Different laws govern motor activity in sleep than in wakefulness

J. J. M. Askenasy 1 and M. D. Yahr 2

1 Sleep Research Institute, Sheba Medical Center, Sackler School of Medicine, Tel-Aviv University, Israel
2 Mount Sinai School of Medicine, New York University, U.S.A.

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Summary. A wide range of elementary and complex motor activities are known to occur during sleep, but very little is known about the basic physiologic condition of the skeletal muscle during sleep. The present study provides evidence that a minute electric random activity constitutes the basic physiologic condition of the skeletal muscles during sleep. During the NonREM stages of each sleep cycle a regression of the continuous random minute activity occurs, followed by a sudden increase of the isolated motor unit action potentials during REM sleep. Particular structural features of the anterior tibial (AT) muscle make it the most active skeletal muscle during sleep. During wakefulness, at rest, the random muscle activity disappears.

Keywords: Anterior tibial muscle, electric muscle events, isolated motor unit action potentials, bursts of motor unit action potentials, continuous random, NonREM regressive gradient.

Introduction

Rapid phasic muscle events in extraocular, middle ear, oral and speech muscles and a significant decrease in chin and neck muscle tonus are characteristic features of paradoxical sleep (Aserinsky and Kleitman, 1953; Jouvet, 1965; Pessah and Roffwarg, 1972; McNeilage and McNeilage, 1973). Positional and large body movements appear during sleep. Many muscle related features were observed and extensively described during sleep such as periodic movements of legs either isolated or associated with sleep apnea or sleep hiccups (De Lisi, 1932; Dagnino et al., 1962; Tassinari et al., 1965; Askenasy, 1988). Night terrors, somnambulism and enuresis were described as being related to NonREM sleep (Diagnostic Classification of sleep and arousal disorders, 1979). Monoamine oxidase inhibitors were observed to determine muscle hyperactivity during sleep most probably through a serotonergic mechanism (Askenasy and Yahr, 1988).
But despite all these well described muscle related features very little is known about the basic sleep condition of the skeletal muscles in normal subjects. It was shown that an electromyographic (EMG) pattern, highly variable in form, duration, number and extent characterises sleep skeletal muscles (Gardner and Grossman, 1975). An EMG study of the muscles during sleep suggested the presence of phasic muscle discharges "even in several nonmimetic muscles" (Satoh and Harada, 1973; Tauber et al., 1977). It was observed that during sleep the muscle discharges may appear as bursts or as isolated motor unit action potentials (Satoh and Harada, 1973). The limited well controlled EMG studies are a result of the very laborious methodology.

**Methods**

Ten normal subjects, 7 males and 3 females, free of major illness, aging from 26 to 51 (average age 37), were monitored for two nights following an adaptation night. The subjects signed informed consent. Three techniques were used in parallel:

I. Polysomnomyography, consisting of: electroencephalogram (EEG) at C3-A1/A2 with a DC resistance less than 3,000 Ohms; electrooculogram (EOG) just lateral to the right and left outer canthi. The EMG was recorded by means of Beckman electrodes interspaced at 15 mm, applied to the motor point of the muscle surface and using a 10 × lower sensitivity. The EMG band pass was adjusted to 1-100 Hz. The time constants were 0.3 for EEG, 5 for EOG and 0.003 for EMG. Forty different skeletal muscles were located by applying resistance to their function, and electrodes were applied as close as possible on the motor point. Up to 8 skeletal muscles were monitored in the same subject for one night. During the whole study, and in all the subjects 40 skeletal muscles were recorded among the axial, upper, lower limb and girdle muscles.

A respitrace device recorded nasal and oral flow breathing. Electrocardiogram was recorded using a bipolar system of electrodes. A video tape closed circuit television monitored muscle movements and body behaviour in sleep.

II. The second technique consisted of parallel polysomnographic (PSG)/EMG equivalence, obtained by means of bipolar surface electrodes, applied simultaneously with intramuscular concentric needle electrodes implanted under the above surface electrodes. EMG was performed with a TECA TE4 instrument in 3 subjects.

III. The third technique consisted of a multichannel recording system of the AT by means of 16 surface electrodes monitoring muscle potentials on 8 channels.

The EMG events were analysed and displayed on five especially designed files for automatic analysis. The means of muscle events per minute per muscle with their standard deviations and ANOVA tests of significance were computed.

**Results**

A spontaneous random skeletal muscle activity at EMG level during sleep was present. The quantification showed a mean of 0.67 ranging between 0.09–1.25 EMG events per muscle and per sleep minute.

Comparing the four groups of skeletal muscles according to their anatomofunctional topography, the limb muscles displayed the highest mean of muscle activity during sleep (see Table 1).

Of the limb muscles, AT displayed the highest number of EMG events per muscle and per total sleep time: 1.03–2.47. The most active muscles during sleep