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Oral diadochokinesis and associated oro-facial function in young and old German mother-tongue speakers: A cross-sectional study

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Abstract

Objectives: The aims of this study were to compare oral diadochokinesis and to test associations with oro-facial functional parameters in healthy young and old German speakers.

Background: Oral diadochokinesis is a key component in the concept of oro-facial hypofunction and relates to tongue and lip motor function but may depend on the linguistic background.

Materials and methods: Healthy German speakers with a minimum of 20 teeth were recruited to form a young (<60 years) and an older group (≥60 years). Oral diadochokinesis was assessed as the number of repetitions/s for the monosyllables /pa/, /ta/ and /ka/ to evaluate movement capacity of the lip, the anterior region of the tongue and the posterior region of the tongue, respectively. Maximum voluntary lip force, maximum voluntary bite force, masticatory performance, maximum voluntary tongue pressure, xerostomia and swallowing function were assessed with validated instruments. Results are presented as median (IQR).

Results: Sixty participants formed the younger group (n = 35, 30.0 years [24.0-49.0]) and the older group (n = 25, 64.0 years [62.0-72.0]). Counts/s of /ta/ were different between age groups (younger group: 6.0 vs older group: 5.4) but not for syllables /pa/ (younger group: 6.0 vs older group: 5.8) and /ka/ (younger group: 5.6 vs older group: 5.0). The oral diadochokinesis with /pa/ was overall associated with maximum voluntary lip force; oral diadochokinesis performed with /ta/ was associated with tongue pressure, and oral diadochokinesis with /ka/ with swallowing function. Masticatory performance was not associated with oral diadochokinesis but with maximum voluntary bite force, xerostomia and with maximum voluntary tongue pressure.

Conclusions: The published thresholds for oral diadochokinesis should be reconsidered in non-Japanese mother-tongue speakers. However, they still play an important role in the overall concept of oro-facial functional assessment.

Tania Domioni and Hristina Bukvic shared equal contribution as second authors.

KEYWORDS
cross-sectional study, oral diadochokinesis, oro-facial fitness, oro-facial hypofunction

1 | INTRODUCTION

In geriatrics, there has recently been increased interest in the assessment and management of oro-facial functional parameters, as the ageing process is an important co-factor in the decline of functional capacity from a fit state to signs and symptoms of hypofunction, which may lead to compromised general health and quality of life.[1-4]

In the position paper of the Japanese Society of Gerodontology (JSG), Minakuchi et al (2018)[5] used the term "oral frailty" to describe an unfavourable oral condition in older people that is characterised by decreased articulation, slight choking or spillage while eating and an increase in the number of non-chewable foods. These characteristics are derived from numerous epidemiological studies, mainly from Japan.[3] In their paper, oral frailty was described as the first step towards manifest painful and functional problems, which can be qualified as oral hypofunction.[5] In Japanese epidemiological studies, the key components of oral hypofunction were identified: poor oral hygiene, oral dryness, reduced occlusal force, decreased tongue–lip motor function, decreased tongue pressure, decreased masticatory function and deterioration of swallowing function.[6]

Oral diadochokinesis (OD) is a key component in the concept of oro-facial hypofunction and relates to tongue and lip motor function. OD is defined in speech-language pathology as the speed necessary to stop a determined motor impulse and substitute it with its opposite. The relative timing of this kind of movements is also called alternate motion rates or sequential motor rates,[7] for example, in the diagnosis of tachyphemia in patients with Parkinson disease.[8] It is commonly assessed as the ability to repeat as quickly as possible the monosyllables /pa/, /ta/ and /ka/ to evaluate movement capacity of the lip, the anterior region of the tongue and the posterior region of the tongue, respectively. OD was suggested to be associated with masticatory and swallowing disorders, that is, oral hypofunction.[9-11] However, most of the research related to oro-facial hypofunction and OD, in particular, was conducted exclusively in Japan with Japanese samples.

