A System for Analysis of Sleep and Nocturnal Activity in Craniomandibular Muscles

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A system was developed for continuous, full-night, polysomnographic recording of sleep using manual sleep scoring and automatic electromyographic analysis of craniomandibular muscle activity. In the sleep laboratory, data are stored on tape with hard copy on paper followed by off-line, computer-controlled digital processing. Muscle activity is described by the Amplitude Probability Distribution Function and by parameters of time and intensity. Sleep and electromyographic data are available graphically on screen, and the results are presented in tables and graphics after statistical treatment. The system was developed to provide a differentiated, detailed analysis of sleep and nocturnal muscle activity in the craniomandibular system that is suitable for comparing groups of individuals, effects of treatments, and physical load of muscles. Applications of the system are demonstrated.
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In 1952, Eschler[1,2] introduced nocturnal electromyography (EMG) from the masseter muscle in humans using a cathode-ray tube camera. With the findings of the cyclic nature and multivariable state of sleep,[3] laboratory polysomnographic recordings with EMG of skeletal muscles were introduced.[4,5] This contributed to the establishment of the international manual for standardization of sleep recording with qualitative electromyography of facial or submental muscles.[6]

Laboratory polysomnographic studies of the craniomandibular system have comprised specific nocturnal EMG of mandibular elevator muscles,[7–11] lip muscles,[12] and geniohyoid muscles,[13] as well as unspecific EMG of submental muscles.[14] Also under study have been muscles of the extremities such as the tibialis anterior muscle for the diagnosis and treatment of periodic leg movements in sleep (PLMS),[15] and the biceps, triceps, extensor digitori, quadriceps, and gastrocnemius muscles for the diagnosis of excessive fragmentary myoclonus in sleep.[16] All the studies have been based on laboratory polysomnographic recordings, and the muscle activity has been manually assessed by qualitative or semiquantitative methods.

Without sleep recording, Kraft[17,18] developed laboratory EMG equipment to quantify time and intensity of nocturnal contractions of craniomandibular muscles. Others have used ambulatory equipment, ie, portable EMG devices, to pick up nocturnal paraspinal muscle activity in patients with low back pain[19] and nocturnal craniomandibular muscle activity.[20–23] Stock and Clarke[24] developed a microprocessor-based ambulatory system connected to a tape recorder on which integrated activity and duration of contraction events were registered. An ambulatory portable integrator producing one accumulated value per night (type AL-200, Aaron Labs,

Sunnyvale, CA)[25] and its forerunner have been used in many studies.[26,27] Some have focused on the intensity of contraction events in craniomandibular muscles,[17,18,23,24,28,29] but none have included the total dynamic range of all nocturnal muscle activity.

Sleep scoring according to the manual of Rechtschaffen and Kales[6] is simple but tedious and time-consuming. The development of automatic sleep scoring has been ongoing during the past decade. So far it has failed to reach the level of validity of the standard manual.[30,31] Therefore, at present, manual scoring is mandatory for assessment of sleep.

The tedious and time-consuming elaboration of sleep and EMG scoring of craniomandibular muscles has limited the outcome of studies exploring physiologic and clinical aspects of nocturnal bruxism. A need for automatic analysis of full-night nocturnal electromyography is obvious.

The intensity and time course interaction of masticatory muscles, their relation to fatigue and overload of the muscles, and consequences to craniomandibular disorders (CMD) have been elaborated in natural craniomandibular functions (ie, mastication, swallowing, and resting posture).[32–34] In relation to nocturnal craniomandibular muscle activity, studies have focused on patients with bruxism and CMD[35–37]; however, these studies have never used methods to quantify nocturnal muscle load to assess development of fatigue, overload, and pain.

Ergonomic work physiologic studies have mainly concerned specific and simple settings to estimate load on individual muscles or parts of individual muscles based on endurance time, rates of perceived exertion, or electromyographic power frequency spectrum and amplitude changes.[38–41] The Amplitude Probability Distribution Function (APDF) was developed to quantify local muscle load during long-term occupational work situations.[42–43] The potential of this method in studying full-night sleep and nocturnal muscle activity is apparent.

The aim of this study was to develop a continuous, full-night, polysomnographic recording system of sleep and EMG of craniomandibular muscles using manual sleep scoring according to the international standard[6] and an automatic electromyographic analysis of the total dynamic range, including both postural and maximal levels of all the nocturnal muscle activity related to sleep stages. The automatic EMG analysis includes a detailed description of contraction characteristics in mandibular elevator muscles during sleep, as well as the APDF analysis.

