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ORIGINAL COMMUNICATION

Writing, reading, and speaking in blepharospasm

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Abstract

The aim of the study was to evaluate the effects of writing, reading, and speaking on orbiculari oculi (OO) muscle spasms and on the blink rate in patients with blepharospasm (BSP). Patients with hemifacial spasm (HFS) and healthy subjects (HS) acted as control subjects. Thirty patients with BSP, 20 patients with primary HFS and 20 age-matched healthy subjects were videotaped according to a standardized procedure: at rest with eyes open; while writing a standard sentence on paper; while writing a standard sentence on a blackboard keeping the head straight; during a conversation based on a simple topic (speaking task); and while reading a standard text aloud. Two independent movement disorders specialists reviewed the videotapes and measured the number of OO spasms and blinks in each segment. Writing and reading reduced the number of OO spasms in BSP patients, whereas speaking did not. On the other hand, writing, reading, and speaking did not modify spasms in HFS patients. These tasks modulated the blink rate in all the three groups of subjects (BSP, HFS, and HS). Our hypothesis is that the modulation of OO spasm in BSP during writing and reading depends on influences coming from occipital areas onto the brainstem circuits. Whether cognitive training with reading and writing may be used to improve OO muscle spasms is an issue that warrants further investigation.

Keywords Blepharospasm · Verbal language task · Writing · Reading · Speaking · Blink rate

Introduction

Blepharospasm (BSP) is a focal dystonia characterized by involuntary, bilateral, and symmetrical spasms of the orbicularis oculi (OO) muscles [1, 2]. BSP patients may also display increased spontaneous blinking, as measured by the blink rate (BR) [2–5]. The severity of OO muscle spasms and spontaneous blinking in patients with BSP may be affected by a number of factors, including ocular irritation, dry eye, and photophobia [6, 7]. In BSP, verbal language tasks (reading and speaking) influence blink rate [3], whereas the effect of these tasks on OO spasms is unknown. Only writing is currently considered when the severity of BSP is evaluated [4].

The main aim of this study was to assess in BSP the effect of writing, reading, and speaking on OO muscle spasms. In the same BSP patients, we also tested the effect of verbal language tasks on blink rate. Data obtained in BSP patients were compared with those obtained in patients with hemifacial spasm (HFS), a disorder characterized by involuntary muscle contractions, whose origin is peripheral, as well as with those obtained in healthy subjects (HS).

Methods

Subjects

We enrolled 30 consecutive patients with idiopathic BSP, diagnosed according to validated criteria [2], and 20 patients with primary HFS from the Department of Human Neurosciences, Sapienza University of Rome. We also studied 20 age-matched healthy subjects as controls. We excluded subjects with a history of exposure to dopamine receptor blocking agents in the 6 months prior to enrolment, and patients with previous and current ophthalmological disorders including inflammatory diseases of the eye (blepharitis, conjunctivitis, keratitis, and others), glaucoma, recent surgery

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for cataract, keratoconus or who used contact lenses. Patients with significant cognitive disturbances (MOCA score < 26) were also excluded. All the patients were assessed at least 4 months after the last botulinum toxin (BoNT) treatment. The experimental procedure was approved by the institutional review boards and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from every participant.

Clinical assessment

Participants were videotaped according to a standardized procedure [4]. Five videotape segments were recorded: (1) at rest with eyes open; (2) while writing a standard sentence on paper; (3) while writing a standard sentence on a blackboard keeping the head straight, to determine whether changes in head position affect spontaneous blinking and OO spasms; (4) during a conversation based on a simple topic (speaking task) that bore no emotional impact and required no memory recall. For the speaking task, we used a standardized procedure asking date and place of birth, family status, address, education, and job; and (5) while reading a standard text aloud. Each segment lasted 60 s, with a 10-s interval being included between the segments. The 10-s interval as a rest time between the different video segments was chosen according to previous standardized video recording procedure [4]. All the videorecordings were performed in a noiseless room with artificial light. We placed the camera on a tripod in front of each participant at a standard distance of 2 m. Each frame was focused on the eyes. During videorecording of writing and reading tasks, the inclination and the height of the tripod were customized to focus the framing on the patients' eyes. In patients with HFS, we evaluated the number of OO spasms in the affected side. Spontaneous blinking was measured by calculating the BR and was expressed as number of blinks per minute. Blink was defined as a transient, bilateral, and synchronous short-duration (< 1 s) eyelid drop unassociated with lowering of the eyebrows beneath the superior orbital margin [3, 5] and a short-lasting spasm was considered as a "sudden orbicularis oculi muscle contraction causing eyelid rim narrowing lasting less than 3 s" [4]. Two independent movement disorder specialists (DB, AF) reviewed the videotapes and measured the number of spasms and the number of blinks in each segment. The Blepharospasm Severity Rating Scale (BSRS) was used to assess the overall severity of BSP [4]. The presence of ocular symptoms was assessed by means of an "ad hoc" questionnaire [7].

