of tooth among individuals aged 35 to 44 years stratified by sex, Brazil 2010

Among the dentate individuals, the mean number of teeth was 25.4 (95 % CI 25.1–25.6) and the mean number of POPs was 5.6 (95 % CI 5.5–5.8). In the group with WDT, the mean number of teeth among men and women was 27.4 and 27.2, respectively, which was higher than among those without WDT (17.5 and 17.1, respectively) and similar to the figures found when FDWHO was considered (27.0 and 26.8, respectively) (Fig. 2 and Online Resource 1). Men and women who reach the cutoff points for levels II to VI (left side of Fig. 2) had, on average, 27 to 29 teeth. The mean number of POPs was considerably higher among the men and women who sequentially met the functionality criteria of levels II to VI. Similar results were found for the number of teeth and POPs when FDWHO replaced WDT on level II (Online Resource 1).

Table 3 shows the results of observed and expected agreement and kappa coefficients among functional dentition definitions. The observed agreement among the definitions was higher than that expected simply due to chance, especially between WDT and FDWHO (93.6 vs. 59.1 %) and between FD_{Class5} and FD_{Class6} (98.1 vs. 53.1 %), for which the calculated kappa coefficients were the only values to express nearly perfect agreement. Lower agreement was found between FDWHO and FD_{Class5} and FD_{Class6}.

Discussion

We hypothesized that the prevalence of functional dentition is affected by the definition employed and that agreement

Table 2 Percentage, Confidence Interval 95% and Count of dentate individuals meeting the criterion after dichotomization at different levels for all cut-offs

	Main definitions					
Cutoffs of different levels	WDT (≥10 teeth in each arch) (n = 6541)			FDWHO (≥20 teeth present) (n = 7153)		
	%*	95 % CI*	n	%*	95 % CI*	n
II—Arch level (WDT = ≥10 teeth in each arch)	–	–	–	93.6	92.0–94.8	6541
III—Anterior level	86.2	84.1–88.0	5537	82.4	80.3–84.3	5745
III—Anterior level + IV—premolar level	68.9	66.2–71.4	4389	64.6	62.0–67.1	4418
III—Anterior level + IV—premolar level + V—molar level (FD_{Class5})	58.4	55.7–61.1	3645	54.7	52.0–57.2	3645
III—Anterior level + IV—premolar level + V—molar level + VI—periodontal level (FD_{Class6})	55.4	52.3–58.4	3428	51.8	49.0–54.6	3428

WDT the well-distributed teeth concept *FDWHO* the World Health Organization functional dentition concept *CI* Confidence Interval *FD_{Class5}* functional dentition classified by esthetics and occlusion *FD_{Class6}* functional dentition classified by esthetics, occlusion and periodontal status

