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Nocturnal Masseter and Suprahyoid Muscle Activity Induced by Wearing a Bionator

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ABSTRACT

The purpose of this study was to examine the effect of a bionator on masseter and suprahyoid muscle activities during sleep. Ten healthy Japanese males (mean age: 26.3 years) participated in this study. Electromyographic (EMG) activities of the right masseter and bilateral suprahyoid muscles were recorded during sleep with and without a bionator. Although no significant changes were observed in the maximal EMG activities of these muscles, the maximal EMG activity of suprahyoid muscles tended to decrease while wearing the bionator. The number of events over 40% maximal voluntary contraction (MVC) tended to decrease in these muscles with a bionator, but these changes were not statistically significant. These findings indicate that there are no significant changes or there is only a tendency to decrease the activities of the masseter and suprahyoid muscles while wearing a bionator during sleep.

KEY WORDS: Bionator, Electromyography, Masseter muscle, Suprahyoid muscles, Sleep.

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INTRODUCTION Return to TOC

A functional appliance, which is considered to stimulate mandibular growth in growing patients with retrognathia, is widely used in daily orthodontic practice. Andersen and Hauple[1] suggested that the mechanism of action involved activation of the masticatory muscles. In an electromyographic (EMG) study, Eschler[2] demonstrated that wearing such an activator increased the EMG activities of the temporalis, masseter, and orbicularis oris muscles. Since then, several studies have investigated and discussed the concept that functional appliances activate orofacial muscles.[3–22]

Most previous studies regarding the effect of a functional appliance on masticatory muscle activities were performed during wakefulness. However, functional appliances, except for the fixed type such as the Herbst appliance, are mainly used during sleep. With regard to the difference in muscular function between wakefulness and sleep, Tangel et al[23] demonstrated a significant decrease in the tonic activity of the masseter muscle during non-rapid-eye-movement sleep. This indicates that changes observed in masticatory muscle activity could be different between wakefulness and sleep. Some authors have proposed that a functional appliance should be used in the daytime to obtain better treatment results.[4,7,10,16] Ahlgren[4,10] cast doubt on the idea that the mechanism of action was functional stimulation during the night, since there were no changes in either the postural resting activity or the biting contraction of jaw-closing muscles upon insertion of an activator.

The purpose of this study was to examine the effect of a bionator on the activities of the masseter and suprahyoid muscles during sleep using a newly developed portable EMG recording unit. In this study, the short-term response of muscle activity to a bionator was experimentally examined in healthy male adults.

MATERIALS AND METHODS Return to TOC

Subjects

Ten healthy Japanese males (mean age of 26.3 years) participated in this study. Each participant had an acceptable incisal relationship and a complete dentition except for their third molars. They had minor crowding among the anterior teeth, however, they were judged to have acceptable occlusion. Among the 10 subjects, 3 were aware of nocturnal bruxism. Prior to the study, all of the subjects gave informed consent to participate after receiving a full explanation of the aim and design of the study.

Experimental procedures

Both maxillary and mandibular plaster models of each subject were mounted on an articulator (YS-714: YDM YAMAURA, Tokyo, Japan) using a construction bite. The construction bite was taken in the protruded mandibular position; the mandible was positioned anteriorly to achieve an edge-to-edge incisal relationship and opened vertically to an inter-incisal distance of 2 mm. Using the working model, a bionator was fabricated using 0.9 mm Co-Cr orthodontic wire (Sun Platinum Orthodontic Wires: SANKIN, Tochigi, Japan) and self-curing resin (Orthodontic Resin: Caulk Dentsply, Milford, Del). Figure 1 shows a bionator fitted in a subject. In this study, the acrylic resin of the bionator was not trimmed to prevent movement of the appliance.

Electromyographic activities of both the right masseter and bilateral suprahyoid muscles were recorded with a portable EMG recording unit (Muscle Tester ME3000 Professional: Mega Electronics, Kuopio, Finland). A bipolar surface electrode was set on the masseter muscle so as to be parallel to muscle fibers, whereas a bipolar surface electrode for recording of suprahyoid muscle activity was positioned bilaterally in the submental region (Figure 2). Ground electrodes for the masseter and suprahyoid muscles were attached to the forehead and ipsilateral ear lobe, respectively.

