Effects of Experimental Occlusal Interferences in Individuals Reporting Different Levels of Wake-Time Parafunctions

Ambra Michelotti, DDS, Spec Orthod
Associate Professor
Department of Oral Sciences
Section of Orthodontics and Temporomandibular Disorders

Iacopo Cioffi, DDS, PhD
Postdoctoral Fellow
Department of Oral Sciences

Donatella Landino, DDS
Postgraduate Student
Discipline of Orthodontics
Department of Oral Sciences
Section of Orthodontics and Temporomandibular Disorders

University of Naples Federico II
Napoli, Italy

Carlotta Galeone, PhD
Researcher
Department of Occupational Health
Clinica del Lavoro Luigi Devoto
University of MIlan
Department of Epidemiology
Mario Negri Institute for Pharmacological Research
Milan, Italy

Mauro Farella, DDS, PhD, Spec Orthod
Professor
Department of Oral Sciences
Discipline of Orthodontics
University of Otago
Dunedin, New Zealand, and
Department of Oral Sciences
Section of Orthodontics and Temporomandibular Disorders
University of Naples Federico II
Napoli, Italy

Correspondence to:
Professor Ambra Michelotti
Dipartimento di Scienze Odontostomatologiche
Universita degli Studi di Napoli Federico II
Via Pansini 5
I-80131 Napoli, Italy
Email: michelot@unina.it

Aims: *To test the hypothesis that the effects of an experimental occlusal interference differ between individuals reporting a high or low frequency of wake-time oral parafunctions.* ***Methods:*** *Study participants reporting very high (HFP group; n = 10) or very low (LFP group; n = 10) levels of oral parafunctions were selected by means of a questionnaire administered to 200 medical students. The selected participants wore an experimental occlusal interference in a single-blind longitudinal study, which comprised different occlusal conditions: interference free (IFC) and active occlusal interference (AIC). Assessments included clinical examination, measurements of nonfunctional tooth contacts, state and trait anxiety, and visual analog scale scores for occlusal discomfort, masticatory muscle pain, and headache. Data were analyzed by repeated measures two-way analysis of variance on ranked data, followed by calculation of within- and between-group differences using Friedman tests and Mann-Whitney tests, respectively.* ***Results:*** *During AIC, the frequency of nonfunctional tooth contacts significantly decreased in both groups (median [interquartile range, IQR]: in HFP from 55.3% [60.0%] to 31.1% [33.5%],* P = *.03; in LFP from 31.8% [32.4%] to 14.0% [22.8%],* P < *.01), the decrease being more pronounced in LFP than in HFP (*P < *.01). Trait anxiety was significantly higher (*P = *.01) in the HFP group (median, IQR = 22.5, 9.0) than in the LFP group (median, IQR = 19.0, 3.0). The interference caused more occlusal discomfort in the HFP group than in the LFP group (*P = *.02) and was associated with a significant increase of masticatory muscle pain (*P = *.05) and headache (*P = *.04) only in the HFP group.* ***Conclusion:*** *The application of an experimental occlusal interference has a different effect in individuals reporting a high or low frequency of oral parafunctions.* J OROFAC PAIN 2012;26:168–175

The role of occlusal interferences in the etiology of temporomandibular disorders (TMD) has been a matter of debate for a long time.[1–5] It has been suggested that occlusal interferences cause muscle hyperactivity, which in turn can lead to muscle overload and pain.[6,7] Hence, the elimination of occlusal interferences has been advocated to prevent the development of TMD.[6] This hypothesis, however, is still not supported by convincing evidence.[8,9]

