Effects of EMG-Activated Alarms on Nocturnal Bruxism

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An experiment evaluated the effects of masseter EMG-triggered nocturnal alarms on rates of bruxing during sleep and on ratings of mood during the day. It also evaluated rates of bruxing following termination of the alarm protocol and the accuracy with which subjects recorded instances of alarm events during the night. Ten nocturnal bruxers were exposed to 14 nights of intervention either before or after 14 nights without treatment. Brux episodes were recorded automatically for 28 nights. Self-reports of sleepiness, vigor, fatigue, and tension were recorded for 28 days. Alarm events were self- and automatically recorded during the 14-day intervention. The EMG-triggered alarm reduced bruxing rates both between and within experimental groups and did not adversely affect self-reports of sleepiness, vigor, or fatigue. There was some evidence that reduced bruxing rates were maintained after the alarm was discontinued. Subjects were not able to accurately record alarm events during the night. Some research directions are summarized.

Nocturnal bruxism is defined as nonfunctional clenching, grinding, or gnashing of the teeth during sleep. It is important to health-care professionals because its symptomatic correlates frequently prompt help-seeking. Common among these symptoms are abnormal tooth wear, damage to the temporomandibular joints, various facial pains, referred pains, and headache (Alling & Mahan, 1977; Ramfjord & Ash, 1983).

Psychological explanations for nocturnal bruxing have invoked psychodynamic, psychophysiological, and behavioral concepts. In turn, psychological treatments have entailed activities such as psychotherapy, muscular relaxation training, and negative practice (Giaros & Rao, 1977; McGlynn, Cassisi, & Dia-

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mond, 1985). The most promising interventions are those that provide feedback of bruxing during sleep (Mealliea & McGlynn, 1987).

Cassisi, McGlynn, and Belles (1987) reviewed in detail several experiments in which auditory signals triggered by facial EMG activity were used to treat nocturnal bruxing. Recommendations for continued research were also formulated. This paper reports a subsequent experiment in which EMG-triggered auditory signals were used to reduce the frequency of nocturnal bruxing. The design and instrumentation incorporated recommendations based on the review, as follows.

Auditory feedback must awaken subjects more or less completely in order to reduce rates of bruxing. Two investigations (Moss et al., 1982; Purzycki, Harsh, & Badia, 1986) promoted wakefulness successfully by requiring manual termination of the auditory signal, but only three subjects were studied. The present experiment used a larger sample of subjects to evaluate the effects on bruxing of a manually terminated auditory signal. Rates of bruxing sometimes rebound above baseline levels following phases using feedback. The design of the experiment permitted comparisons (between subjects) of bruxing rates before and after auditory-feedback phases. Little attention has been paid to the potentially harmful effects of repeated awakenings (Bonnett, 1985; Pearlman, 1982) during bruxing-feedback treatments. The protocol for the experiment called for daily ratings of sleepiness, fatigue, vigor, and tension. Finally, subjects routinely have been instructed to record times and sleep variables following alarm events. If such nightly sleep diaries portray numbers of alarm events accurately, then the clinical instrumentation required for research and clinical evaluation would be simplified. This experiment permitted comparisons (within subjects) of self- and automatically recorded alarm events.

Previewed, briefly, 10 identified bruxers were exposed to 14 nights of no treatment and to 14 nights of EMG-initiated auditory feedback in one of two counterbalanced orders. Brux episodes were recorded automatically for 28 nights. Ratings of sleepiness, vigor, fatigue, and tension were self-recorded for 28 days. Alarm events were self- and automatically recorded during the 14-day feedback phases.

**METHOD**

**Subjects**

Individuals who suspected themselves of bruxing were recruited with bulletin board notices placed around the University of Florida campus and health science center. Respondents were asked if they ever had a dentist remark about bruxing, a room-mate report hearing grinding sounds at night, or facial pain/muscular soreness. If there was an affirmative answer to any question, then the potential subjects were given an informed consent document to sign after which they entered the screening phase. Criteria for participation in the study included dental confirmation of pathognomonic wear facets on the teeth, an absence of dental infection, and at least 20 bruxes for one night during three nights of screening assessment. Criteria for exclusion were report of cur-
rent alcohol or drug use, refusal to remain drug- or alcohol-free during the project, and age less than 18 or more than 65.

Twelve of 18 individuals who responded to the notices met the inclusion criteria. Of the 12, one dropped out following a death in her family. Another was excluded after volunteering that she had been untruthful about taking medication. Four males and six females participated. Their mean ages, by sex, were 25 and 32, respectively. On average, the subjects reported having been aware of nocturnal bruxing for 7.5 years. Three of the males and five of the females reported histories of facial pain/discomfort. Two had received dental treatment for the problem. None had significant facial pain at the time of the experiment.