The overnight experiment was conducted in a room at a lodging managed by the Dental Alumni of Tokyo Medical and Dental University. At midnight, the subject was asked to lie on a bed following complete preparation of the surface electrodes. The subject was instructed to perform maximal clenching in the intercuspal position 3 times for 3 seconds each time, and maximal jaw opening 3 times for 3 seconds each time. The mean EMG activities recorded during maximal clenching and jaw opening were used as a basis (100% MVC) for the following analysis of masseter and suprahyoid EMG activities, respectively. After the maximal clenching and jaw-opening effort, the subject was allowed to fall asleep. The experimental session consisted of 2 parts. In the first half of the night, EMG activities were recorded for about 3 hours of sleep without the bionator. Following the first recording session, the subject was awakened to fit the bionator and then asked to sleep again. In the second half of the night, EMG activities were recorded during about 3 hours of sleep with the bionator. After the second recording session was completed, all electrodes and the bionator were removed.

Data Analysis

Integrated EMG activities were transferred to a personal computer (FMV-BIBLO NR IX 30L: FUJITSU, Tokyo, Japan) using a SRAM card (MELCARD: MITSUBISHI, Tokyo, Japan), and data analysis was performed with accessory software (Muscle Tester ME3000P Software v.1.4-program: Mega Electronics, Kuopio, Finland). First, the total recording time with and without the bionator was calculated. Second, the periods between 30 minutes after the beginning of the first and second halves of the experiment and 5 minutes before the end of each half of the experiment were used for further analysis (Figure 3). Maximal EMG activities of each muscle recorded during sleep with and without the bionator were calculated as percentages of 100% MVC for each muscle.

Number of events beyond 40% MVC per hour

Electromyographic activities beyond 40% MVC in the masseter muscle were regarded as bruxing events during sleep[24]. The total number of these events was counted for recordings with and without the bionator, and divided by the hours in the recording period to give the number of events per hour. Similarly, EMG activities beyond 40% MVC in the suprahyoid muscles were regarded as significant events, and the number of events per hour was calculated in the same manner. Two or more consecutive events separated by less than one second were regarded as a single event.

Distribution of muscle activities

The duration of recording for each level of muscle activity (0–1% MVC, 1–5% MVC, 5–10% MVC, and over 10% MVC) with and without the bionator was measured and ratios to the total recording time were calculated.

The Wilcoxon signed-rank test was used for the statistical analysis. A value of *P* < .05 was considered significant.

RESULTS Return to TOC

Changes in the maximal EMG activities of the masseter and suprahyoid muscles with and without a bionator are shown in Figure 4 for each subject. In both muscles, the maximal EMG activities showed no significant changes with the bionator. However, the maximal EMG activity of the suprahyoid muscles tended to decrease when the bionator was inserted (*P* = .0593). The mean maximal EMG activities of the masseter and suprahyoid muscles without the bionator were 59.9% MVC and 167.3% MVC, respectively. Those values recorded with the bionator averaged 42.7% MVC and 102.0% MVC, respectively. In all of the subjects, the maximal EMG activity of the masseter muscle did not exceed 100% MVC either with or without the bionator, whereas that of the suprahyoid muscle recorded without the bionator exceeded 100% MVC in 7 subjects, and thus was beyond the EMG activity during maximal jaw opening in the awake state. Changes in the number of events beyond 40% MVC before and after insertion of a bionator are shown in Figure 5. Although no significant changes were found in the number of events in either muscle, the number of events tended to decrease in both the masseter (*P* = .0756) and suprahyoid (*P* = .0663) muscles. The mean number of events in the masseter and suprahyoid muscles was 9.8 per hour and 17.2 per hour without the bionator and 2.0 per hour and 7.2 per hour with the bionator, respectively.

Table 1 shows changes in the duration of the lowest (0–1% MVC) and highest (over 10% MVC) levels of EMG activities of the masseter and suprahyoid muscles by wearing the bionator. In the masseter muscle, the duration of the lowest level of EMG activity increased in 6 subjects, decreased in 2 subjects, and did not change in 2 subjects. In the suprahyoid muscles, the duration of the lowest level of EMG activity increased in 6 subjects and decreased in 4 subjects. On the other hand, in the masseter muscle, the duration of the highest level of EMG activity decreased in 9 subjects and increased in only one subject. In the suprahyoid muscles, the duration of the highest level of EMG activity decreased in 7 subjects and increased in 3 subjects. Collectively, the masseter and suprahyoid EMG activity tended to decrease with the bionator, although no definite change was observed.