In recent decades, a number of studies have investigated the potential influence of experimental occlusal interferences on signs and symptoms of TMD.[10] The overall findings indicate that the application of an occlusal interference increases the risk of developing TMD, but also that the symptoms are transient.[10] More recently, it was found that the introduction of experimental interferences in healthy volunteers is accompanied by a reduction of habitual masseter activity assessed in the natural environment and does not cause signs or symptoms of TMD. This reduced activity was interpreted as an avoidance behavior in response to perceived occlusal discomfort.[11] On the other hand, the application of an experimental interference in patients reporting a former TMD history has been reported to increase the risk of clinical signs and symptoms of TMD.[12] This has been ascribed to a reduced adaptation to occlusal interferences.[13]

Parafunctional oral behaviors, such as tooth grinding and clenching, are risk factors for the development of TMD,[14] especially for myofascial pain of the masticatory muscles.[15] It has been reported that TMD patients have higher levels of nonfunctional tooth contact than healthy volunteers.[16,17] It is possible that the occurrence of TMD after the application of an occlusal interference depends on the individual response in terms of frequency of parafunctional daytime oral behaviors. This might explain the different findings obtained between healthy controls and patients reporting a previous history of TMD.[11,12]

Therefore, the aim of the present study was to test the hypothesis that the effects of an experimental occlusal interference differ between individuals reporting a high or low frequency of wake-time oral parafunctional behaviors.

Materials and Methods

Study Participants

Two hundred subjects attending the School of Medicine at the University of Naples Federico II were screened by the Oral Behaviors Checklist (OBC[18]). The questionnaire included 21 items assessing self-reported awareness and the extent of waking-state oral parafunctions. The reliability and validity of OBC for detecting the occurrence of waking-state oral parafunctional behaviors have been previously demonstrated.[18,19] The students were asked to report the daily frequency for each oral parafunction listed in the questionnaire by choosing among the following options: "none of the time," "a little of the time," "some of the time," "most of the time," and "all of the time." Each answer was ranked from 0 to 4.

For each subject, the scores corresponding to the OBC items 3, 4, 5, 10, 12, and 13 (ie: grind teeth together during waking hours; clenching teeth together during waking hours; press, touch, or hold teeth together other than eating; bite, chew, or play with tongue, cheeks, or lips; hold between the teeth or bite objects such as hair, pipe, pencils, pens, finger, fingernails, etc; use chewing gum) were summed, and the frequencies tabulated in order to select two study groups (> 90th percentile and < 10th percentile of the frequency distribution). The first group included 28 students with a total score above the 90th percentile and was defined as the high-frequency parafunction group (HFP), whereas the second group included 33 students with a total score below the 10th percentile and was defined as the low-frequency parafunction group (LFP). Exclusion criteria were: dental prostheses, current orthodontic treatment, one or more missing teeth with the exception of third molars, neurological disorders, intake of drugs affecting the central nervous system, and refusal to participate in the study. The final study sample included 20 students, 10 in the LFP group (6 females, 4 males; mean age ± SD: 22.3 ± 1.8 years) and 10 in the HFP group (9 females, 1 male; mean age ± SD: 20.4 ± 1.2 years). The study participants received no financial compensation for participation and were assured that they could leave the study at any time. The majority of the excluded individuals refused to participate to the study or were undergoing orthodontic treatment.

Preliminary oral clinical examination according to the Axis I of the Research Diagnostic Criteria for TMD (RDC/TMD)[20] was performed by an examiner calibrated for TMD diagnosis (AM), who was unaware of the allocation group. Each subject was requested to complete the State-Trait Anxiety Inventory (STAI).[21]

The local ethics committee approved the study protocol, and each participant signed an informed consent.