Statistical analysis

Data are expressed as mean ± SD. The statistical analysis was performed using the SPSS software. A one-way ANOVA was used to evaluate changes in the number of OO muscle spasms during writing, reading and speaking between BSP and HFS patients. A paired t test was used for the post hoc analysis. To evaluate any changes in BR during the execution of the cognitive task, we performed a repeated measures ANOVA with factors GROUP (three levels: BSP patients, HFS patients, and HS) and the factor TASK (five levels: rest, writing on paper, writing on a blackboard, reading, and speaking). Bonferroni's test was used for the post hoc analysis. We assessed inter-rater agreement between the two raters by means of Cohen's Kappa coefficient. A p value < 0.05 was considered to indicate statistical significance. Pearson's correlation coefficient was used to investigate whether the demographic and clinical variables were correlated with changes in BR and OO spasms.

Results

The 30 BSP patients, the 20 HFS patients and the 20 healthy subjects were similar for age, gender, and disease duration (all $p > 0.05$) (Table 1). The mean ± SD of BSRS score was 8.03 ± 4.73. Ocular symptoms including burning sensation, dry eyes, and photophobia were present in 19 of the 30 BSP patients examined. Cohen's Kappa yielded a high inter-rater agreement between the two neurologists who reviewed the videotapes ($K = 0.93$). The number of OO spasms at rest was higher in BSP patients than in HFS patients ($p = 0.001$).

Orbicularis oculi muscle spasms were modulated by the three verbal language tasks (writing, reading, and speaking) to a significantly greater extent in the BSP group than in the HFS group ($F = 7.17$; $p < 0.0001$) (Table 2). In BSP patients, we observed that the different tasks significantly modified the number of OO spasms ($F = 12.4$; $p < 0.0001$) and that there was a significant interaction between the factor GROUP and factor TASK ($F = 2.45$; $p = 0.04$). The post hoc analysis in BSP patients showed that the number of OO spasms in these patients was significantly lower while writing on paper ($p < 0.0001$), writing on a blackboard ($p < 0.0001$), and reading ($p = 0.002$) than at rest. No difference emerged in the number of OO spasms

Table 1 Demographic data of BSP patients, HFS patients and HS

	Number of subjects	Age (Y)	Sex (m/f)	Disease duration (Y)
BSP	30	68.3 ± 9.7	10m/20f	10 ± 7.6
HFS	20	67.9 ± 7.8	8m/12f	9.5 ± 6.8
HS	20	67.5 ± 9.2	7 m/13f	–

Data are expressed as mean ± SD

BSP blepharospasm, *HFS* hemifacial spasm, *HS* healthy subjects, *Y* years

Table 2 Changes in orbicularis oculi (OO) muscle spasm during writing, reading and speaking in patients with blepharospasm (BSP) and in patients with hemifacial spasm (HFS)

	OO spasms at rest	OO spasms while writing on a paper	*p* value	OO spasms while writing on a blackboard	*p* value	OO spasms while reading	*p* value	OO spasms while speaking	*p* value
BSP	4.5 ± 4.7	0.7 ± 1.7	< **0.001**	0.9 ± 2.2	< **0.001**	1.5 ± 3.1	< **0.001**	4.1 ± 4.7	0.7
HFS	3.05 ± 8.3	2.3 ± 5.8	> 0.05	1.4 ± 2.7	> 0.05	2.8 ± 3.7	> 0.05	3.1 ± 3.5	> 0.05

Data are expressed as mean ± SD. *p* value refers to changes in the number of OO muscle spasm during each cognitive task compared with the OO muscle spasm at rest in each group

OO orbicularis oculi, *BSP* blepharospasm, *HFS* hemifacial spasm

during speaking ($p = 0.7$). Furthermore, in BSP patients, we observed that the different tasks significantly modified the time spent with eyes closed ($F = 14.0$; $p < 0.0001$). The post hoc analysis in BSP patients showed that the time spent with eyes closed was significantly lower while writing on paper ($p = 0.002$), writing on a blackboard ($p = 0.001$), and reading ($p = 0.004$) than at rest. No differences were found in the time spent with eyes closed during speaking ($p = 0.5$). By contrast, none of the verbal language tasks affected OO spasms in HFS patients ($F = 0.77$; $p = 0.5$) (Table 2). In BSP patients, OO spasms reappeared within 10 s after the end of the task (writing on a sheet: 4.2 ± 1.2 s; writing on a blackboard: 4.1 ± 1.8 s; reading: 4.5 ± 1.3 s; and speaking: 1.8 ± 1.5 s).