DISCUSSION Return to TOC

Methodology

Previous studies used a conventional EMG recording unit to examine changes in nocturnal masticatory muscle activities induced by wearing oral appliances including the functional appliance[4,10] and occlusal splint.[25,26] However, such a recording unit seems to be inappropriate for the precise evaluation of EMG activity. We should be aware of noises derived from unconscious body movements when we record EMG activities of masticatory muscles during sleep. In this context, with the portable EMG recording unit used in the present study, problems with motion interference that normally occur in field measurements have been solved using state-of-the-art amplification technology in which the amplifier is connected directly to the ground electrode. This very effectively eliminates noises caused by disturbances such as body movements[27,28] and retains EMG signals. Therefore, we can expect that actual EMG activities were measured much more accurately in this study than in previous reports.

In all of our subjects, EMG activities were invariably recorded without and with a bionator in the first and second halves of the experiment, respectively. Recently, it has been demonstrated that bruxism shows day-to-day variation within individuals.[29] To distinguish the actual effect of a bionator on EMG activities from the day-to-day variation in nocturnal bruxism, EMG activities of the masseter and suprahyoid muscles both with and without a bionator were recorded during sleep on the same night.

One of the most critical limitations of the design of this study is that the electroencephalograms and electro-oculograms were not simultaneously monitored to determine sleep stages during this study. It is generally considered that there is a definite sleep cycle in normal sleep. The average period of the NREM-REM sleep cycle is approximately 90 minutes throughout the night.[30] In the present study, the recording time of both the first and second halves of the one-night sleep was about 3 hours (180 minutes), which is twice the period of the normal sleep cycle. Since all of the subjects in this study were normal young adults who had conventional sleep-wake schedules with no sleep complaints, the distribution of the sleep stage is probably similar between the first and second halves of the one-night sleep. It was also demonstrated that the distribution of sleep stages across full-night polysomnography and polysomnographic recording during first half of night was not statistically different. From this finding, it was suggested that the split-night study was an appropriate method for diagnosis and treatment of sleep-disordered breathing, instead of conventional 2 night diagnostic and therapeutic studies.[31,32] Moreover, it is generally suggested that a sleep latency shorter than 5 or 10 minutes can be related to abnormal sleep such as sleep-disordered breathing, although the precise definition of the onset of sleep is controversial.[30] To make sure that the EMG activities recorded during sleep could be analyzed, the data analysis began 30 minutes after the beginning of the first and second halves of the experiment.

In the present study, EMG activity of the masseter muscle exceeding 40% MVC was considered to be significant. This is consistent with a previous study[24] in which clenching of less than 40% MVC was intermingled with swallowing, which generally occurred at less than 30%

MVC. On the other hand, regarding the suprahyoid muscles, EMG activity beyond 40% MVC was analyzed in the same manner as for the masseter muscles because no previous study has provided criteria for evaluating the EMG activity of the suprahyoid muscles.

To evaluate the distribution of EMG activity, 4 levels (0–1% MVC, 1–5% MVC, 5–10% MVC, and over 10% MVC) were established for this study. The lower level of EMG activity was recorded throughout almost the entire night of sleep; therefore, the lower level of EMG activity was subdivided and analyzed in more detail than the higher level.

Changes in EMG activity with a bionator

The maximal EMG activity during sleep did not show any significant changes in either the masseter or suprahyoid muscles. However, the maximal EMG activity in the suprahyoid muscles tended to decrease after insertion of the bionator (Figure 4). While the maximal EMG activity of the masseter muscle recorded during sleep was below 100% MVC in all of the subjects, the EMG activity of the suprahyoid muscles during sleep exceeded 100% MVC in many subjects. This means that the EMG activity recorded during maximal jaw opening during wakefulness was not necessarily the actual maximal activity of the suprahyoid muscles. Among the suprahyoid muscles, EMG activities of the anterior belly of the digastric, geniohyoid, and mylohyoid muscles could be recorded with surface electrodes attached to the submental region in this study. Moreover, this type of surface electrode could also record the EMG activity of the genioglossus muscle. In the present study, several suprahyoid muscles were regarded as a single muscle group, and the overall EMG activity was recorded without distinction among individual muscles. These muscles are considered to be active during jaw opening, swallowing, and controlling the position of the hyoid bone and tongue posture. Therefore, suprahyoid EMG activities beyond 100% MVC during sleep were likely to be associated with these behaviors rather than maximal jaw opening.