Instrumentation

Bruxing in the form of suprathreshold EMG activity was recorded via three disposable pregelled, 10 mm-diameter ECG electrodes (two reference, one ground) with 40-mm leads. Unilateral placement of the electrodes on the face followed exactly the standard masseter site described in Fridlund and Cacioppo (1986, p. 571). The electrodes are supplied with surgical-tape adhesive collars. In addition, a strip of 25-mm wide hypoallergenic surgical tape was placed over the two active electrodes, over the ground, and over the wire leads on the subject’s neck. In order to enhance electrode stability, the leads were looped over the ear before being taped down.

A portable EMG alarm/monitor was built for the experiment and tested electronically (Cassisi, McGlynn, & Claros, 1988). The alarm/monitor is contained within a small plastic box and weighs 411 g. In brief, the internal components of the unit are a signal amplifier/rectifier, a gain/threshold control, a comparator, a Schmitt trigger, an alarm-disabling jumper switch, a piezo buzzer, an EMG response (brux) counting chip, and an alarm event counting chip. The external components are an on/off switch, an alarm termination/reset switch, a momentary data display push button, and an LED data display. The device operates as an EMG-activated, manually terminated nocturnal alarm or, when the alarm is disabled, as an EMG brux-episode monitor. The buzzer produces at least 75 dB when sounded from 1 m away.

Measures

A brux episode is counted whenever the comparator detects rectified EMG activity that exceeds the preset threshold of 50 μV integral average (bandpass 10–550 Hz) for .2 seconds or more and that returns below the threshold for at least one second. The brux-episode count is registered on a column of ten LED lights and is recorded by the subject after the LED display has been activated by pushing a button. The count is encoded into a binary numbering system such that illuminated lights represent “1’s” and nonilluminated lights represent “0’s.” Binary-to-decimal transformation of the recorded configuration is done with the calculating function of the IBM PC-standard computer.
software Sidekick, version 1.56 (Borland International Inc., Scotts Valley, California).

The alarm sounds and is counted whenever the comparator detects the onset of a brux episode. The alarm remains on until the subject manipulates the termination/reset switch. Alarm events are registered on second column of ten LED lights and are recorded by the subject and handled as above. Subjects were instructed that the entire light array was a measure of "how much you brux."

During auditory-feedback phases, subjects recorded the times of night when the alarm sounded. They were instructed to place the record in a convenient, dimly lit area and to acquire an illuminated clock. Instructions explained that accurate timing of the alarm soundings was important to treatment.

Daytime sleepiness was assessed in the morning and evening via self-reports on the Stanford Sleepiness Scale or SSS (Hoddes, Dement, & Zarcone, 1972). This seven-item scale is psychometrically sound (Carskadon, 1982), and it correlates significantly with behavioral measures of sleepiness such as the Sleep Latency Test (Magee et al., 1986).

Vigor, fatigue, and tension were measured with relevant subscales from the Profile of Mood States or POMS (McNair, Lorr, & Droppleman, 1981). At least six reported factor analytic studies have identified vigor, fatigue, and tension as mood factors on the POMS (Eichman, 1978; McNair et al., 1981). The vigor factor is defined by adjectives suggesting a mood of vigor, high energy. The fatigue factor represents a mood of weariness, inertia, and low energy. While negatively related, the vigor and fatigue factors do not appear to be opposite extremes of a single bipolar dimension. The tension factor represents heightened musculoskeletal tension and psychomotor activity.

The POMS has been used to investigate the effects of sleep deprivation (Friedman et al., 1977; Johnson, 1982, p. 129). The instructions for the POMS were modified to read "How have you been feeling today?" instead of "How have you been feeling during the past week, including today?" McNair et al. (1981) reported having replicated the original factor structure with similar instructions.

Procedure

During the first contact with each potential subject, the experimenter explained the screening and treatment procedures, offered $10.00 for participating in screening, offered $50.00 for completing the experiment if selected, and obtained the informed consent signature. The experimenter then trained the subject to use the monitoring function of the alarm/monitor, and to complete the various self-report forms. All individuals were instructed in skin preparation and electrode placement, and twice demonstrated correct electrode application and use of the monitor.