Specification of the System

Recording Procedure

Electrode Placement. The international standard for sleep recording was used for evaluation of sleep.[6] Two channels of cortical activity (EEG) were picked up with monopolar surface electrodes (EEG Ag/AgCl, Siemens-Elena, Solna, Sweden) at C4 and O2 placements in connection with a reference electrode (type C-120-N, Medicotest, Ølstykke, Denamark) at A1 placement on the mastoid process.[44] Eye movements (AOG) were recorded with a movement sensor (type E232E, Siemens, Erlangen, Germany) on the right eyelid.[45] Muscle activity for sleep assessment (chin-EMG) was picked up unspecifically from submental, mimic, and elevator mandibular muscles (SME) with bipolar recording from surface electrodes (Medicotest, type VL-120-C) placed bilaterally over the mandibular base halfway between the mental tubercle and angulus of the mandible.

Activity in the anterior part of the temporal muscles (RAT, LAT), masseter muscles (RMA, LMA), and muscles in the lower lip (RLL) was picked up with bipolar surface electrodes.[34] All cables were fixed by collodium or adhesive tape at a distance of 2 to 4 cm from electrodes and gathered above the vertex to permit movements of the subject in the bed. The subject was grounded by a cable connected to three electrodes (Medicotest, type VL-00-S) placed around the neck of the patient.

Amplification. Amplifiers (Type 15C01, Dantec, Copenhagen, Denmark) (Fig 1, a1) were of the differential input type, with electrode cable capacitance reduction, input impedance greater than 250 MΩ, a common-mode rejection ratio higher than 100 dB, and with first order (6 dB/octave) low- and high-pass filters. Overall electrical noise corresponded to input noise lower than 1 μVpp. Gain was set to 1,000 and 10,000 for AOG and EEG channels, respectively, with bandpass filtering from 0.5 to 50 Hz. The gain setting was 50,000 on chin-EMG and 5,000 (linear up to 4800 μVpp input) for temporal, masseter, and lip muscles. EMG channels were bandpass filtered from 20 Hz to 10 kHz.

Artefact Filtration. The amplified EMG signals were passed through third order (18 dB/octave), high-pass filters (type 00026 B3HM, Fonema, Julita Sweden) (Fig 1, a2) with a 25-Hz cutoff frequency to minimize the effect of electrode movement artefacts.

Data Recording. The signals were recorded on VHS videocassette tapes (Super High Grade, E240,

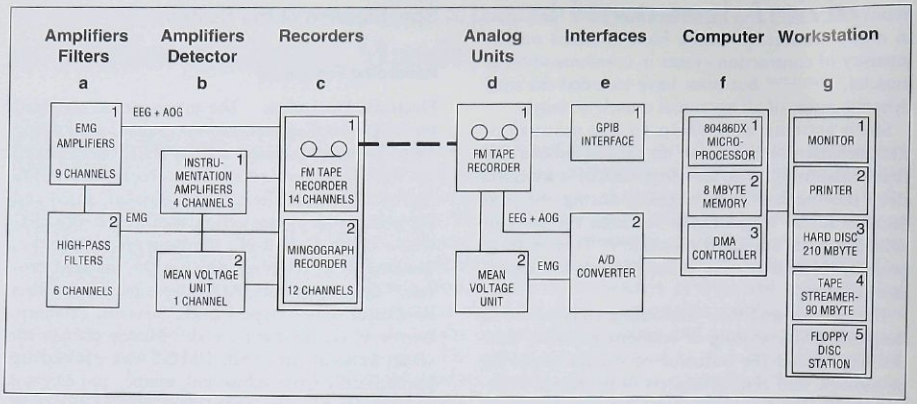

Fig 1 Experimental setup. Recording is obtained by EMG amplifiers (a1), and specific surface electromyographic signals are passed through high-pass filters (a2) before storage on tape (c1) and mingograph hard copy (c2). Off-line acquisition and digitalization of EEG and eye movement signals and specific electromyographic signals quantified by mean voltage (d2) are performed by a personal computer (e, f, g) controlling the tape recorder (d1) and a GPIB-interface (e1). Data are processed, stored on hard disk (g3) and tape streamer (g4), and displayed on monitor (g1) with printout of results (g2).