The between-group ANOVA showed that the spontaneous BR at rest was significantly higher in BSP patients than in either HFS patients or HS (BSP patients vs HFS patients: $p < 0.001$; BSP patients vs HS: $p = 0.03$). The BR was significantly modified in all the three groups of subjects by the verbal language tasks ($F = 82.7$; $p < 0.0001$), with a significant interaction being observed between the factor GROUP and factor TASK ($F = 3.07$; $p = 0.002$). The post hoc analysis of the BR during the three tasks in all three groups is summarized in Table 3. Changes in OO spasms and the BR induced by the verbal language tasks did not correlate with the demographic or clinical features of BSP (gender, age, and ocular symptoms).

Discussion

The distinctive finding of our study is that writing and reading reduced OO spasms in BSP patients, whereas speaking had no effect on OO spasms. Writing and reading did not instead modify OO spasms in HFS patients. We also extend the previous observations by showing that writing and reading reduced the BR, whereas speaking left BR unchanged in patients with BSP. In patients with HFS and in HS writing and reading reduced BR, whereas speaking increased BR.

We took precautions to avoid any factors that might affect OO spasms and the BR. First, we performed the video recording in a comfortable environment so as to ensure that the setting, including the light intensity, did not affect the OO spasms or BR. In addition, we excluded all subjects with ophthalmological conditions that might affect the OO spasms and BR. Moreover, since cortical dopamine levels may alter the BR, we excluded any subjects treated with drugs that act on the dopaminergic system. Since BoNT improves the clinical features in patients with BSP and HFS [8–10], we tested all patients at least 4 months after the last BoNT injection. To see whether changes in a subject's head position during the writing task induce changes in spontaneous blinking and OO spasms, we examined all the participants, while they wrote on paper as well as while they wrote on a blackboard keeping their heads straight. Since in all BSP patients, we observed the reappearance of OO spasms within 10 s after each task, we believe that the

Table 3 Changes in blink rate (BR) during writing, reading and speaking in patients with blepharospasm (BSP), in patients with hemifacial spasm (HFS) and healthy subjects (HS)

	BR at rest	BR while writing on a paper	*p* value	BR while writing on a blackboard	*p* value	BR while reading	*p* value	BR while speaking	*p* value
BSP	35.5 ± 23.5	5.8 ± 8.7	< **0.001**	9.0 ± 11.7	< **0.001**	10.9 ± 16.5	< **0.001**	36.6 ± 16.5	0.2
HFS	16.1 ± 11.1	1.2 ± 2.1	< **0.001**	1.2 ± 2.2	< **0.001**	1.8 ± 3.2	< **0.001**	26.6 ± 14.6	**0.01**
HS	12.4 ± 4.9	3.6 ± 7.9	< **0.001**	6.9 ± 6.0	< **0.001**	5.05 ± 4.8	< **0.001**	35.8 ± 17.7	< **0.001**

Data are expressed as mean ± SD. *p* value refers to changes in the blink rate (BR) during each cognitive task compared with the BR at rest in each group

BR blink rate, *BSP* blepharospasm, *HFS* hemifacial spasm, *HS* healthy subjects

10-s rest interval was long enough to exclude any possible protracted effects induced by the various tasks. Finally, the video recordings were assessed by two neurologists with extensive experience in movement disorders and for whom the inter-rater agreement coefficient was excellent.