It was reported that the linguistic background plays a significant role in the performance of OD tests. For example, there are important differences between Hebrew speakers and English speakers to this respect.[12] Therefore, the objective of the current study was to assess OD in healthy younger and older German-speaking convenience samples and discuss those with the widely applied Japanese normal values. Additionally, associations with selected oro-facial functional parameters and OD should be assessed.[12]

2 | METHODS

Ethics approval was obtained (KEK Bern, No. 2020-02410). Participants were recruited for this cross-sectional study from patients and staff of the School of Dental Medicine (University of Bern, Switzerland) if they fulfilled the inclusion criteria: age >18 years, Caucasian origin, mother tongue "German" and n ≥ 20 teeth and were excluded if they presented with neuro-cognitive diseases, history of severe surgical interventions in the head and neck area, presence of temporo-mandibular disorders or removable dental prostheses. It was attempted to recruit a younger sample (18-59 years) and an older group of participants (60+ years). The assessments took place in the dental chair, with the participants in seated upright position and were performed by one specifically trained dentist. Basic characteristics like age, gender and the number of functional occluding premolar units (OU) were noted.[13] Occluding premolar units (OU) signify the total number of premolar units in occluding contact; premolars are counted as 1 OU and molars as 2 OU.[13]

2.1 | Oral diadochokinesis

Oral diadochokinesis was assessed as the number/s of the monosyllables /pa/, /ta/ and /ka/ to evaluate the function of the lips, the tip of the tongue and the posterior region of the tongue with an automatic counter (Kenkokun Handy, Takei Scientific Instruments Co., Niigata, Japan). Participants were asked to repeat the monosyllables as quickly as possible for 5 seconds, and the number of repetitions/second was calculated by the device individually for each monosyllable.[11] A training with each participant was performed prior to the test recording to ensure that the participant had fully understood the instructions and was familiar with the test.

2.2 | Maximum voluntary lip force

Maximum voluntary lip force (MLF) was recorded with a hand-held force gauge (ZP50-N; Imada Co.) that was connected with a steel wire to an oral screen with the dimensions 55 × 24 mm, which was placed in the oral vestibule (Dentaurum "Oral screen Ulmer Modell" maxi/size 2; Dentaurum GmbH). An anterior rectangular displacement force was applied by pulling the dynamometer. The participant was asked to withstand the force as long as possible, and the peak force (N) was recorded. The mean of the three peak forces was used for further analysis.[14]

2.3 | Maximum voluntary bite force

For the evaluation of maximum voluntary bite force (MBF), the Occlusal Force-Meter GM 10® (Nagano Keiki Co.) was used. It comprises an 8.6-mm-thick bite element that was placed between the first molars. Participants were instructed to bite as hard as possible on the gauge for approximately 3 seconds. If the first molar was missing, the second premolar was used for the recording. Measurements were performed three times on each side. The peak force (N) of each side was used to calculate the mean between sides, which resulted in one force value/participant for statistical analysis.[13]

2.4 | Masticatory performance

The chewing function was measured as masticatory performance (MP) with a previously validated color-mixing ability test.[15,16] The test specimen (Hue-Check Gum©, University of Bern, Switzerland) consisted of a pink and an azure layer. The layers were manually stuck together, placed on the tongue of the participant who was instructed to chew the gum for 20 chewing cycles. The number of chewing cycles was verified by the examiner who subsequently removed the specimen from the mouth, air dried it and put it in a transparent plastic bag. The gum was flattened to a wafer of 1 mm thickness and scanned with a flatbed scanner from both sides (300 dpi, jpg format, Epson Perfection V30; Seiko Epson Corp.). The resulting images were analysed by means of custom-made software (ViewGum©; dhal.com) to obtain the variance of hue (VOH) as a measure of the degree of color mixture. The higher the VOH, the lower is the masticatory performance, and vice versa.[17]