Although the number of events beyond 40% MVC per hour did not change significantly in the masseter and suprahyoid muscles, it tended to decrease with a bionator. Interestingly, events beyond 40% MVC were recorded in the masseter muscle of all of the subjects, which inferred that all of the subjects performed bruxing during sleep. Three subjects were aware of their nocturnal bruxism, however, there was no relationship between the number of bruxing events and awareness of nocturnal bruxism.

The duration of the lower level of EMG activity tended to increase and that of the higher level tended to decrease with a bionator (Table 1), although no definite changes related to the insertion of a bionator were observed in the distribution of EMG activities. Regardless of the presence of a bionator, EMG activity of 0–1% MVC was recorded for almost the entire recording period, indicating that the masseter and suprahyoid muscles showed a low level of EMG activity during most of the sleeping period. This is consistent with the findings regarding the maximal EMG activity and the number of events over 40% MVC.

The activities of the masseter and suprahyoid muscles did not seem to be stimulated by wearing a bionator and, indeed, nocturnal use of a bionator appeared to relax these muscles. This supports previous reports which demonstrated that there was no increase in the postural EMG activity while wearing an activator during sleep.[4,10] While it is unclear why the EMG activities of the masseter and suprahyoid muscles were reduced by wearing a bionator, there are several possible explanations. It has been reported that an increase in the occlusal vertical dimension reduced jaw-closing muscle activity.[33] Therefore, such a change in the vertical dimension induced by wearing a bionator might lead to a decrease in masseter EMG activity through a reduction of proprioceptive feedback from the muscle spindle. On the other hand, insertion of a bionator could bring the mandible to a forced forward position. It has been demonstrated that forward positioning of the mandible could contribute to increase the sagittal upper-airway dimension.[34] Since the suprahyoid muscles play an important role in maintaining the upper airway,[35] the increase in the upper-airway dimension induced by wearing a bionator could reduce the tonus of the upper-airway-dilating muscles. This may be equivalent to the tendency for suprahyoid EMG activity to decrease.

It has been suggested that anterior repositioning of the mandible[9] and the facilitation of mandibular growth could be induced through the functional activation of masticatory muscles resulting from the forced forward positioning of the mandible by a bionator.[36] Furthermore, it has been indicated that the tongue posture could be retrained through the activating effect of a palatal bar on tongue muscles.[36] However, based on the findings in the current study, it is apparent that the activities of the masseter and suprahyoid muscles tend to decrease by wearing a bionator during sleep (ie, the bionator does not stimulate these muscles during sleep). Therefore, it may not be advisable to use the appliance during sleep to obtain the treatment effect through the working mechanism traditionally suggested in the clinical application of the bionator. This agrees with previous studies which suggested that a functional appliance should be used during daytime.[4,7,10,16] It has been reported that the adaptation of the muscular function could be established within a short period of time.[22] Therefore, future studies should examine the longitudinal change in activities of these muscles with the bionator to clarify the mechanism of action of the bionator and propose a more effective and evidence-based *modus operandi.*

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REFERENCES Return to TOC

1. Andresen V. The Norwegian system of functional gnatho-orthopedics. *Acta Gnathol.* 1936; 1:5–36.

2. Eschler J. *Die Funktionelle Orthopadie des Kausystems*. Munchen: C Hauser; 1952.

3. Uner O, Darendeliler N, Bilir E. Effects of an activator on the masseter and anterior temporal muscle activities in class II malocclusions. *J Clin Pediatr Dent.* 1999; 23:327–332. [PubMed Citation]

4. Ahlgren J. An electromyographic analysis of the response to activator (Andresen—Häuple) therapy. *Odontol Rev.* 1960; 11:125–151.

5. Grossman WJ, Greenfield BE, Timms DJ. Electromyography as an aid in diagnosis and treatment analysis. *Am J Orthod.* 1961; 47:481–497.

6. Grosfeld O. Changes of muscle activity patterns as a result of orthodontic treatment. *Trans Eur Orthod Soc.* 1965:203–214.