Occlusal Interference

Contact points between the first molars were marked for each subject in intercuspal position by means of marking papers (Bausch Articulating Papers). The occlusal surface was then conditioned by using a self-etching adhesive (Adper Scotchbond SE, 3M ESPE) following the supplier's instructions. An experimental interference was built by one of the authors (IC), who was unaware of the subject's allocation group. The active occlusal interference was applied on the mandibular first molar of the preferred chewing side by placing an orthodontic separator (Radio Opaque Separators, American Orthodontics) on the occlusal contact of the mesiobuccal cusp, and then filling the separator with a layer of resin (New Composite Flow, General Orthodontic System). The interference size was approximately 1.2 × 0.4 mm (base diameter × height) and it interfered with maximum intercuspation but not with laterotrusive and protrusive

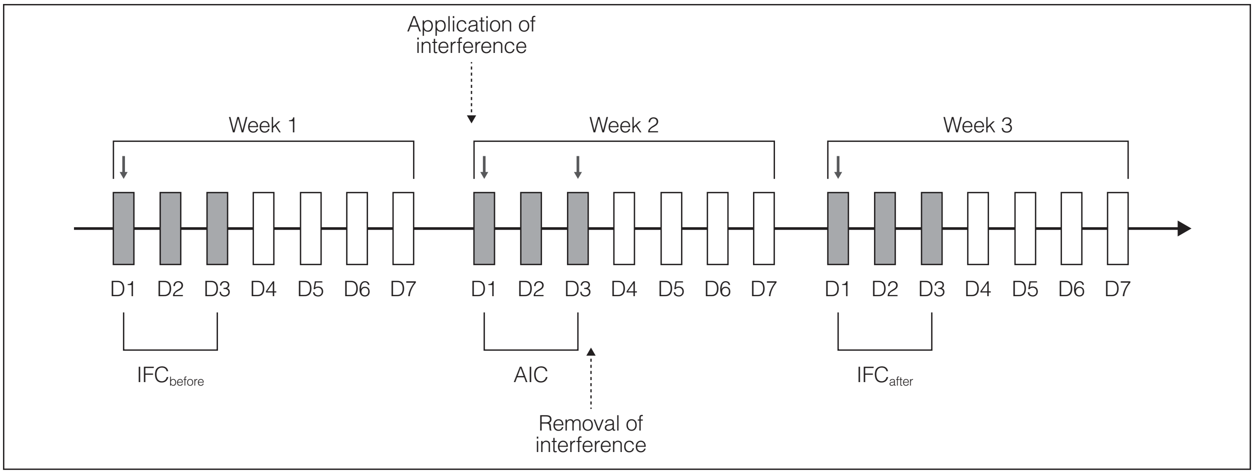

Fig 1 Schematic representation of the study design. Each subject went through three different occlusal conditions: interference-free condition before (IFC_{before}), active experimental interference condition (AIC), and interference-free condition after (IFC_{after}). Data were collected over three separate recording sessions each lasting 3 days. Recording days (D1, D2, D3) are indicated as grey rectangles and correspond to the first 3 days of a week. Data were collected over 3 consecutive weeks. The occlusal interference was placed early in the morning at AIC D1 and was removed late in the evening at AIC D3 (see dashed arrows). Tooth contacts were recorded by ecological momentary assessment at D1, D2, and D3 of each recording session, whereas VAS data were collected at the end of every recording day. Dark arrows indicate the assessment of occlusal contact in intercuspal position. Clinical examination for TMD was performed at D1 during IFC_{before}, and IFC_{after}, and at D3 during AIC, immediately after removal of the interference.

movements. None of the participants showed a lateral or forward slide from centric occlusion after application of the interference.

Occurrence of Jaw Activities with Tooth Contact in the Natural Environment

Occurrence of jaw activities with tooth contact was assessed by ecological momentary assessment[22] using a microprocessor-controlled recorder.[17] The recorder was set to emit a sound every 20 minutes. This sound alerted the participant and brought his/her attention to the position of the jaw. Thereafter, the participant had to choose among the following reply options: teeth not in contact, teeth in contact, speaking, swallowing, and chewing. If an answer was not entered within 32 seconds, the "no reply" choice was automatically recorded. The recorder was in use for 14 hours/day (8 am to 10 pm) and was silent at night. To avoid habituation and to prevent any anticipatory behavior, the recorder was programmed to add or subtract a random interval (0 to 9 minutes) to the preselected time. Hence, participants received random alerts 43 times per day. Participants became acquainted with the procedures during a preliminary training session, and they received detailed explanations about the functioning of the recorder, which were given always by the same examiner (DL).