2.5 | Maximum voluntary tongue pressure

Maximum voluntary tongue pressure (MTP) was assessed with two different tongue pressure measuring devices, which are both balloon based, but have different technical specifics in regard to balloon size and material as well as connection tubes and electronic manometers. Firstly, the participants underwent an evaluation of MTP with the JMS device (TPM-01, JMS Co., Ltd.),[18] and secondly with the Iowa Oral Performance Instrument® (IOPI; Northwest Co., LLC).[19] Participants were asked to place the balloon between the anterior hard palate and dorsum of the tongue with closed mouth and subsequently try to compress the balloon with the highest available tongue pressure against the hard palate for approximately 7 seconds. The experiment was repeated twice, and the mean of the three pressure readings (kPa) was used for further analysis for each of the two instruments separately. The IOPI is currently the gold standard for assessing MTP globally, but the JMS device shows very promising results in the scope of the diagnosis of oro-facial hypofunction.[5] MTP assessments with the IOPI or JMS device might be comparable when the values obtained are normalised to each other.[14]

2.6 | Swallowing function

To assess swallowing function, the EAT-10 questionnaire was completed by the participants. It was designed to assess subjective swallowing complaints in terms of symptom severity, impact on quality of life and treatment success.[20] The questionnaire comprises 10 questions with a Likert scale (0, *no problems* to 4, *maximum problems*, range 0-40). A sum score of 3 or higher indicates the presence of dysphagia.[21] Swallowing function (SF) was analysed as a binary factor (0; 1+) as in the healthy study population; no diagnosis of clinically relevant dysphagia was expected.

2.7 | Xerostomia

Xerostomia as subjective symptoms of dry mouth was assessed using the German 14-item version of the Xerostomia Inventory.[22] Participants were asked to report the frequency of 14 symptoms that are related to dry mouth and throat using a five-point ordinal rating scale. The Xerostomia Inventory sum score may range from 0 to 56, and with higher scores indicating more symptoms of dry mouth.[23]

2.8 | Statistical analysis

The rationale for the sample size was based on the following studies that assessed OD in relation to oral function in Japanese cohorts: Komagamine et al included 54 participants in their cross-sectional study and found significant association to MP in elderly denture wearers.[10] Yamada et al[11] included 51 dentate adults in their cross-sectional study and equally found that OD is a significant predictor for MP. Hence, it was expected that 60 participants would suffice to find meaningful results.

Data were assessed descriptively showing medians (with 25%-75% quantiles) or frequencies (with percentages) for the overall sample size and by age groups. Differences in parameters between age groups were assessed using Mann–Whitney or exact Fisher tests, depending on data distribution.

Correlation between counts of monosyllables /pa/, /ta/, /ka/ and several numerical parameters were assessed with the help of Spearman's rank correlation coefficient ("Rho"). Group-wise comparisons on numerical outcomes were assessed by calculating the Hodges–Lehmann estimator for location difference and performing again a Mann–Whitney test. Finally, impacts on the binary outcome EAT-10 were assessed with the help of logistic regression.

All analyses in this report were performed with the statistics software R, version 3.5.0.[2] Throughout, P-values less than .05 were considered statistically significant. No correction for multiple testing was applied because of the explorative nature of this study.

3 | RESULTS

Sixty participants participated in the study and formed younger and older age groups. Median counts/s of the monosyllable /ta/ were significantly different between age groups but not for syllables /pa/ and /ka/. Participants of the older age group had a higher median MLF compared with younger participants, but the younger group exhibited a higher median MTP as measured with JMS and IOPI devices. The JMS device discriminated the two groups better. The MBF was higher in the younger group than in the older group (Table 1).

Counts/s of /pa/ were overall positively weakly correlated with MLF. In the younger group, the correlation was moderate but only weakly in older group. Also, median counts/s of /pa/ significantly differed between male and female participants in the overall sample (effect for female participants: −0.6 [−1.0-0.0], *P* = .03); no differences were found in the subgroups age/gender. Counts/s of /ta/ were overall weakly correlated with MTP-JMS and MTP-IOPI. A further weak positive correlation was found between repetitions/s of /ta/ and OU (Table 2).