*Percentages and 95 % CIs weighted by sample weight
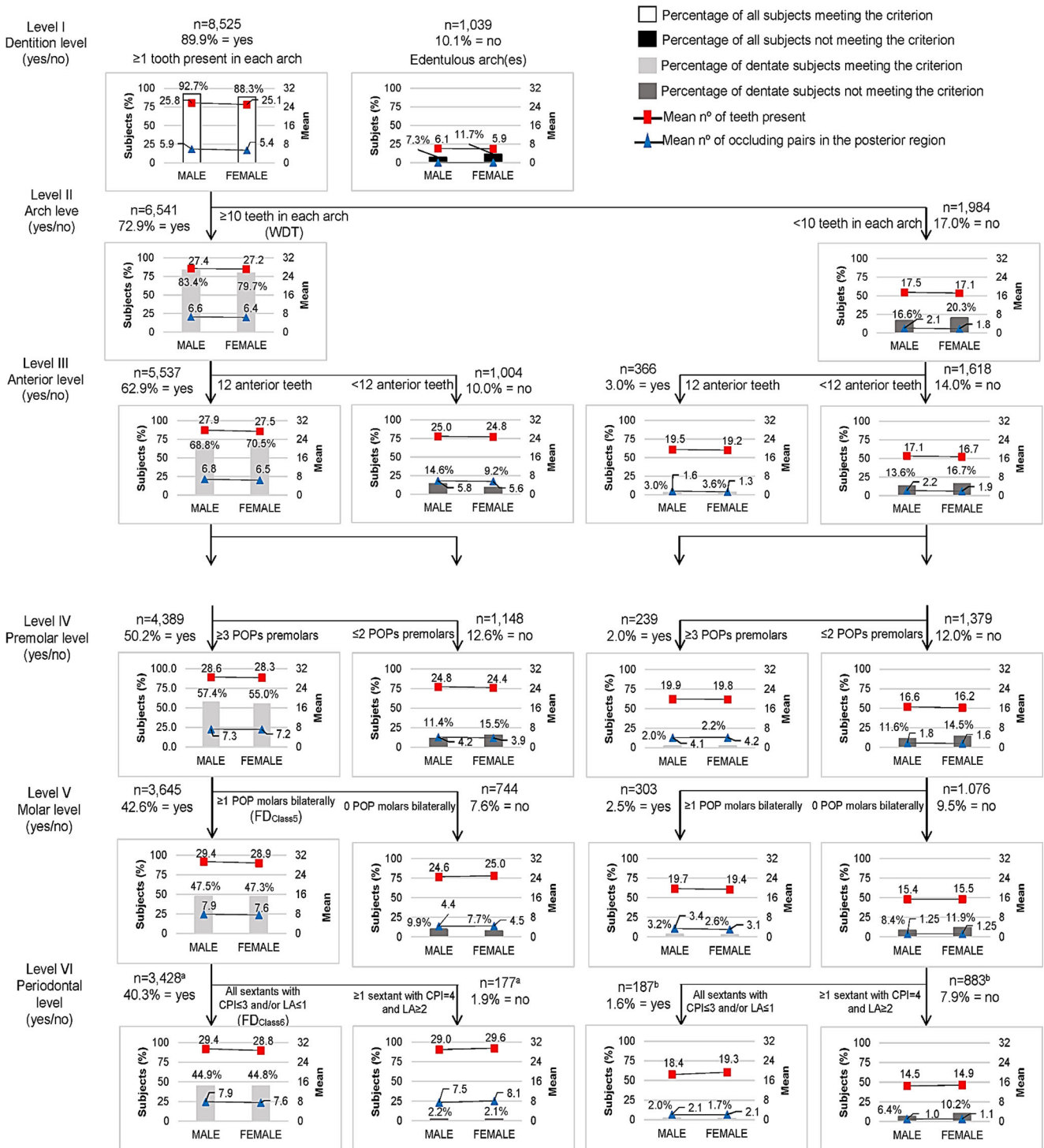
Fig. 2 Distribution of subjects, by sex, according to the dental functional status classification system adapted from Nguyen et al. (Level II—WDT). *WDT* the well-distributed teeth concept, *POP* posterior occluding pairs, *FD_Class5* functional dentition classified by esthetics and occlusion, *FD_Class6* functional dentition classified by esthetics, occlusion, and periodontal status, *CPI* Community Periodontal Index, *LA* loss of attachment. superscript letter a 40 missing periodontal exams, superscript letter b 6 missing periodontal exams

among the four definitions must be low. Our assumptions were confirmed. Prevalence rates of functional dentition varied considerably among Brazilian adults using four different definitions. Lower prevalence rates were found for FD_Class5 and FD_Class6, which were more demanding in terms of function. Agreement expressed using kappa coefficients was fair

Table 3 Observed and Expected Agreement, and kappa coefficients among functional dentition definitions

Functional dentition definitions	FD$_{Class6}$		WDT		FDWHO	
	%	Kappa[a]	%	Kappa[a]	%	Kappa[a]
WDT	67.7 (44.9)	*0.41*	–	–	–	–
FDWHO	61.3 (43.2)	*0.32*	93.6 (59.1)	*0.84*	–	–
FD$_{Class5}$	98.1 (53.1)	*0.96*	69.7 (45.6)	*0.44*	63.3 (44.1)	*0.34*