Fuji, Tokyo, Japan) using a 14-channel FM tape recorder (type XR-510, Teac, Tokyo, Japan) (Fig 1, c1 and d1) with a controller (type EC-100, Teac) and GPIB (IEEE-488) interface (type AR-503, Teac) (Fig 1, e1). With a tape speed of 2.4 cm/s, the frequency response was DC to 625 Hz (-0.1-dB cutoff frequency). The effective bandwidth of the recorded EMG signal was 25 to 625 Hz. The dynamic range of the myoelectric signals, including both postural and maximal levels, exceeded the tape recorder's input range. Therefore, each of the amplified electromyograms from RAT, LAT, RMA, and LMA, respectively, were recorded on two channels with different amplifications on the tape recorder with a 14-dB dynamic overlap (Fig 2). The SME and RLL were recorded at an input range optimal to postural activity. One channel of the tape recorder was used to control input range, ID-file number, tape counter number, tape speed, and time code. For continuous observation and sleep scoring, all signals were recorded on a 12-channel ink-jet writer (Mingograph, Siemens-Elema) (Fig 1, c2) with a frequency response of up to 1.2 kHz and a paper speed of 1 cm/s. The specific muscle signals were first amplified through instrumentation amplifiers (O-byte Hardware, Copenhagen; gain 20×) (Fig 1, b1) to reproduce postural activity clearly. Beside representation of the raw signal, RLL was passed through a mean voltage unit with a time constant of 20 ms (Dantec, type 31C11) (Fig 1, b2) before representation on Mingograph to reproduce signals beyond postural activity.

Calibration. The calibration signal at the input level of each EMG-amplifier (1.0-Vpp output, 20-Hz square wave) was recorded on tape and paper at the beginning and at the end of the night with filters (Fig 1, a2) and instrumentation amplifiers (Fig 1, b1) were turned off.

Standard Examination. The subjects arrived 2 hours before their normal bedtime for electrode placement, presleep recording, etc, according to the following schedule.

Presleep (evening):

1. Resting posture, subject supine, open eyes, 20 seconds.
2. Resting posture as in 1, closed eyes, 20 seconds.
3. Maximal voluntary contraction of muscles under study: elevator muscles of the mandible at maximal bite in the intercuspal position and biting on a splint; and muscles of the lips at maximal protrusion. Four contractions are sampled.
4. Repetition of 1.
5. Repetition of 2.

Sleep (night):

6. When the subject decides to sleep, the light is turned off, and the recording is started. Sleep recordings are finished when the subject is awakened between 7 and 8 am.

Postsleep (morning):

7. Repetition of steps 1 through 5.

Videotape recordings were taken throughout the night with an infrared, charge-coupled-device camera that had a remote-controlled zoom and pan, and a microphone was placed over the subjects' head.

Computer Analysis

Software written in ASYST 4.0 (Keithley Instruments) has been developed for off-line acquisition of the polysomnographic signals and further analysis of EMG measurements.

Computer Equipment (Fig 1). The system is based on a personal computer (Fig 1, f and g) with an Intel 80486DX microprocessor (Fig 1, f1), analog-to-digital (A/D) conversion board (Data Translation, type DT 2801A) (Fig 1, e2), GPIB (IEEE-488) interface board (Fig 1, e1), and 90-megabyte tape streamer (Tecmar, type QT-90e) (Fig 1, g4). For numeric and graphic representation, a printer (HP LaserJet Series II and IBM proprinter XL) (Fig 1, g2) was connected to the work station. The A/D conversion board was set to single-ended and unipolar input range on 0 to 2.5 V with 12-bit resolution (Fig 2). The output range of the tape recorder was set up to 2.5 V (Fig 2). The AOG and EEG channels were converted direct with offset shift to 1.25 V, and EMG channels are filtered by a mean voltage unit (Dantec, type 31C11) (Fig 1, d2) before digital conversion.

Data Analysis. *Data Acquisition.* Examination data, tape recorder identification files, and gain of EMG-amplifiers were keyed in a menu before signal conversion. The computer operates the tape recorder automatically through the GPIB-interface (Fig 1, e1). All channels were sampled with a 50-Hz sampling frequency and a cyclic buffer on real-time play back. The data were corrected by a calibration factor obtained by a 10-second mean of the recorded calibration signal generated by the amplifiers and reduced by the tape recorder's upper frequency limit. Each of the four muscle signals (RAT, LAT, RMA, LMA) recorded on two separate channels (low gain, high gain) were computed to one channel at a threshold of 2.44 V on the high-gain channel of the A/D conversion

