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Relationship between sleep stages and nocturnal trapezius muscle activity

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ABSTRACT

Objective: Former studies reported a relationship between increased nocturnal low level trapezius muscle activity and neck or shoulder pain but it has not been explored whether trapezius muscle relaxation is related to sleep stages. The goal of the present study was to investigate whether trapezius muscle activity is related to different sleep stages, as measured by polysomnography. *Methods*: Twenty one healthy subjects were measured on four consecutive nights in their homes, whereas the first night served as adaptation night. The measurements included full polysomnography (electroencephalography (EEG), electrooculography (EOG), electromyography (EMG) and electrocardiography (ECG)), as well as surface EMG of the m. trapezius descendens of the dominant arm. *Results*: Periods with detectable EMG activity of the trapezius muscle lasted on average 1.5% of the length of the nights and only in four nights it lasted longer than 5% of sleeping time. Neither rest time nor the length of periods with higher activity levels of the trapezius muscle did significantly differ between sleep stages. *Conclusions*: We found no evidence that nocturnal trapezius muscle activity is markedly moderated by the different sleep stages. Thus the results support that EMG measurements of trapezius muscle activity in healthy subjects can be carried out without concurrent polysomnographic recordings.

1. Introduction

Human sleep is generally considered as the most important regeneration phase for the whole body, including the recovery from physical and psychological demands (Adam and Oswald, 1984). As the overexertion of low-threshold motor units is a common model to explain musculoskeletal disorders in the neck and shoulder (Hägg, 1991), muscle relaxation and recovery during sleep might play an important role for pain development. Former studies showed increased overall nocturnal activity in the trapezius muscle in subjects with shoulder and neck pain compared to pain-free controls (Mork and Westgaard, 2006). Holte and Westgaard, 2002 showed that pain-afflicted subjects showed significantly higher trapezius muscle activity during leisure time (including sleep) than pain-free subjects. Additionally, Steingrimsdottir et al. (2005) found the presence of self-reported sleep disturbances to be a strong individual predictor of increased trapezius muscle activity during standardized cognitive and motor tasks. A recent study by Alsaadi et al. (2011) also showed a moderate relationship between self-reported sleep disturbances and the intensity of low back pain in patients.

There is also evidence of long-term rhythmic muscle activity during the night, possibly influencing pain development (Westgaard et al., 2002; Mork and Westgaard, 2006).

The aforementioned studies either concentrated on electromyography (EMG) parameters over the whole night or on special EMG events occurring during the night without simultaneous polysomnographic sleep recordings. Thus, it remains unclear how trapezius muscle activity is related to sleep as such, whether e.g. deeper sleep is characterized by lower trapezius muscle activity. Sleep can be described by polysomnographic (PSG) recordings that allow dividing sleep into different stages as they occur in a normal night, namely in rapid eye movement (REM) sleep (with its typical rapid eye movements) and nonREM sleep. NonREM sleep can be further divided in the four sleep stages S1, S2, S3, and S4 (Rechtschaffen and Kales, 1968). The sleep stages S3 and S4 (slow wave sleep) and REM are known to be very important for the restorative power of sleep, whereas W (the wake stage) and S1, on the other hand, do not contribute to recuperation, or only very little (Wesensten et al., 1999). The present study aims to elucidate

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the relationship between trapezius activity and sleep stages determined by PSG.

2. Methods

2.1. Study protocol

The present study was part of a larger field study that investigated polysomnographically measured awakening reactions due to environmental noise (Brink et al., 2011) which allowed us to capitalize on synergies in subject recruiting, data collection and the usually very sumptuous sleep stage analysis.

Thirty subjects were measured in a period of six months, each for four nights with the first night as an adaptation night to avoid a "first night effect" (Agnew et al., 1966; Mendels and Hawkins, 1967). The measurements took place in the subjects' homes. Subjects were visited by one or two investigators each evening before a recording night and were prepared for the PSG and EMG recordings. The study protocol was approved by the interdisciplinary ethics committee of ETH Zürich. Subjects were instructed according to the Helsinki declaration, participated voluntarily and were free to discontinue their participation at any time without explanation. Subjects were paid 200 Swiss Francs upon completion of the study.

2.2. Subjects

The study sample was selected to represent the Swiss population between the ages of 18 and 66 years as close as possible. Exclusion criteria for this study were:

- Shoulder and neck pain due to injury or systemic disease.
- Intake of muscle relaxant.
- BMI > 30.
- Skin disease in shoulder and neck area (electrode placing).
- Use of tranquilizing medication.
- Excessive snoring or clinically diagnosed sleep apnea.
- Unusual sleep-wake pattern (Subjects were required to usually maintain a steady sleep-wake rhythm with regular sleeping times covering at least the time period from midnight to 06 am in the morning).