Median counts/s of /ka/ significantly differed between participants having a perfect EAT-10 score (score = 0) and higher EAT-10 scores (effect for 0-score participants: −0.6 [−1.2-0.0], *P* = .0499). Also, a highly significant difference between male and female participants was found in older group (effect for female participants: −1.0 [−1.6 to −0.4], *P* = .009), showing that female participants in the older group tended to have greater difficulties in pronouncing this syllable.

Masticatory performance was not significantly correlated with OD but weakly with MBF overall and xerostomia overall (especially in the older group); MP was further correlated with MTP-JMS overall (−0.30 [−0.52 to −0.05], *P* = .02) but not with MTP-IOPI (−0.19 [−0.43-0.08], *P* = .17; Table 3).

Xerostomia and MLF were overall negatively weakly correlated and even more so in the older group. Furthermore, participants with xerostomia had a higher chance for subjective swallowing difficulties. Female study participants showed lower MLF than male ones (Table 3).

4 | DISCUSSION

The present report aimed to assess OD and their relationship to specific motor skills of the oro-facial system in younger and older German mother-tongue speakers. The OD with the monosyllable /pa/ was overall associated with MLF, OD performed with the syllable /ta/ correlated with TP when assessed with the new JMS device, and OD with /ka/ with subjective disturbances of the swallowing function. There were significant age differences for the number of repetitions/s with the monosyllables /ta/ but not for /pa/ and /ka/ (trend). It is noteworthy that the participants in the older group, despite being in good general condition, did not meet the thresholds

TABLE 1 Descriptive statistics of the study sample

	All participants	Younger group	Older group	*P*-value
N	60	35	25	—
Age	52.5 (27.8-63.0)	30.0 (24.0-49.0)	64.0 (62.0-72.0)	—
Gender	Male: 34 (56.7%) Female: 26 (43.3%)	Male: 19 (54.3%) Female: 16 (45.7%)	Male: 15 (60.0%) Female: 10 (40.0%)	.79
repetitions/s /pa/	5.8 (5.0-6.4)	6.0 (5.2-6.7)	5.8 (5.0-6.2)	.18
repetitions/s /ta/	5.9 (5.4-6.4)	6.0 (5.7-6.9)	5.4 (4.8-6.2)	.003
repetitions/s /ka/	5.5 (4.6-5.8)	5.6 (4.9-6.0)	5.0 (4.4-5.6)	.08
MLF (N)	21.8 (17.9-27.5)	20.2 (16.5-25.5)	24.0 (19.1-29.1)	.03
MTP-JMS (kPa)	24.8 (26.8-39.1)	37.8 (29.6-40.6)	29.1 (25.3-35.5)	.005
MTP-IOPI (kPa)	49.7 (40.3-57.4)	52.3 (43.0-59.0)	45.3 (37.0-53.3)	.12
EAT-10 binary	0:43 (71.7%) 1+: 17 (28.3%)	0:24 (68.6%) 1+: 11 (31.4%)	0:19 (76.0%) 1+: 6 (24.0%)	.58
MBF (N)	417.5 (271.4-572.0)	476.5 (363.0-615.2)	287.0 (164.0-405.0)	.0005
OU (n)	12.0 (10.0-12.0)	12.0 (11.0-13.0)	10.0 (7.0-12.0)	.004
MP (VOH)	0.10 (0.06-0.17)	0.09 (0.06-0.17)	0.10 (0.08-0.16)	.99
Xerostomia	10.0 (2.8-13.2)	11.0 (3.0-13.0)	7.0 (1.0-15.0)	.37

Note: Data are median (25% quantile-75% quantile) and absolute frequencies (percentages). *P*-values checking for differences between age groups as of Mann–Whitney and exact Fisher tests.