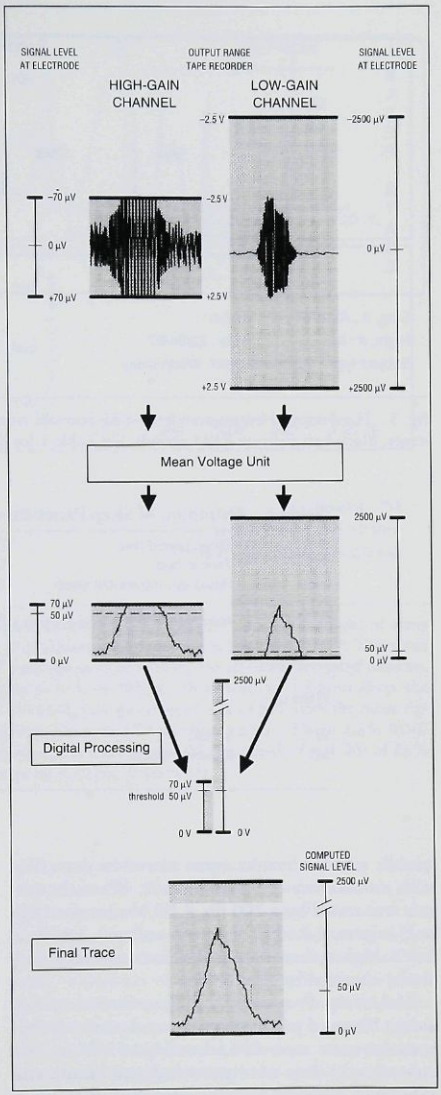

Fig 2 Signal pathway from EMG electrode to computer. The signal is split up on the tape recorder into low- and high-gain channels of both a 48-dB signal-to-noise ratio and a 14-dB overlap between channels. Output ranges of tape recorder and A/D conversion board are up to 2.5 V. After mean voltage passage, the two channels are computed into one channel and calibrated according to signal level at the electrode.

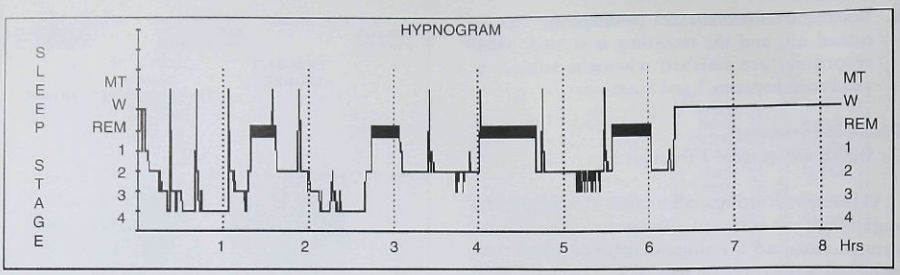

Fig 3 Hard copy of hypnogram from a 25-year-old woman with a normal sleep architecture and distribution of sleep stages. Black bars indicate REM periods. See Table 1 for description of sleep parameters.

Table 1 Definition of Sleep Parameters

SPT	Sleep period time	Time from fall-asleep to wake-up
TIB	Time in bed	Time from start to end of night recording
REM	Rapid eye movement sleep	The stage of sleep with highest brain activity and dreaming
NREM	Non–rapid eye movement sleep	The major sleep state apart from REM sleep comprises sleep stages 1-, 2-, 3-, and 4-NREM
Fall-asleep		The first epoch of stage 1-NREM followed by stage 2-, 3-, or 4-NREM
Wake-up		The first epoch of wake without recurrence to sleep stages
W	Wake	Stage of wakefulness in a polysomnogram
MT	Movement time	Stage of obscure polysomnographic tracings because of movements

board, and the results were stored in data files with an accuracy of 0.1 μV (Fig 2). When the system was tested by a 200 Hz ± 1.0 V sine wave signal, it gave a 0.6457 V (mean voltage), which is 1.4% higher than the ideal value (averaged sine wave) obtained by calculation.

Measuring Programs and Presentation of Results. Data of postural activity and maximal contractions were measured according to Michler and coworkers[34]; they were presented graphically and tabulated with the evening and morning values separated.

Sleep scorings were made manually[6] on 30-second epochs from the Mingograph printout and the screen. The latter was made possible by a specially developed display program ensuring concordance of sleep score and muscle activity, and the option of rejecting epochs with EMG artefacts. Sleep data were presented in a hypnogram on screen or printer (Fig 3), and sleep parameters were tabulated with the statistics.

The activity in the masticatory muscles was analyzed automatically both by the APDF[42,43] and by classification of the activity.

The APDF analysis was performed separately for the sleep period time (SPT), non-REM (NREM), and REM in 20-msec samples (see Table 1 for definition of sleep parameters). The amplitude domain from 0 to 600 μV was grouped in classes of 0.25 μV. The number of samples were presented as cumulative probability (P) against amplitude in absolute (μV) or relative value (percent of maximal voluntary contraction = % MVC). The distribution function was measured in relation to SPT, REM, and NREM inclusive movement time (MT) (Fig 4).