During screening, potential subjects were evaluated for wear facets and dental infection by a specialist at the University of Florida Dental Occlusion and Facial Pain Center. The dentist either did or did not state that bruxism had occurred at some point in the patient's life.
Individuals who met the criterion of 20 brux events for at least one of three nights during screening and who were identified as having been bruxers were considered as subjects. They were assigned randomly to one of two groups that had equal sizes and that differed only in the order of no-treatment monitoring and auditory-feedback phases.

During the first meeting after screening, five subjects were shown how to use the alarm function of alarm/monitor, and five were told to continue monitoring as in the screening phase. Four meetings were held during the subsequent 14-day phase in order to collect data, provide materials, change batteries, troubleshoot, and check for threshold drift in the alarm/monitor. During the first meeting of the second 14-day phase the alarm mode was activated or disabled, depending on the subject’s experimental condition, and subjects received appropriate instructions. Four additional meetings were held as above for the next two weeks.

Data for one to two nights in one or both phases were missing for four subjects because the subject “forgot,” the batteries failed, or an electrode fell off during the night. Phases were extended for appropriate numbers of nights for these four subjects.

RESULTS

Effects of Manually Terminated Feedback

Average hourly brux frequencies for each group during the screening phase are shown in Table 1. The 30 nightly brux frequency values from the screening phase were subjected to a $2 \times 3$ (groups $\times$ days) repeated-measures Analysis of Variance (ANOVA; Dixon, BMDP Statistical Software Manual, 1983). This analysis yielded no significant effects when tested literally at the .15 level. Hence there was no evidence that bruxing among subjects in the two groups differed before treatment.

Average hourly brux frequencies for each group during each experimental phase are shown also in Table 1. The 280 nightly brux frequency values were subjected to a $2 \times 2 \times 14$ (groups $\times$ phases $\times$ days) repeated-measures ANOVA. This analysis yielded significance for the group $\times$ phase interaction.

<table>
<thead>
<tr>
<th></th>
<th>Screening</th>
<th>Phase 1</th>
<th>Phase 2</th>
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<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
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<td>2.3</td>
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<td></td>
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<tr>
<td>Group 2</td>
<td>3.4</td>
<td>2.3</td>
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TABLE 1

MEANS AND STANDARD DEVIATIONS FOR NIGHTLY BRUXES PER HOUR BY GROUP DURING SCREENING, PHASE 1 AND PHASE 2
Fig 1. Nightly number of bruxes per hour for each subject during feedback and during monitoring.
[F(1, 8) = 6.18, p < .05] and prompted post hoc analyses of simple main effects as follows.

Comparisons between groups at each experimental phase were done initially. A 2 \times 14 (groups \times days) ANOVA within the 140 values from the first experimental phase yielded a significant main effect for group [F(1, 8) = 14.19, p < .01]. The same analysis within the 140 values from the second experimental phase did not yield significance. Hence the significant group \times phase interaction in the initial ANOVA shows that significant differences between groups occurred but only during the first phase of the experiment. Table 1 shows that the group receiving auditory feedback displayed lower brux frequencies during this phase than did the group who monitored bruxing without feedback.

Comparisons within groups across experimental phases were done as well. A 2 \times 14 (conditions \times days) ANOVA within the 140 values from Group 1 yielded a significant main effect for condition [F(1, 8) = 11.63, p < .01]. The same analysis within the 140 values from Group 2 did not yield significance. Hence significant differences within groups occurred but only when monitoring preceded auditory feedback. Table 1 shows that auditory feedback reduced bruxing frequencies when it followed monitoring.

Graphic display of the bruxing data from each subject during the experimental phases appears in Figure 1. At the level of visual inspection, four of the five subjects in Group 1 replicated the overall effect for that group. Three of the 5 subjects in Group 2 displayed roughly equivalent bruxing during the auditory-feedback and subsequent monitoring phases.

Post-Feedback Rebound

There was no evidence that bruxing rates returned to or exceeded untreated levels following manually terminated auditory feedback. As just noted, Figure 1 shows that three of five subjects continued to brux at treated rates during two weeks following auditory feedback. In addition a 2 \times 14 (groups \times days) ANOVA within the 140 values for monitoring before versus monitoring after treatment failed to yield significance.

Adverse Effects

Group mean ratings for sleepiness, vigor, fatigue, and tension during each experimental phase are shown in Table 2. Visual inspection revealed only small differences in means between groups and phases. However, visual inspection pointed also to small variances. Therefore, each data set was subjected to a separate ANOVA. (A repeated-measures Multivariate Analysis of Variance was rejected as unduly complex, given the appearance of nondifferent values.)