Orbicularis oculi muscle spasm and spontaneous blinking arise from neural generators located in the brainstem and are controlled by cortical and subcortical structures [5, 6, 11, 12]. In BSP, OO muscle spasms are due to enhanced excitability of the trigeminal–facial circuit in the brainstem due to a reduced inhibition likely from basal ganglia [5, 13–16]. The trigeminal–facial circuit involved in OO spasms receives facilitatory projections from the substantia nigra and the superior colliculus, and inhibitory projections from the cerebellum and the occipital cortex [11, 17]. Although cerebral structures generating spontaneous blinking have not yet been identified evidence from studies in rats suggests that the spinal trigeminal complex plays an important role in the spontaneous blink generator circuit [18]. The spinal trigeminal complex is controlled by the paramedian pontine reticular formation, which in turn receives facilitatory and inhibitory projections similar to those described above for OO spasms [11]. Moreover, evidence from functional MRI and electrooculogram studies suggests a role of the mesial frontal region in the spontaneous blinking [19].

The observation that writing and reading reduced OO spasms in BSP patients, whereas speaking did not modify OO spasms rules out the possibility that non-specific attentional mechanisms in BSP are responsible for the modulation of OO spasms [20, 21]. The modulation of OO spasms observed in BSP during writing, reading, and speaking might depend on the specific role played by the various cortical and subcortical structures activated during each of these tasks in controlling brainstem circuits. In normal subjects, functional neuroimaging studies have shown that the cerebral areas activated during writing include the primary motor cortex, the ventral and dorsal premotor cortex [22], the anterior and posterior cerebellum [23], and the anterior putamen [24]. Reading also depend on a complex cortical network, including the left ventral visual cortex located within the left occipito-temporal cortex [25], the left posterior superior temporal gyrus, and the inferior parietal lobe [26]. Speaking involves a feed forward motor control system that activates the premotor and primary motor cortex, the cerebellum and the auditory cortex, and a somatosensory feedback control that activates somatosensory areas [27]. Other brain structures involved in the selection, initiation, and sequencing of speech include the anterior cingulate area, the supplementary motor area, the basal ganglia, and the anterior insula [28].

Occipital cortical areas, which are those most involved in writing and reading, which both require visual attention and visual fixation, though not in speaking, may be responsible for the inhibition of OO spasms in BSP patients. In keeping with this hypothesis, functional neuroimaging studies in BSP patients have shown that the occipital cortex plays a role in the modulation of the blink reflex circuit, and visual fixation is widely known to inhibit spontaneous blinking [29]. Inhibitory projections from occipital cortical areas are likely to modulate the trigemino-facial circuits in the brainstem, either directly, by targeting the facial motoneurons, or indirectly, through other neural structures that mediate inhibitory effects to the facial motoneurons. The putative neural structures that may mediate the indirect inhibitory modulation of the trigemino-facial circuits are the basal ganglia and, in particular, the substantia nigra. The substantia nigra pars reticulata influences the activity of the superior colliculus, which is involved in visual information processing, and of the nucleus raphe magnus [6], which in turn projects to the trigeminal blink reflex circuits. The observation that writing and reading failed to improve OO spasms in patients with HFS, a condition that is ascribed to peripheral abnormalities [30, 31], suggests that the changes in OO spasms observed in BSP patients are not due to direct inhibitory effects on the facial motoneurons in the brainstem. We instead hypothesize that in BSP, the inhibitory effects from the occipital areas are likely to act through the basal ganglia, which in turn inhibits the trigeminal blink reflex circuit.

Our study has also shown that in BSP patients, the modulation of BR is similar to that observed for OO spasm, i.e., the BR reduces during writing and reading, while it does not change during speaking. This result suggests that although OO spasms and spontaneous blinking likely arise from different endogenous generators [5, 6, 11, 12], the neural structures that control the two brainstem circuits are shared. The other noteworthy finding of the present study is that speaking but not writing and reading increased the BR in HFS patients and HS. This may possibly be due to the social saliency of the speaking task [32] in comparison with the other tasks. Since the BR at rest is already higher in BSP patients than in HFS and HS because of the increased activation of the spontaneous blink generator [5, 15]. The normal increase in BR during speaking in HFS patients lends further support to the hypothesis that HFS arises from facial peripheral mechanisms and does not involve mechanisms of altered descending control from the cortical and subcortical areas.

In conclusion, our findings show that verbal language tasks such as reading and writing significantly reduce the number of OO spasms in BSP patients. Whether visuospatial tasks not involving verbal language also modulate OO muscle spasms in BSP patients warrant future studies. Writing and reading may possible be used for rehabilitation therapeutic strategy in BSP patients.

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Compliance with ethical standards

Conflicts of interest None of the authors have any potential conflicts of interest to disclose.

Ethical standards The experimental procedure was approved by the institutional review boards and was conducted in accordance with the Declaration of Helsinki.

Informed consent Written informed consent was obtained from every participant.

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