Abbreviations: /pa/ /ta/ /ka/, monosyllables; EAT-10 binary, EAT-10 questionnaire score; MBF, maximum voluntary bite force; MLF, maximum voluntary lip force; MP (VOH), masticatory performance as assessed by the variance of hue (high value signifies low masticatory performance); MTP-IOPI, maximum voluntary tongue pressure as assessed with the IOPI device; MTP-JMS, maximum voluntary tongue pressure as assessed with the JMS device; N, absolute number of sample; OU, occluding premolar units.

TABLE 2 Impact of chosen covariates on repetitions/s of the monosyllables /pa/, /ta/ and /ka/

Parameter	Covariate	All participants	Young group	Old group
Number/s /pa/	MLF (N)	0.4 (0.1-0.6)	0.6 (0.30-0.78)	0.0 (−0.1-0.6)
Number/s /pa/	OU	0.2 (−0.1-0.4)	0.0 (−0.3-0.4)	0.2 (−0.2-0.6)
Number/s /pa/	MP (VOH)	−0.1 (−0.3-0.2)	−0.0 (−0.4-0.3)	−0.1 (−0.4-0.3)
Number/s /pa/	Xerostomia	−0.1 (−0.3-0.2)	−0.1 (−0.4-0.3)	−0.2 (−0.6-0.2)
Number/s /pa/	MBF (N)	0.4 (0.1-0.5)	0.2 (−0.2-0.5)	0.4 (−0.0-0.7)
Number/s /ta/	MTP-JMS (kPa)	0.3 (0.0-0.5)	0.1 (−0.2-0.4)	0.3 (−0.2-0.7)
Number/s /ta/	MTP-IOPI (kPa)	0.2 (−0.0-0.5)	0.1 (−0.3-0.4)	0.3 (−0.2-0.7)
Number/s /ta/	OU	0.3 (0.1-0.6)	0.2 (−0.1-0.5)	0.3 (−0.1-0.7)
Number/s /ta/	VOH	0.0 (−0.2-0.3)	0.0 (−0.3-0.4)	0.1 (−0.4-0.5)
Number/s /ta/	Xerostomia	0.2 (−0.1-0.4)	0.2 (−0.1-0.4)	0.1 (−0.3-0.5)
Number/s /ta/	MBF (N)	0.3 (0.0-0.5)	0.2 (−0.2-0.5)	0.2 (−0.2-0.6)
Number/s /ka/	EAT-10 bin BL: 1+	−0.6 (−1.2-0.0)	−0.4 (−1.2-0.3)	−0.8 (−1.8-0.1)
Number/s /ka/	OU	0.2 (−0.1-0.5)	0.0 (−0.4-0.4)	0.3 (−0.1-0.6)
Number/s /ka/	VOH	0.1 (−0.2-0.3)	0.1 (−0.3-0.4)	0.1 (−0.31-0.5)
Number/s /ka/	Xerostomia	0.2 (−0.1-0.4)	0.3 (−0.0-0.6)	−0.1 (−0.5-0.3)
Number/s /ka/	MBF (N)	0.2 (−0.0-0.5)	−0.1 (−0.4-0.3)	0.3 (−0.1-0.7)

Note: Data are Spearman rank correlation coefficient or Hodges–Lehmann estimator for location (95% CI).

Abbreviations: BL, baseline; EAT-10 binary, EAT-10 questionnaire score; MBF, maximum voluntary bite force; MLF, maximum voluntary lip force; MP (VOH), masticatory performance as assessed by the variance of hue (high value signifies low masticatory performance); MTP-IOPI, maximum voluntary tongue pressure as assessed with the IOPI device; MTP-JMS, maximum voluntary tongue pressure as assessed with the JMS device; OU, occluding premolar units; xerostomia, sum score of the German version of the xerostomia inventory.