WDT well-distributed teeth concept, *FDWHO* World Health Organization functional dentition concept, *FD$_{Class5}$* functional dentition classified by esthetics and occlusion, *FD$_{Class6}$* functional dentition classified by esthetics, occlusion, and periodontal status

Kappa coefficients in italic type with *p* value <0.001

to moderate between the new proposed definitions (FD$_{Class5}$ and FD$_{Class6}$) and the most widely employed definitions (WDT and FDWHO). Classifying the configurations of dentitions using the dental functional status classification system adapted from Nguyen et al. [5], nearly half of the dentate individuals met all proposed functionality criteria. The proportions of dentate individuals with WDT and FDWHO that reached the cutoff points subsequently were similar, which contrasts the notion that WDT would be capable of meeting the other criteria in a broader-scoped fashion in comparison with FDWHO [5].

One limitation of this study is that a POP was defined as a pair of antagonist posterior teeth, but it was not possible to verify occlusal contact due to the fact that the data were obtained indirectly through the databank provided by the BMH. Another limitation concerning clinical exams is that only index teeth were evaluated and each individual was classified based on the highest CPI and LA values encountered, as proposed by the WHO [25] due to its greater viability in epidemiologic studies. On the other hand, one of the strengths of our study is the high number of participants in this national representative sample, which was approximately three times larger than samples in previous studies [5, 15, 17]. Moreover, to the best of our knowledge, this was the first time that the dental functional status classification system proposed by Nguyen et al. [5] was adapted, with the inclusion of periodontal status and administered to a population in the Americas.

The configuration of dentitions was evaluated based on the presence of groups of teeth, which demonstrated that the first molars were the most frequently missing teeth in both arches in men and women. This finding confirms previous evidence that molars are at a greater risk of developing caries and being extracted in comparison to anterior teeth and premolars [26, 27]. Such risks are even greater for molars in the mandibular arch [27], which may explain the greater frequency of missing mandibular first and second molars in both sexes in the present study. The poorer status of molars in different populations may be explained by the long exposure time of the first molar in the oral cavity due to its earlier eruption as well as the anatomic aspects of molars that hinder adequate hygiene, such as the more posterior location and more retentive grooves and

fissures. Considering this greater risk, the fact that molars are less retained in dentitions and evidence that prosthetic replacement is not justified in terms of either clinical [12, 13] or subjective [14, 15] aspects, it seems sensible to incorporate shortened dentitions to the premolars into clinical practice and oral health goals.

The prevalence rates of WDT and FDWHO among the total sample of Brazilian adults were significantly higher than those found among Vietnamese adults [5] and slightly lower than the proportion of Chinese adults with WDT. A study involving Bulgarian adults identified the same proportion of dentate adults with WDT [15]. These comparisons demonstrate that, although the goal proposed by the WHO [7] is far from being reached, the situation in Brazil is not much different from that in other countries. However, one must consider the difference that the participants in the studies cited ranged in age from 20 to more than 70 years [5, 15, 17], a rather large range that encompasses the range employed in the present study (35 to 44 years).

A significant difference between the sexes was found on level I, as the frequency of edentulism was greater among the women. This finding is in agreement with data from previous studies that report that women have a greater chance of exhibiting missing teeth in the dentition as a whole [26] as well as a smaller chance of having a functional dentition [3]. Regarding the sequential levels (II to VI), the only significant difference between sexes was found for level III: the proportion of women without a complete anterior region was lower than the proportion among the men. This finding is also supported by data reported in the literature. According to Damyanov et al. [26], women have less chance of losing the anterior teeth than men, probably due to their higher esthetic demands.

Direct comparisons among studies regarding the mean number of teeth and POPs in the dentitions on each level is not possible due to the fact that previous studies using the dental functional status classification system pooled the sexes in the analyses and also analyzed a broader age range [5, 15, 17]. However, the means reported in the four populations were quite similar, likely demonstrating a similar pattern: Greater mean numbers of teeth and POPs were found in groups whose

dentitions met all functionality criteria and the lowest means were found in groups that failed to meet any of the cutoff points.