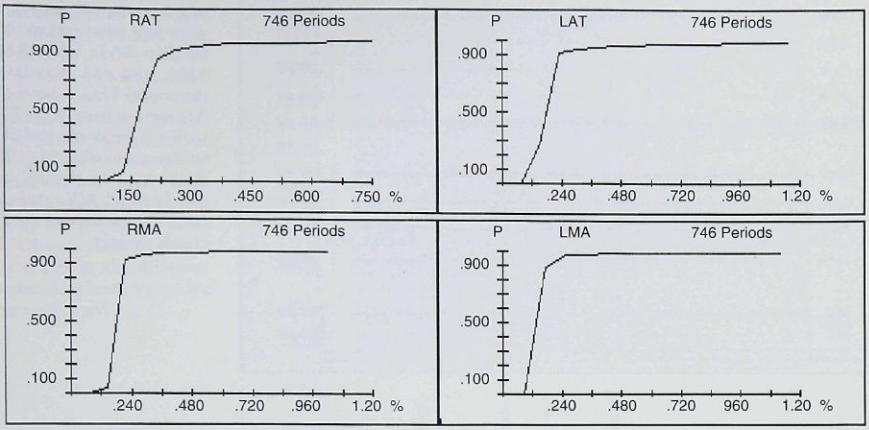

Fig 4 Graphic presentation of an APDF analysis of RAT, LAT, RMA, and LMA of SPT during one night of sleep from a 25-year-old woman. The x-axis indicates the percent of maximal voluntary contraction (% MVC). The static level ($P = .10$), median level ($P = .50$), and peak level ($P = .90$) were below 0.26% MVC for all of the recorded muscles. Between the peak level ($P = .90$) and the $P = 0.99$ corresponding to 9 % of SPT, ie, 38 minutes of a 7-hour sleep, the activity level only rose to 0.5% to 1.0% MVC. Above the $P = .99$ level corresponding to 1% of SPT with the most vigorous activity by nocturnal bruxism, ie, 4 minutes of a 7-hour sleep, the activity level only rose to 1.5% to 2.3% MVC for the first 2 minutes ($P = .995$), and increased for the last 2 minutes to the absolute 20-msec peak ($P = 1.00$) of 26% to 35% MVC and 58% to 66% MVC for the masseter and temporal muscles, respectively.

The activity in mandibular elevator muscles of 145 night recordings from 20 subjects without CMD (characterized as control subjects) and 10 patients with heavy nocturnal bruxism were descriptively classified to fit into an automatic analysis model. The activity level in the largest part of the sleep period was very low without fluctuations (Fig 5), but it was interrupted now and then by well-defined, short rhythmic contractions (Fig 6). Such succeeding contractions appeared as an entity, which was defined as an activity period (ActPer). The ActPers were separated by intervals of more than 30 seconds with constant low activity. If the rhythmic contractions within an ActPer were separated by more than 5 seconds, each event of contractions was termed a contraction episode (ConEp) (Fig 6). Thus, contractions formed one or more ConEp comprising one ActPer. Classification of contractions was computerized using a sliding 10-sample (20 msec/sample) window with a 5% MVC threshold. If 8 of 10 samples exceed the threshold, a contraction was recorded and the first sample above the threshold was depicted as the onset. Cessation of contraction is indicated when the number of samples above the threshold in the sliding window was 2 or less. The contractions of RAT, LAT, RMA, and LMA were assessed as a whole and classified even if the activity in one of the muscles continued. The activity in RLL was classified separately. The results were visualized graphically in 30-second epochs (Fig 7). For the total night recording, the average duration in seconds and mean and peak amplitude in μV and % MVC of the contractions of all muscles were printed according to the sleep stages, using the sleep stage of the epoch preceding the ActPer as well as

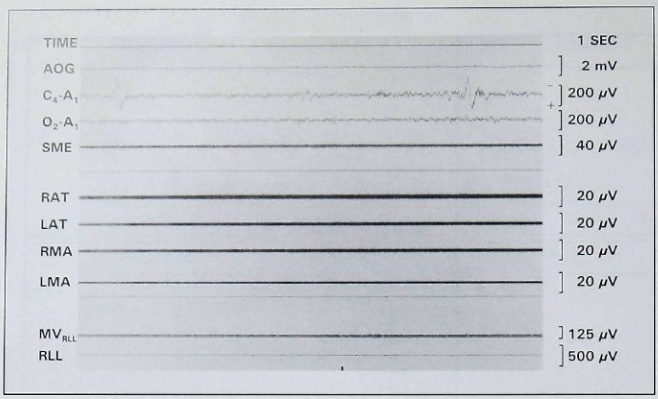

Fig 5 Hard copy of a 60-second, stage-2 sleep epoch with low postural activity level in RAT, LAT, RMA, LMA, and RLL muscles. In the central EEG channel (C4-A1) theta activity (3 to 7 Hz) with K-complexes and sleep spindles are observed. Tick marks on time channel indicate 1 second. MV_{RLL} indicates mean voltage trace of the RLL muscle channel.