7. Thilander B, Filipsson R. Muscle activity related to activator and intermaxillary traction in Angle Class II, Division 1 malocclusions. An electromyographic study of the temporal, masseter and suprahyoid muscles. *Acta Odontol Scand.* 1966; 24:241–257. [PubMed Citation]

8. McNamara JA Jr. Neuromuscular and skeletal adaptations to altered function in the orofacial region. *Am J Orthod.* 1973; 64:578–606. [PubMed Citation]

9. Witt E. Muscular physiological investigations into the effect of bi-maxillary appliances. *Trans Eur Orthod Soc.* 1973:448–450.

10. Ahlgren J. Early and late electromyographic response to treatment with activators. *Am J Orthod.* 1978; 74:88–93. [PubMed Citation]

11. Auf der Maur HJ. Electromyographic recordings of the lateral pterygoid muscle in activator treatment of Class II, division 1 malocclusion cases. *Eur J Orthod.* 1980; 2:161–171. [PubMed Citation]

12. Pancherz H, Anehus-Pancherz M. Muscle activity in Class II, Division 1 malocclusions treated by bite jumping with the Herbst appliance—an electromyographic study. *Am J Orthod.* 1980; 78:321–329. [PubMed Citation]

13. Pancherz H, Anehus-Pancherz M. The effect of continuous bite jumping with the Herbst appliance on the masticatory system: a functional analysis of treated Class II malocclusions. *Eur J Orthod.* 1982; 4:37–44. [PubMed Citation]

14. Ingervall B, Bitsanis E. Function of masticatory muscles during the initial phase of activator treatment. *Eur J Orthod.* 1986; 8:172–184. [PubMed Citation]

15. Carels C, van Steenberghe D. Changes in neuromuscular reflexes in the masseter muscles during functional jaw orthopedic treatment in children. *Am J Orthod Dentofacial Orthop.* 1986; 90:410–419. [PubMed Citation]

16. Miralles R, Berger B, Bull R, Manns A, Carvajal R. Influence of the activator on electromyographic activity of mandibular elevator muscles. *Am J Orthod Dentofacial Orthop.* 1988; 94:97–103. [PubMed Citation]

17. Sessle BJ, Woodside DG, Bourque P, Gurza S, Powell G, Voudouris J, Metaxas A, Altuna G. Effect of functional appliances on jaw muscle activity. *Am J Orthod Dentofacial Orthop.* 1990; 98:222–230. [PubMed Citation]

18. Yuen SW, Hwang JC, Poon PW. Changes in power spectrum of electromyograms of masseter and anterior temporal muscles during functional appliance therapy in children. *Am J Orthod Dentofacial Orthop.* 1990; 97:301–307. [PubMed Citation]

19. Ingervall B, Thuer U. Temporal muscle activity during the first year of Class II, Division 1 malocclusion treatment with an activator. *Am J Orthod Dentofacial Orthop.* 1991; 99:361–368. [PubMed Citation]

20. Yamin-Lacouture C, Woodside DG, Sectakof PA, Sessle BJ. The action of three types of functional appliances on the activity of the masticatory muscles. *Am J Orthod Dentofacial Orthop.* 1997; 112:560–572. [PubMed Citation]

21. Tallgren A, Christiansen RL, Ash MM, Miller RL. Effects of a myofunctional appliance on orofacial muscle activity and structures. *Angle Orthod.* 1998; 68:249–258. [PubMed Citation]

22. Hiyama S, Ono T, Ishiwata Y, Kuroda T, McNamara JA Jr. Neuromuscular and skeletal adaptations following mandibular forward positioning induced by the Herbst appliance. *Angle Orthod.* 2000; 70:442–453. [PubMed Citation]

23. Tangel DJ, Mezzanotte WS, Sandberg EJ, White DP. Influences of NREM sleep on the activity of tonic vs. inspiratory phasic muscles in normal men. *J Appl Physiol.* 1992; 73:1058–1066. [PubMed Citation]

24. Okeson JP, Phillips BA, Berry DTR, Cook Y, Paesani D, Galante J. Nocturnal bruxing events in healthy geriatric subjects. *J Oral Rehabil.* 1990; 17:411–418. [PubMed Citation]

25. Solberg WK, Clark GT, Rugh JD. Nocturnal electromyographic evaluation of bruxism patients undergoing short-term splint therapy. *J Oral Rehabil.* 1975; 2:215–223. [PubMed Citation]

26. Clark GT, Beemsterboer PL, Solberg WK, Rugh JD. Nocturnal electromyographic evaluation of myofascial pain dysfunction in patients undergoing occlusal splint therapy. *J Am Dent Assoc.* 1979; 99:607–611. [PubMed Citation]

27. Hamalainen O, Vanharanta H. Effect of Gz forces and head movements on cervical erector spinae muscle strain. *Aviat Space Environ Med.* 1992; 63:709–716. [PubMed Citation]

28. Hofmann P, Leitner H, Gaisl P. Heart rate threshold, lactate turn point and anaerobic threshold determination by electromyography. *Exerc Physiol.* 1992; 33:13–20.