Subjective Assessments

Occlusal discomfort (ie, the occlusal disturbance induced by the experimental interference), headache, and masticatory muscle pain were each assessed by means of a 100-mm visual analog scale (VAS), ie, horizontal line with the left endpoint indicating "no occlusal discomfort/headache/muscle pain at all" and the right endpoint corresponding to "worst occlusal discomfort/headache/muscle pain I can now imagine." Participants were invited to mark the position on the scales that best represented the assessment of their present occlusal discomfort, headache, and masticatory muscle pain.

Clinical Procedure

The study was carried out as a single-blind (ie, examiner) longitudinal design. Each subject went through three different occlusal conditions: interference-free condition before (IFC_{before}), active experimental interference condition (AIC), and interference-free condition after (IFC_{after}). Data were collected over three separate recording sessions each lasting 3 days and corresponding to the first 3 days of a week (Fig 1).

Each volunteer was asked to complete the VAS scales every evening (between 8 pm and 10 pm) of all recording days. The number and distribution of occlusal contacts with the jaw in maximum intercuspal position were assessed by means of plastic

Table 1 TMD Diagnosis According to Axis I of RDC/TMD in the HFP Group and the LFP Group During the Three Experimental Conditions (IFC_{before}, AIC, IFC_{after})

	HFP			LFP		
Subject	IFC_{before}	AIC	IFC_{after}	IFC_{before}	AIC	IFC_{after}
1	Ia	Ia	Ia	Ia	–	–
2	–	Ia	–	–	–	–
3	IIa†	IIa†	IIa†	–	–	–
4	–	–	–	–	–	–
5	Ia	Ia	Ia-IIIa*	–	Ia	–
6	–	IIa*	IIa*	–	–	–
7	IIa*	IIa*	IIa*	–	–	–
8	IIIa*	IIIa*	–	IIa* – IIIa*†	–	–
9	Ia	Ia	Ia	IIa*	IIa*	IIa*
10	–	–	–	–	–	–

*Same side of the interference; †other side.

strips 100 microns thick (KerrHawe Striprol n°686). An occlusal contact was defined as the ability to maintain the strip between opposing teeth against a strong pull, during firm biting.[23] Occlusal contacts were assessed by an examiner (AM) who was unaware of the subject's allocation group (ie, the allocation group and the OBC score were concealed in the dataset) at day 1 of IFC_{before}, immediately after the build-up of the interference (at day 1 of the AIC session), immediately before the removal of the interference (at the end of day 3 of the AIC session), and again at day 1 of IFC_{after}.

TMD examination (Axis I RDC/TMD) was performed by the examiner AM before the assessment of occlusal contacts at IFC_{before}, immediately after the removal of occlusal interference, at day 3 of AIC, and at IFC_{after}.

All participants received the recording device at the beginning of each recording day. A total of 9 recording days was obtained from each participant.

Statistical Analyses

The frequency of nonfunctional tooth contacts assessed by the microprocessor-controlled recorder was expressed as a percentage of the total number of replies. The number of occlusal contacts assessed by plastic strips, missing data, VAS scores, and the frequencies of nonfunctional tooth contacts were presented as median and interquartile range (IQR), because these variables were not normally distributed, as indicated by Shapiro-Wilk statistics.

Data analysis started with an overall test, followed by post-hoc tests, if appropriate. In particular, data were analyzed by repeated measures two-way analysis of variance (RM-ANOVA) on ranked data, followed by calculation of within- and between-group differences, using Friedman tests and Mann-Whitney tests, respectively.[24] Mann-Whitney nonparametric tests were also used to compare state and trait anxiety scores between groups and between sexes, and to assess sex differences in the frequency of nonfunctional tooth contacts. Statistical significance was set at $P \leq .05$. Data were analyzed using SAS version 9.1 software (SAS Institute).