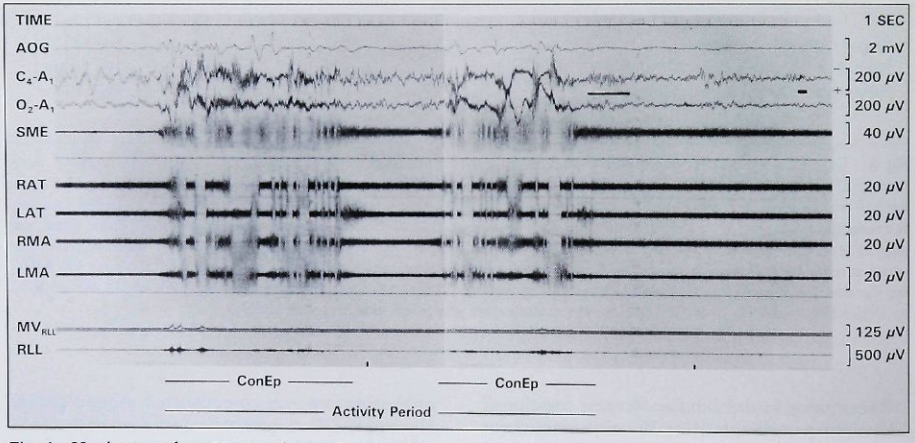

Fig 6 Hard copy of an 80-second period with a 38-second activity period (ActPer) composed of two contraction episodes (ConEp) of short rhythmic contractions in RAT, LAT, RMA, and LMA muscles. The ActPer is preceded by stage-3 sleep and succeed by alpha activity (wake; thin bar) and stage 1 until a sleep spindle arises (thick bar). MV_{RLL} indicates mean voltage trace of the RLL muscle channel.

totally for SPT and TIB. Figure 8 shows the duration and mean contraction level (% MVC) of 642 contractions in the left masseter muscle during 7 hours of sleep in a 27-year-old male patient with severe myogenic headache and extreme nocturnal bruxism. Furthermore, the number and average duration of activity periods and contraction episodes and the average duration of pauses between activity periods during SPT were recorded.

The postural level of activity of each epoch without ActPers was measured by 60 mean levels each of 500 msec and recorded as absolute (μV) and relative (% MVC) average values according to sleep stages.

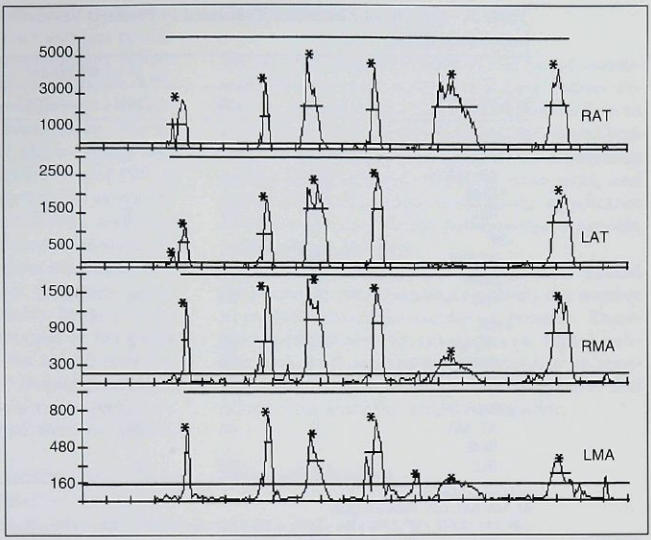

Fig 7 Screen display of a 30-second epoch of RAT, LAT, RMA, and LMA muscles with an ActPer (Bar at top of each channel). Peak (stars) and mean (thin bars) contraction levels are indicated at each contraction. Threshold level is indicated by continuous bar above baseline. Tick marks of 1-second interval are plotted on baseline. Observe different amplitude scales in the different muscles. Amplitude values are shown in 0.1 μV.