TABLE 3 Impact of chosen covariates on outcomes VOH, MLF and EAT-10 Bin

Parameter	Covariate	All participants	Young group	Old group
MP (VOH)	MBF (N)	−0.33 (−0.55-0.07)	−0.32 (−0.63-0.04)	−0.27 (−0.61-0.15)
MP (VOH)	Xerostomia	0.25 (0.00-0.48)	0.14 (−0.24-0.49)	0.41 (0.07-0.66)
MP [VOH]	MTP-JMS (kPa)	−0.30 (−0.52 to −0.05)	−0.29 (−0.54-0.02)	−0.31 (−0.67-0.12)
MP [VOH]	MTP-IOPI (kPa)	−0.19 (−0.43-0.08)	−0.06 (−0.40-0.29)	−0.27 (−0.65-0.18)
MP [VOH]	Gender BL: male	0.02 (−0.02-0.06)[a]	0.04 (−0.01-0.10)[a]	−0.01 (−0.09-0.06)[a]
MLF (kPa)	Xerostomia	−0.28 (−0.51 to −0.02)	−0.10 (−0.44-0.28)	−0.42 (−0.68 to −0.06)
MLF	Gender BL: male	−4.72 (−8.01 to −1.15)[a]	−5.54 (−9.22 to −0.78)[a]	−3.51 (−9.08-2.02)[a]
EAT-10 Bin	Xerostomia	1.10 (1.02-1.21)[a]	1.12 (1.01-1.28)[a]	1.07 (0.94-1.24)[a]

Abbreviations: BL, baseline; EAT-10 bin, EAT-10 questionnaire score; MBF, maximum voluntary bite force; MLF, maximum voluntary lip force; MP (VOH), masticatory performance as assessed by the variance of hue (high value signifies low masticatory performance); MTP-JMS, maximum voluntary tongue pressure as assessed with the JMS device; xerostomia, sum score of the German version of the Xerostomia Inventory.

[a]Data are Spearman rank correlation coefficient or Hodges–Lehmann estimator for location difference followed by a Mann–Whitney test (95% CI).

for scoring oral hypofunction in the domains OD and MTP that were described in the JSG position paper.[5] This effect was even more obvious for female study participants.

The chewing function was not different between younger and older study participants, although the number of occluding posterior teeth and the maximum available bite force was higher in the younger group; however, MP was correlated to overall biting force and tongue pressure. Surprisingly, the median MLF was higher in the older participants.

The concept of oral frailty and oral hypofunction was firstly described in Japan, with its population being quite homogenous in regard to ethnical background and language use. Furthermore, in Japan, there is a long-standing interest in oral function, and some of the most advanced assessment devices today are industrially produced and distributed there, for example, for tongue movement and force distribution, bite force measurement devices, masticatory performance analyser and oral moisture analyser, but most of these instruments are exclusively available in Japan and were validated with Japanese samples.

In contrast, Europe is very diverse in regard to ethnicity and language use, and although many instruments for assessing oro-facial function have been developed and successfully used, their use is not widespread. The current study was designed in a new line of research to adapt the concept of oro-facial hypofunction to European circumstances and requirements. In previous research, we studied in Caucasians factors like masticatory performance,[24-27] lip force,[28] intra-oral sensitivity[29] or tongue force[14] and currently the feasibility of assessing OD in German-speaking individuals but never compared those findings to data from Japan. Therefore, as the current study was a scoping research project, there are some inherent weaknesses of the study. The study sample was not a representative sample of the German-speaking Swiss, German or Austrian population but rather a convenience sample comprising patients and staff of the School of Dental Medicine, Bern. However, because this study sample consisted only of healthy participants, the observed values could provide a first idea of a threshold for defining oro-facial fitness in younger and older individuals, based on OD, in German-speaking populations. Nevertheless, the sample size was too small to detect differences between the two different age groups and to define thresholds. Most differences between parameters only became significant when the complete sample was pooled, whereas differences, for example, in MBF and MTP, were expected to be different as demonstrated in very similar groups of participants.[18,30,31] Last but not least, the older group had a low median age compared with other studies that studied oro-facial function. However, it was difficult to fulfill the inclusion criteria of having 20 teeth or more in the older group, but it was deemed necessary to fulfill this criterion as otherwise patients with removable dental prostheses might have been included, which may have interfered with factors like MP and MBF.