29. Ichiki R, Tsukiyama Y, Koyano K. Development of a portable electromyographic recording device and an application for the evaluation of the day to day variation of nocturnal masseter muscle activity. *J Jpn Soc Stomatognath Funct.* 1999; 6:67–77.

30. Carskadon MA, Dement WC. Normal human sleep: an overview. In: Kryger MH, Roth T, Dement WC, eds. *Principles and Practice of Sleep Medicine.* London: WB Saunders; 1994:16–25.

31. Sanders MH, Black J, Costantino JP, Kern N, Studnicki K, Coates J. Diagnosis of sleep-disordered breathing by half-night polysomnography. *Am Rev Respir Dis.* 1991; 144:1256–1261. [PubMed Citation]

32. Strollo PJ Jr,, Sanders MH, Costantino JP, Walsh SK, Stiller RA, Atwood CW Jr. Split-night studies for the diagnosis and treatment of sleep-disordered breathing. *Sleep.* 1996; 19: (suppl). 255–259. [PubMed Citation]

33. Carlsson GE, Ingervall B, Kocak G. Effect of increasing vertical dimension on the masticatory system in subjects with natural teeth. *J Prosthet Dent.* 1979; 41:284–289. [PubMed Citation]

34. Özbek MM, Memikoglu TUT, Gogen H, Lowe AA, Baspinar E. Oropharyngeal airway dimensions and functional-orthopedic treatment in skeletal Class II cases. *Angle Orthod.* 1998; 68:327–336. [PubMed Citation]

35. Van de Graaff WB, Gottfried SB, Mitra J, Van Lunteren E, Cherniack NS, Strohl KP. Respiratory function of hyoid muscles and hyoid arch. *J Appl Physiol.* 1984; 57:197–204. [PubMed Citation]

36. Graber TM, Neumann B. Bionator. In: Graber TM, Neumann B, eds. *Removable Orthodontic Appliances.* 2nd ed. Philadelphia, Penn: WB Saunders; 1984:357–375.

TABLES Return to TOC

TABLE 1. Changes in the Duration of Muscle Activity Among 10 Patients After Wearing the Bionator

	Increase	No Change	Decrease
Lowest level of muscle activity (0–1% MVC)			
Masseter muscle	6	2	2
Suprahyoid muscles	6	—	4
Highest level of muscle activity (over 10% MVC)			
Masseter muscle	1	—	9
Suprahyoid muscles	3	—	7

MVC indicates maximal voluntary contraction.

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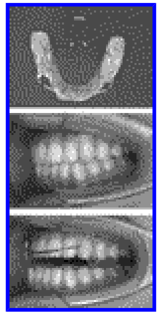

Click on thumbnail for full-sized image.

FIGURE 1. A bionator used in the present study

Click on thumbnail for full-sized image.

FIGURE 2. Surface electrodes to record EMG activities of the masseter and suprahyoid muscles

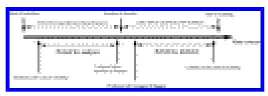

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FIGURE 3. Definition of recording periods for analysis

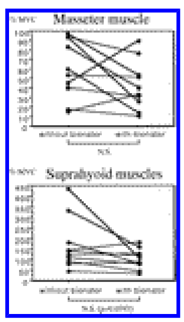

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FIGURE 4. Changes in the maximal EMG activities of the masseter and suprahyoid muscles recorded during sleep with and without a bionator. NS: not significant

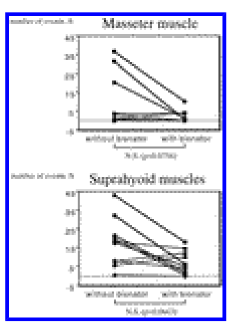

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FIGURE 5. Changes in the number of events beyond 40% MVC recorded during sleep with and without a bionator (per hour). NS: not significant

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