Initially, 2 \times 3 (groups \times days) repeated measures ANOVAs were performed on each of the five sets of 30 values acquired from the 10 subjects during the three-day screening. No significant effects were produced by any of the five analyses. Next, separate 2 \times 2 \times 14 (groups \times phases \times days) repeated-measures ANOVAs were done within each of the five sets of self-report data. For morning and evening sleepiness, vigor, and fatigue, these analyses pro-
TABLE 2
MEANS AND STANDARD DEVIATIONS FOR THE DAILY RATINGS OF SLEEPINESS, VIGOR, FATIGUE, AND TENSION BY GROUP DURING PHASE 1 AND PHASE 2

<table>
<thead>
<tr>
<th></th>
<th>Phase 1</th>
<th>Phase 2</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>(Monitoring)</td>
<td>(Feedback)</td>
</tr>
<tr>
<td>Group 1</td>
<td>SSS (AM)</td>
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<tr>
<td></td>
<td>SSS (PM)</td>
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<tr>
<td></td>
<td>VIG</td>
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<td></td>
<td>FAT</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>TEN</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>(Feedback)</td>
<td>(Monitoring)</td>
</tr>
<tr>
<td>Group 2</td>
<td>SSS (AM)</td>
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</tr>
<tr>
<td></td>
<td>SSS (PM)</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>VIG</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>FAT</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>TEN</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Note: SSS = Stanford Sleepiness Scale (R = 0-7); VIG = Vigor subscale from the Profile of Mood States (R = 0-32); FAT = Fatigue subscale from the Profile of Mood States (R = 0-28); TEN = Tension subscale from the Profile of Mood States (R = 0-36).

duced no significant effects. The analysis for tension yielded a significant Group × Phase Interaction [F(1,8) = 6.77, p < .05]. Because the feedback phases were counterbalanced, this amounts to a significant main effect for condition. As is shown in Rows 5 and 10 of Table 2, higher tension ratings were obtained during feedback than during monitoring phase.

Accuracy of Self-Monitoring

A 2 × 14 (methods × days) repeated measures ANOVA within the 280 values for self-monitored and automatically recorded alarm events yielded a significant main effect for method [F(1,18) = 4.52, p < .05]. The self-monitored alarm-event tally was 50% of the automatically recorded tally. The accuracy of subjects’ self-monitoring ranged from 23 to 100%.

DISCUSSION

The nocturnal-alarm protocol reduced bruxing rates both between and within experimental groups. There was no evidence of rebounding brux rates when the alarm protocol was discontinued. The nocturnal alarm protocol did not affect self-reports of sleepiness, vigor, or fatigue over and above any effects of monitoring alone. It did produce a statistical effect on self-reports of tension. It did show also that subjects inaccurately self-monitored instances of alarm events during the night.
The effect of the nocturnal alarm replicates and extends the findings of Moss et al. (1982) and of Purzycki et al. (1986) who also used manually terminated alarms to reduce nocturnal bruxing. The absence of "rebound" effects after intervention also is consistent with their findings. The absence of adverse intervention effects should not be overinterpreted because it implies confirmation of the null and it rests on only one domain of behavioral assessment. Neither should the effect of intervention on self-reported tension be overinterpreted. It rests also on one domain of assessment and is not arguably significant actuarially. The error rates for self-monitoring of alarm events are hardly surprising, but it is nonetheless worthwhile to have empirical confirmation.

There is opportunity for research within virtually all domains of experimental variables, e.g. procedures, subjects, measures, feedback protocols, and the like. For example, the electromyographic definition of bruxism itself is without consensual endorsement (see Cassisi et al., 1987). A relatively brief (.2 seconds) supra-threshold duration was coupled with a relatively high (50 mV) threshold here in order to intervene early in a series of bruxes and, at the same time, minimize alarm events triggered by behaviors such as swallowing. However, the success of this approach is not known, and many parameter variations can be envisioned. Similarly, the 75-dB minimum intensity buzzer was chosen because it is representative of the intensities used in similar work (Purzycki et al., 1986). Clearly, however, parameter variations of considerable impact are possible.

Among the more general questions that might be answered are the following representative ones. Would clinical patients with chronic facial pain problems adhere to a self-care protocol that is fairly demanding and potentially aversive? Would the intervention produce statistically significant effects on bruxing by these patients? Would the reduced bruxing be sufficient to produce clinically, i.e., adaptively, significant effects on measures of facial pain and/or mandibular dysfunction? Cassisi et al. (1987) have provided a detailed narrative about methodological directions for continued research and a theoretical overview of the area.

REFERENCES


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