Results

The RDC/TMD Axis I examination performed at baseline revealed a higher proportion of TMD diagnoses in the HFP group than the LFP group (Table 1). Trait anxiety score was significantly higher ($P = .01$) in the HFP group (median, IQR=22.5, 9.0) than in the LFP group (median, IQR=19.0, 3.0), while state anxiety did not differ significantly between groups (HFP: 25.5, 5.0; LFP: 21.5, 2.0, $P = .10$). Trait and state anxiety also did not differ significantly between males and females ($P = .17$ and $P = .31$, respectively).

In the HFP group, the median number of occlusal contacts in intercuspal position at IFC_{before} was 13.0 (IQR = 3.0). After the experimental occlusal interference was built up (at day 1 of the AIC session), only a single contact point could be recorded. Before interference removal (at day 3 of the AIC session), the median number of contacts was 3.0 (IQR = 7.0). Finally, at IFC_{after}, the median number of occlusal contacts was 9.5 (IQR = 5.0).

In the LFP group, at IFC_{before}, the median number of occlusal contacts in intercuspal position was 10.5 (IQR = 5.0) and dropped to a single contact immediately after building up the interference. Before interference removal, the median number of

Table 2 Descriptive Values and Comparisons of Missing Data and Frequencies (%) of Nonfunctional Tooth Contacts in the HPF Group and the LFP Group During Three Times of Observation (IFC_{before}, AIC, IFC_{after})

	LFP (n = 10)		HFP (n = 10)		Between-group differences (*P* values)	
	Missing data	Nonfunctional tooth contacts	Missing data	Nonfunctional tooth contacts	Missing data	Nonfunctional tooth contacts
IFC_{before}						
Median	4.8	31.8	5.0	55.3	–	.21
IQR	5.1	32.4	10.9	60.0		
AIC						
Median	7.2	14.0	8.3	31.0	–	**< .01**
IQR	14.1	22.8	6.2	33.5		
IFC_{after}						
Median	5.2	18.4	6.0	18.2	–	.99
IQR	7.0	17.3	9.1	23.0		
Within-group differences (*P* values)	–	**< .01**	–	**.03**	2.62 (.11)	5.12 **(< . 01)**
					Two-way RM ANOVA F values (*P* value)	

The within- and between-group differences were evaluated only when the two-way RM-ANOVA was statistically significant. Dark grey background: Two-Way RM-ANOVA results. *P* values in **bold** type = statistically significant.

occlusal contacts was 6.5 (IQR = 6.0). At IFC_{after}, the median number of occlusal contacts was 8.5 (IQR = 4.0). The number of occlusal contacts across conditions did not differ significantly between groups ($P = .13$). In each group, a significant difference was found between occlusal contacts measured at IFC_{before} and IFC_{after} ($P < .01$).

The recording devices stored data for 126 hours for each participant, and a total of 2,520 hours of data in both groups were collected. The frequency of missing data did not differ significantly between groups or between the three experimental conditions ($P = .11$, Table 2).

Within and between-groups differences in the frequency of nonfunctional tooth contact are reported in Table 2. At IFC_{before}, the frequency of nonfunctional tooth contacts did not differ significantly between the HFP and the LFP groups (median, IQR: 55.3, 60.0% in HFP; 31.8, 32.4% in LFP; $P = .21$). During AIC, the frequency of nonfunctional tooth contacts significantly decreased in both groups (HFP: $P = .03$, LFP: $P < .01$), and it was higher in the HFP group (median, IQR: 31.0, 33.5%) than in the LFP group (median, IQR: 14.0, 22.8%; $P < .01$). No significant differences between groups were found at IFC_{after} (median, IQR: 18.2, 23.0% in HFP; 18.4, 17.3% in LFP; $P = .99$). The frequency of nonfunctional tooth contact did not differ significantly between males and females ($P = .68$).