In the field of dentistry, and Gerodontology in particular, the introduction of the assessment of OD in the context of oro-facial hypofunction is relatively new.[4] Most of the research has been performed in Japan with Japanese samples, but it is widely acknowledged that thresholds for OD need to be adapted to different cultural and linguistic backgrounds (for review, refer to Ben-David and Icht[12]). Monosyllables /pa/, /ta/, and /ka/ have been used in speech-language clinics and research for many decades,[32] mostly to test neuro-motor skills rather than linguistic performance although the latter has a significant impact.[33]

In the diagnosis of “oral frailty” as described by the JSG position paper,[5] the number of repetitions/s of the monosyllable below n = 6 is regarded as one of the seven diagnostic criteria to score oral hypofunction. This threshold is based on large studies carried out in Japan[34,35] that found that a number of repetitions below 6 can be detected predominantly in frail older adults.[36] However, the majority of the present study sample could not reach this threshold despite none or very few functional issues, and furthermore we did not include frail individuals. This clearly indicates that in the scope of the diagnosis of this condition, OD thresholds need to be defined for German-speaking individuals, and furthermore, their age and frailty status need to be taken into consideration.

A further factor for which the current older group could not fulfil the Japanese requirements for an intact oro-facial function is the maximum available tongue pressure. The threshold as defined by Minakuchi et al is 30 kPa. This value was based on a study with 201 older Japanese adults.[37,38] The median tongue pressure in the current older sample was 29.1 kPa, and again, there was no significant functional impairment in relation to mastication, swallowing or speech. Recently, there is also emerging research that the cut-off values of the diagnosis for oral frailty may need to be revisited for Japanese samples,[39] and the current results demonstrate that these thresholds cannot be applied without further research to German mother-tongue speakers. This is a clear indication that cut-off values to differentiate oro-facial fitness from oro-facial hypofunction need to be found for groups of different language use and maybe even ethnic background.

At first glance, it seems difficult to understand why MP was not different in the older group compared with the younger group, despite fewer occluding tooth pairs and lower MBF. This might be explained by the fact that the employed chewing gum for testing MP was too easy to chew, even for the older participants, with a fit condition of the oro-facial system. Furthermore, the test depends on the ability of an individual to knead and form a bolus and less on the maximum available bite fore. Hence, the higher lip force in the older group might have contributed to this effect, as the lips might have contributed significantly to mixing and shaping the bolus. Previous research has shown that complete denture wearers exhibit higher forces than partially edentate individuals, independently of their age.[28,40,41] Nevertheless, the older study participants had on average fewer teeth than the younger study participants and might have developed higher lip forces to compensate this deficiency in regard to masticatory function.

For future research, it will be crucial to understand the multifactorial function of mastication and swallowing, especially in older individuals. In the current study, only objective tests have been employed but not the adaptive behaviour of an individual to cope with a possibly reduced chewing function, like the increase of the number of chewing cycles, or choice of food.[25,42] Furthermore, the impact of impaired overall oro-facial function on social engagement, nutritional status and quality of life should be included in further research to better understand its significance in the care for old and frail individuals. Last but not least, it should be aimed to develop effective and simple rehabilitation programs to increase overall function. A diagnosis of oro-facial hypofunction without consecutive therapeutic intervention may be ethically questionable and of little use to the individual, the health insurance or policy makers.

5 | CONCLUSIONS

Similar to Japanese samples, OD might also be a key component of oro-facial function in German mother-tongue speakers. Larger epidemiological studies in these populations are needed to define thresholds and to better understand the multifactorial bio-psycho-sociological concept of oro-facial fitness and hypofunction.

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CONFLICT OF INTEREST

Martin Schimmel is a member of the oral function scientific advisory board for Sunstar Suisse SA (Etoy, Switzerland). All other authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data can be made available upon request.

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