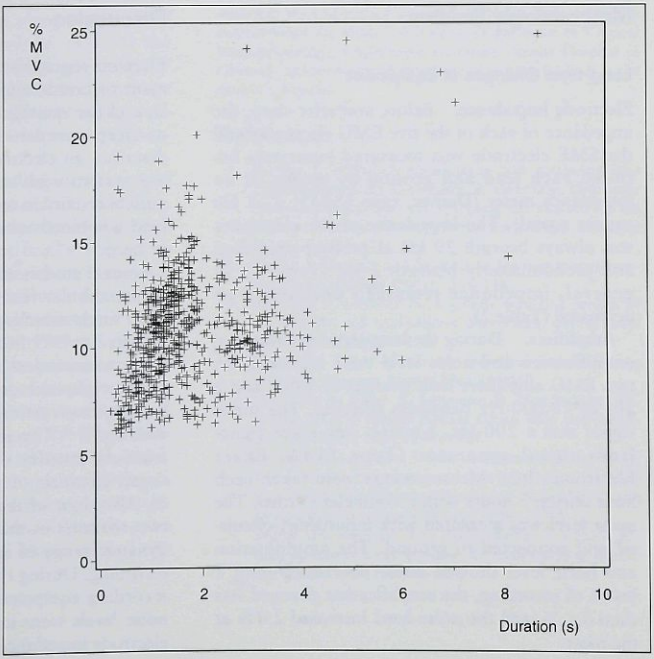

Fig 8 Scatter diagram showing the duration of contractions in seconds (SEC) and mean contraction level (% MVC) of LMA during 7 hours of sleep in a 27-year-old male patient with severe myogenic headache and extreme nocturnal bruxism. The duration and mean intensity level of contractions range from 0.2 to 8.8 seconds and 6.0% to 24.8% MVC, respectively. The duration of contractions throughout the night is predominantly short with a median duration of 1.5 seconds, with 0.5 and 3.6 seconds as 5 and 95 percentiles, respectively. The mean intensity level of these contractions is also predominantly low with the median on 10.7% MVC, and 6.9% and 15.0% MVC as 5 and 95 percentiles, respectively.

Table 2 Percent of Electrodes Tabulated in Presleep Versus Postsleep Electrode Impedance (Elm)

	% of electrodes					
POSTSLEEP	<2K	<5K	<10K	<20K	>20K	N
Presleep						
<2K						
AT, MA	100	–	–	–	–	112
SME	100	–	–	–	–	24
RLL	24	61	3	12	–	33
<5K						
AT, MA	89	11	–	–	–	73
SME	89	11	–	–	–	9
RLL	31	63	6	–	–	16
<10K						
AT, MA	48	45	6	1	–	69
SME	17	83	–	–	–	6
RLL	20	60	20	–	–	10
<20K						
AT, MA	22	43	24	11	–	54
SME	–	–	–	–	–	0
RLL	–	60	40	–	–	10

N: Number of electrodes.
AT, MA: RAT, LAT, RMA and LMA.
<2K: Elm <2 KΩ; <5K: 2 KΩ ≤ Elm <5 KΩ; <10K: 5 KΩ ≤ Elm <10 KΩ; <20K: 10 KΩ ≤ Elm <20 KΩ; >20K: Elm ≥ 20 KΩ.

Methodologic Studies

Long-term Changes of Equipment

Electrode Impedance. Before and after sleep, the impedance of each of the five EMG electrodes and the SME electrode was measured separately between each lead and ground by means of an impedance meter (Dantec, type 15B45; 27.5 Hz square signal). The impedance of the electrodes was always beneath 20 kΩ at presleep recording and predominantly beneath 2 kΩ (Table 2). In general, impedance remained unchanged or decreased (Table 2).

Amplifiers. During the long-term registrations, amplification and noise level were measured on two EMG amplifiers with gain set to 2,000 and a 20- to 10,000-Hz bandpass filtering. The input signal was a 200-Hz, 1-mVpp sine wave signal from signal generator (Type 514A, Exact Electronics Inc). Measurements were taken each hour during 7 hours with a voltmeter (Vrms). The noise level was measured with input short-circuited and connected to ground. The amplification and noise level showed linear courses. During 7 hours of recording, the amplification changed less than 0.1 % and the noise level increased 2.0% at the most.

Discussion

Electromyographic systems developed for assessment of craniomandibular function during sleep lack either quantitative estimates of muscle load or sleep parameters.[17,18,24,25] The present report describes an electromyographic and sleep recording system with automatic off-line analysis of muscle activity in terms of time course and relative load combined with an adequate manual scoring of sleep.

Several studies based their findings about craniomandibular function during sleep on recording from single muscles, eg, unilateral masseter muscle activity.[27,36,37,46,47] In addition, the limited dynamic range of recorders and use of thresholds to limit activity has excluded a full evaluation of activity varying from strong bursts to low level postural activity.[24,25,48] The present system permits pick up from six muscles simultaneously with four additional channels of sleep information (Figs 5 and 6). Also, four of the electromyograms are fed into two channels at the same time to cover the entire dynamic range of approximately 60 dB of surface recording. During the typical 6 to 8 hours of sleep, recording equipment properties such as gain and noise levels were stable and the typical change of electrode impedance was a lowering (Table 2).