If the oral health status of the Brazilian population were evaluated using the WDT and FDWHO definitions, the conclusion would be that the situation is more favorable due to the higher prevalence rates. When taking into account the distribution of the teeth in the regions of the mouth and periodontal status (FD_{Class5} and FD_{Class6}), the majority of individuals (approximately 60 %) does not have oral status that meets the requirements for function proposed by the dental functional status classification system adapted from Nguyen et al. [5]. Incorporating these requirements to the concept of functional dentition leads to a qualitative definition that is more compatible with esthetic and nutritional demands. These requirements have been demonstrated to have a positive association with satisfaction with the mouth [15] as well as chewing ability [18, 19] and satisfaction with chewing performance [15]. The addition of these requirements to the quantitative criterion makes the new definitions studied the "best" definitions of functional dentition from both the normative and subjective standpoints.

Among the advantages of using these new definitions is the adoption of clinical parameters that involve esthetics, which is related to the functions of speaking and smiling as well as satisfactory occlusion and periodontal status, which contribute favorably to chewing function. Occlusal contacts due to POPs favor chewing by enabling the adequate shredding of food. Moreover, the role of satisfactory periodontal status can be explained because it is intuitive that high occlusal forces demand that teeth are firmly supported by healthy periodontal tissue [22]. According to Alkan et al. [28], occlusal harmony exists when the various components of the masticatory system (teeth and supporting bone, temporomandibular joint, muscles, and ligaments) are healthy and can withstand the functional stress. Occlusal equilibrium is impaired by periodontal disease when the bone around the teeth is reduced, tooth mobility is increased, and teeth migrate [28]. The disadvantage of adopting these new definitions is the more restrictive nature of these conditions and the need to add new items to clinical exams performed in studies, such as occlusal contact between posterior teeth, to allow the evaluation of oral status not to be restricted to counting the number of teeth present.

WDT and FDWHO exhibited high and significant agreement, demonstrating that these definitions can be considered almost as the same outcome in populations with similar characteristics to those of Brazilian adults. Despite this, agreement between WDT and the new proposed definitions (FD_{Class5} and FD_{Class6}) was slightly higher than that found between them and FDWHO. However, agreement in both cases was considered low. Thus, one of the main definitions of functional dentition proposed in the literature (WDT) were not completely capable

of determining the new criteria of functionality in the adult Brazilian population, as suggested in previous studies [5, 6].

The present findings point to the comparison of four definitions of functional dentition as a direction for other study designs, which should include a clinical evaluation of bite force and other subjective aspects. Case-control and cohort studies could evaluate which of these definitions is most related to occlusal force and satisfaction with the mouth over time. One question that remains without an answer regards the inclusion of periodontal status to the original system. This can only be determined in future studies that involve the evaluation of the periodontal status of each tooth and are conducted with different populations. The recognition of the new definitions of functional dentition implies a revision of public policies and clinical practices of rehabilitation, since prosthetic replacement in adults should not only be based on the teeth that are absent but also on how the teeth present are distributed and their periodontal status.

Conclusions

The oral health status of Brazilian adults varied considerably using the different definitions proposed for functional dentition, and a low level of agreement was found between the new definitions (FD_{Class5} and FD_{Class6}) and those currently employed (WDT and FDWHO). The use of function criteria that consider esthetics, occlusion, and periodontal status demonstrates that only a small portion of this population have dentitions that meet all these criteria. There is no evidence of the need to replace FDWHO with WDT in public oral health policies for populations with similar epidemiological characteristics to the sample analyzed herein. When considering the adoption of the new definitions for the establishment of oral health goals, researchers and administrators should bear in mind their restrictive nature. The indication and planning of prosthetic rehabilitation should not only be based on the teeth that are absent but also on how the teeth present are distributed and their periodontal status. This is valid both for the treatment of patients in clinical practice as well as the establishment of goals in public policies.

Compliance with ethical standards

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare that they have no competing interests.

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