Differences between groups and between sessions for perceived occlusal discomfort, headache, and muscle pain are reported in Table 3. The interference caused more occlusal discomfort in the HFP group than in the LFP group ($P = .02$) and was associated with a significant increase of masticatory muscle pain ($P = .05$) and headache ($P = .04$) only in the HFP group.

Discussion

This study tested the hypothesis that the effects of an experimental occlusal interference differ between individuals who report a high or low frequency of oral parafunctional behaviors. It was found that, following the application of an occlusal interference, both groups showed a significant reduction in the number of nonfunctional tooth contacts, which was more pronounced in the LFP group than in the HFP group. This indicates that the reaction to the application of the interference was avoidance of tooth contact. This is consistent with the authors' previous findings obtained from a group of healthy participants.[11] It needs to be emphasized, however, that the occlusal interference used in the present study was higher than that used in the previous report.[11] This might have influenced the individual reaction to interference and facilitated the occurrence of avoidance behaviors.

Interestingly, the participants reporting a high frequency of oral parafunctional behaviors also reported higher levels of occlusal discomfort, headache, and jaw muscle pain than the participants with a low frequency of oral parafunctional behaviors. The

Table 3 Descriptive Values and Within-Group and Between-Group Comparisons of VAS Scores (cm) for Occlusal Discomfort, Headache, and Muscle Pain in HPF Group and LFP Group During Three Times of Observation (IFC_{before}, AIC, IFC_{after})

	LFP (n = 10)			HFP (n = 10)			Between-group differences (*P* values)		
	Occlusal discomfort	Headache	Muscle pain	Occlusal Discomfort	Headache	Muscle pain	Occlusal Discomfort	Headache	Muscle pain
IFC_{before}									
Median	0.2	0.3	0.2	0.0	0.5	0.2	.44	.91	.96
IQR	1.2	0.8	2.7	0.7	1.3	1.1			
AIC									
Median	4.4	0.1	0.4	7.5	2.6	3.4	**.02**	**.01**	**.02**
IQR	6.4	2.0	0.8	3.6	5.4	7.0			
IFC_{after}									
Median	0.2	0.0	0.0	0.3	1.8	0.7	.68	**.04**	.19
IQR	0.8	1.7	0.3	1.7	2.7	2.3			
Within-group differences (*P* values)	**.01**	.80	.37	**< .01**	**.04**	**.05**	6.40 **(< .01)**	7.23 **(< .01)**	5.27 **(< .01)**
							Two-way RM ANOVA F values (*P* value)		

Dark grey background: Two-way RM ANOVA results. *P* values in **bold** type = statistically significant.

increased subjective complaints found in HFP subjects may be the consequence of an oral hyperactivity. Indeed, it is possible that in order to avoid the interference, the subjects braced their jaws in a tense nonphysiological position.[19] In the present study, the electromyographic activity of the jaw muscles was not assessed, and therefore it is not possible to draw a conclusion on the motor responses of the masticatory muscles. An alternative explanation for increased levels of subjective complaints in the HFP group may be ascribed to the fact that this group showed higher levels of trait anxiety than the LFP group. High levels of trait anxiety indicate an anxious personality disposition, which can be associated with a high rate of environmental scanning, which is termed hypervigilance.[25] As a consequence, high trait anxious individuals are more cautious and present a reduced ability to switch attention away from the threatening stimulus.[26,27] It is possible that the presence of an occlusal interference was regarded as a threatening factor, more in the HFP group than in the LFP group. Unfortunately, in this study, trait anxiety and state anxiety were assessed only at baseline, and the possible effects of occlusal disturbances on state anxiety cannot be evaluated. It has also been reported that myofascial pain patients have high levels of somatosensory amplification[28] that is characterized by a bodily hypervigilance to unpleasant sensations.[29] In the HFP group, the proportion of TMD diagnoses was greater than in the LFP group. Hence, different levels of somatosensory amplification might account for the different subjective complaints found.[28]

Nonetheless, increased risks of clinical signs and symptoms in response to induced occlusal interferences have been reported in individuals already suffering from TMD.[12] Hence, it is possible that the greater headache and jaw muscle pain reported by the HFP group may be related to the current presence of TMD.