Laboratory investigations of natural craniomandibular functions in stationary subjects permit instant visual control of electromyograms before analysis.[34] In contrast, noise and artefacts are difficult to detect in nocturnal recordings with ambulatory devices.[24,25] To eliminate artefacts, eg, due to electrode movements, surface electromyograms have been filtered at 100 to 510 Hz[20,24] and 100 to 310 Hz.[25] Surface electromyograms of temporal and masseter muscles obtained during isometric contractions have 80% of the power between 52 and 290 Hz.[49] Therefore, high-pass filtering at 100 Hz, ie, close to the mean power frequency, hampers power assessment considerably. In the present study, a 25-Hz high-pass filtering of the third order after amplification of the signal removes artefacts without affecting the frequency content of the signal. Furthermore, low-noise amplifiers with high-input impedance were used to prevent distortion of signals.[32,50,51]

An adequate assessment of muscle activity during sleep should include load exposure and classification of muscle action relative to full-night sleep scoring. Previously, full-night recordings from the muscles of mastication have been limited to integration of unilateral masseter activity,[25] which provided only one absolute measure of muscle load. In occupational studies of muscle activity, the APDF method has been used routinely to evaluate the load exposure during long-term muscle work.[52,53] The APDF analysis has been adapted in the present study for automatic off-line assessment of the nocturnal exposure of temporalis and masseter muscles related to sleep measures.

In polysomnographic recording of nocturnal activity in the elevators of the mandible, classification of activity has either been omitted or limited to rhythmic contractions specifically related to events of bruxism.[8,9,54] Both intensity and temporal thresholds have been applied to distinguish between normal and abnormal activity.[8,29,35,36,55,56] For classification of muscle activity, events of contractions have been defined in the present study as ActPers, which are subdivided into ConEps, and in time related to sleep. This definition considers all activity during a night recording. To assess full-night muscle exposure without attempts to distinguish between normal and abnormal activity, a threshold of 5% MVC[43] was selected to detect contractions. However, concerning exposure, the APDF analysis also included levels of activity below 5% MVC.

Conclusion

The present analysis system of nocturnal craniomandibular muscle activity and sleep relates exposure and characteristics of muscle action to well-accepted parameters of sleep. The system provides differentiated data suitable for comparing groups of individuals, effects of treatments, and physical load of muscles to assess the significance of nocturnal events in the pathogenesis, diagnosis, and treatment of CMD.

In full-night laboratory recordings with manual sleep scoring, time-consumption limits the number of recordings and the number of subjects. Therefore, ambulatory devices with raw signal validation as well as subsequent automatic or semiautomatic analysis of sleep, load exposure, and activity characteristics would be desirable.

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Resumen

Un sistema para el análisis del sueño y la actividad nocturna de los músculos craneomandibulares

Se desarrolló un sistema para el registro polisomnográfico nocturno, continuo del sueño con registros manuales y análisis electromigráficos automático de la actividad muscular craneomandibular. En un laboratorio para estudiar el sueño se guardó la información en cintas con una copia dura en papel seguida por procesamientos digitales controlados por una computadora. La actividad muscular es descrita por la Función de Destribución de Probabilidad de Amplitud y por los parámetros de tiempo e intensidad. La información electromiográfia y de sueño están desponibles gráficamente en la pantalla y los resultados son presentados en tablas y gráficos después de ser analizados estadícamente. El sistema fue desarrollado para proveer en un análisis detallado y diferenciado del sueño y actividad muscular nocturna en el sistema craneomandibular adecuado para comparar grupos de individuos, efectos de tratamients y carga física muscualar. Se demuestran las aplicaciones del sistema.

Zusammenfassung

Ein System zur Analyse des Schlafs und der nächtlichen Aktivität der Kaumuskulatur

Es wurde ein System entwickelt zur fortgesetzten polysomnographischen Aufzeichnung des Schlafs während der ganzen Nacht. Das Schlafscoring erfolgte von Hand, die elektromyographische Analyse der Kaumuskulatur automatisch. Die Datenspeicherung im Schlaflabor erfolgte auf Band - mit einer Kopie auf Papier-, die digitale Verarbeitung off-line durch den Computer. Die Muskelaktivität wird durch die Amplitudenwahrscheinlichkeits Verteilungsfunktion und die Parameter Zeit und Intensität beschrieben. Schlaf und elektromyographische Daten werden graphisch auf dem Bildschirm dargestellt. Die statistischen Resultate wurden in Tabellen und graphischen Darstellungen zusammengefasst. Das System wurde entwickelt, um eine differenzierte und detaillierte Analyse des Schlafs und der nächtlichen Aktivität im craniomandibulären System zu erhalten, zum Beispiel zum Vergleich von Gruppen von Individuen, von Behandlungsresultaten und der physischen Belastung von Muskeln. Anwendungen werden diskutiert.