Detailed information about the recruitment can be found in Brink et al. (2011).

2.3. Polysomnographic (PSG) measurements

With portable polysomnographic recorders (PD3) developed at the German Aerospace Center (DLR), the electroencephalogram (EEG) at position O2, C4 and F4, electrooculogram (EOG), electromyogram (EMG) of the chin, electrocardiogram (ECG), respiratory movements (with strain gauges), finger pulse amplitude (with a finger pulse oximeter) and position in bed were recorded continuously during the night. To diagnose sleep disordered breathing, the respiratory movements were recorded as well. To derive the polysomnogram (sleep profile), each experimental night was divided into 30s- epochs. To mark the beginning of the sleep period, subjects were required to press a marker button on the recorder when they switched off the lights and wanted to sleep. As validation studies on various automated sleep analysis systems have reached contradictory conclusions (Drinnan et al., 2006), we decided for a visual scoring of sleep stages. Two trained scorers independently assigned sleep stages in every 30s-epoch according to the Rechtschaffen & Kales manual (Rechtschaffen and Kales, 1968). The nights to analyze were allocated randomly, but at least one night of each subject was assigned to each scorer. Finally each scorer cross-checked the scored nights of the other scorer. As in recommendations of the American Academy of Sleep Medicine (Iber et al., 2007) S3 and S4 are not discriminated anymore, we chose to set these two stages equal after the final scoring of each night.

2.3.1. Sleep disturbance index

As the subjects also participated in a study about environmental noise and sleep (Brink et al., 2011), there might be some concerns about the subjects' sleep quality. Therefore a noise specific sleep disturbance index (SDI) developed by Griefahn et al. in 2008 was used to compare the sleep quality of the present study's participants with reference values from quiet and noisy nights (Griefahn et al., 2008).

2.4. Surface EMG

Muscle activation of the trapezius during sleep was measured by surface EMG. Shoulder muscle load is commonly measured by bipolar surface EMG of the trapezius descendens (Westgaard et al., 2002; Mork and Westgaard, 2006).

2.4.1. Portable EMG tool

A small, portable 2-channel device (manufactured by Stefan Erni, Clinic for Masticatory Disorders, Removable Prosthodontics, and Special Care Dentistry, University of Zurich, Switzerland) was used to measure nocturnal trapezius activity (channel 1) and heart ECG (channel 2). The device contained a built-in 70–400 Hz band-pass filter, an acquisition frequency of 2000 Hz, a 10 bit resolution and an amplifier gain of 4000. The subjects wore the apparatus in a carry pouch around the waist.

2.4.2. Electrode placement

One pair of pre-gelled silver–silver chloride bipolar electrodes (sensor size 9×6 mm, Alpine Biomed ApS, Skovelunde, Denmark) was attached to the subject, who sat in an upright position, according to SENIAM (2006). Hence, these electrodes were placed at 2/3 of the line from the lateral edge of the acromion toward the spinous process of the 7th cervical vertebra (C7) to generate an EMG signal of the trapezius descendens (SENIAM, 2006). The inter-electrode distance was 2 cm with a reference electrode placed on the process spinae of C7 (Fig. 1). Electrodes' positions of each subject were noted to reproduce the same conditions for all measuring nights. Previous to the attachment of electrodes, the skin was cleaned with an abrasive paste (Nuprep, Weaver and Company, Aurora, USA) to enhance skin conductivity. Then,

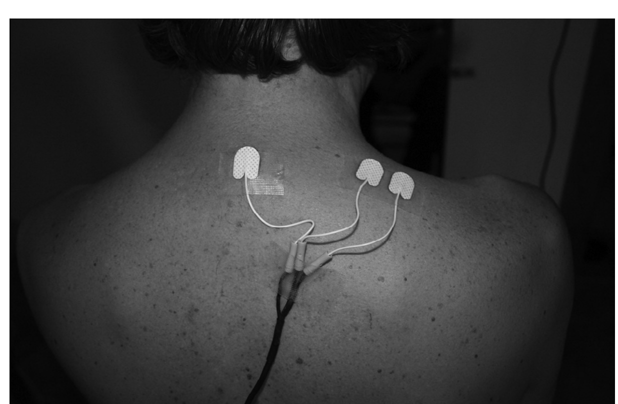

Fig. 1. EMG electrode placing and wiring on the trapezius.