It may be speculated that HFP participants felt particularly hampered by not being allowed to perform their habitual oral behaviors due to the presence of the occlusal interference, and thus they reported a high level of occlusal discomfort. Conversely, it is possible that the LFP participants, who were low–trait-anxious individuals, adopted an avoidant attention style and that they shifted their attention away from threats. This can explain why LFP participants showed a reduced number of tooth contacts, which was more pronounced than that occurring in HFP participants in reaction to the same type of occlusal interference. It is possible that LFP participants adapted better than HFP participants to the interference, and this may explain why, similarly to the authors' previous findings,[11] they did not develop any significant level of headache and/or muscle pain. These observations indicate that the relationship between oral parafunctional behaviors, trait anxiety, and/or somatosensory amplification needs to be further investigated in future studies.

The number of occlusal contacts assessed by a plastic strip decreased significantly from IFC_{before} to IFC_{after}. This might be explained by a different mandibular position or by a temporary intrusion of the tooth with the interference in the periodontal space. Therefore, the washout period was probably not sufficient to allow a complete occlusal recovery after removal of the interference.

It was noted that the HFP group at IFC_{before} had a higher mean number of nonfunctional tooth contacts than the LFP group, but the difference was not statistically significant. This contrasts with the fact that myogenous pain patients report significantly more nonfunctional tooth contacts than healthy controls.[17] However, this may be explained by the observation that only some participants in the HFP group were diagnosed with myofascial pain at the beginning of the study. Furthermore, the HFP and the LFP groups were selected by means of a questionnaire that aimed to assess the self-reported frequency of various oral behaviors, which are not always associated with tooth contacts. Hence, parafunctions other than those accompanied with tooth contact could explain the large differences in the OBC between the two groups. This might be related to the fact that, before using the microprocessor-controlled recorders, the accuracy of each subject's response was not tested by occlusal sensors as done in a previous study.[17]

The HFP sample included more women and more TMD diagnoses than the LFP group. The authors are confident that the disparity in sex distribution might reflect common epidemiologic findings, which suggest a higher proportion of females suffering from TMD.[30] Instead, the higher frequency of TMD diagnoses can be related to the increased risk of developing TMD in subjects reporting a high frequency of oral parafunctional behaviors.[15] Nevertheless, this relation might be a possible confounding factor in the present study's data analysis. Interestingly, one participant of the HFP group was diagnosed as having disc displacement with reduction (RDC/TMD IIa) during AIC and at IFC_{after}. Based on the result of a telephone interview made a few months after the end of the experiment, the participant reported that her jaw was still clicking but only sporadically. This is consistent with the fluctuation of signs and symptoms of TMD reported in the literature.[31,32]

It is important also to note that the experimental active interference phase was not prolonged over time. Hence, information about the effects of occlusal interferences on parafunctional behaviors in the long term cannot be provided.

Finally, it must be pointed out that the study sample was selected among medical students. Therfore, it is possible that the study suffered from a selection bias, since the sample may not be representative of the whole population. Medical students were preferred over dental students, as the latter may be aware of the possible effects of occlusal interferences.

In conclusion, within the limitations of the present study design, the findings showed that application of an occlusal interference has different effects in individuals reporting a low or high frequency of oral parafunctions. While the application of an occlusal interference had a minor impact in individuals reporting a low frequency of parafunctional behaviors, it may aggravate masticatory muscle pain and headache in individuals who report a high frequency of parafunctions.

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