SLEEP — A MULTIFREQUENT RHYTHMIC-HIERARCHICAL ACTIVE BRAIN-FUNCTION

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Сон — мультичастотная ритмически-иерархически организованная функция мозга

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Реалистичное заключение о физиологии и патофизиологии функции сна может быть сформулировано только на основе электрофизиологических данных и ритма. Непрерывная запись электрофизиологических данных функции сна в течение недель и месяцев позволила получить совершенно новые данные о многочастотной динамике сна. Нормальный профиль сна может сохраняться до глубокой старости. И наоборот, любая болезнь, стрессовые ситуации могут привести к патологическим изменениям в электрофизиологической функции сна.

The out-patient and curative medicine thinking and acting in static spheres proposes that sleep is a rigid thing which starts with falling asleep and ends with awakening. A too short or interrupted sleep is called sleep disturbance. Not few patients orient themselves a mysterious, average organism related duration of sleep of 8 hours. If they would not reach it, they assert to have sleep disturbances. This is an imaginary value and never a norm value. There is nowhere a scientific evidence fort he duration of sleep.

The diagnostic of sleep (except the sleep laboratories) is still proceeded through inquiries (and not through measurements). Therefore the uncontrollable assertion of the patients is the basic for therapeutic acting that means to give sleeping pills. Sleep medicines of the USA find out that a patient with sleep disturbance will be «diagnosed» and «treated» within 1,5 to 3 minutes by the family doctor. Nobody asks if a patient is able to give real assertions about his sleep from the memory of the limited conscience while sleep. Hereby you have to note, that he has to regard 7 hours retrospectively in the mean with a more or less natural limitation of conscience and with different vigilance caused by NON-REM — and REM-sleep-phases.

The estimation about sleep, meaning to have slept, depends on many factors. As Amrhein and Schulz [2] showed, healthy people can give quite different assertions after awakening from sleep.

They examined 22 young persons in which a registration of the electrophysiological sleeping- profiles has taken place. They have been awaked 4x through a signaltone in different conditions of vigilance (sleep-wake-phases). The signaltone has been used:

1. In the awake phase
2. In NON-REM-sleep-phase S2 with short duration in this phase
3. In NON-REM- sleep-phase S2 with longer duration and
4. during REM-sleep.

After awakening they had to answer questions relating to mental activity and aspects of perception. The estimation about sleep, meaning the assertion to have slept, have been diagnosed most frequently after awakening from REM-sleep and less frequently if they have been awaked after a short duration of S2-NON-REM-phase. The authors concluded from these results that the estimation of sleep will be influenced by physiological condition on the one hand and by mental activity of the sleeper on the other hand after awakening. The authors deduce a hypothesis of continuity from the perception of sleep. The hypothesis of continuity says that the condition of sleep will be estimated as wake when the mental proceedings are regarded as congruent with being awake and then as sleep when the mental proceedings are different from being awake [2].

Comparing studies from Rotenberg [21] found out that healthy people when they have been awaked in the sleeping-phase S2 two fold said «awake» as in REM-sleep. Hecht [11] had observed in patients in the sleep-laboratory of the clinic Charit? Berlin that these said in the morning that they have not slept the whole night although the sleep-profile showed only 6—8 short wake-phases from 1—2 minutes during sleep. Sewitsch [23] and Gibson [7] showed similar results.

These examples showed that the uncontrollable assertion of a patient about his sleep doesn't allow a real diagnosis. No medical doctor would give the diagnosis e. g. «arterial hypertension» due to a patient's assertion, he would always take the blood pressure. The sleep, which is much more difficult than the regulation of the blood pres-

Fig. 1. Handling of an automatic, electrophysiological sleep-analyser — AAESA. There is following classification of the sleep-phases:

Being awake
REM-sleep (Rapid-Eye-Movement)
NON-REM-sleep
S1 = transition wake-sleep (half asleep)
S2 = superficial (shallow) sleep
S3 = middle deep sleep
S4 = deep sleep
S3 and S4 commonly called DELTA-sleep or deep sleep or Slow-Wave-Sleep.

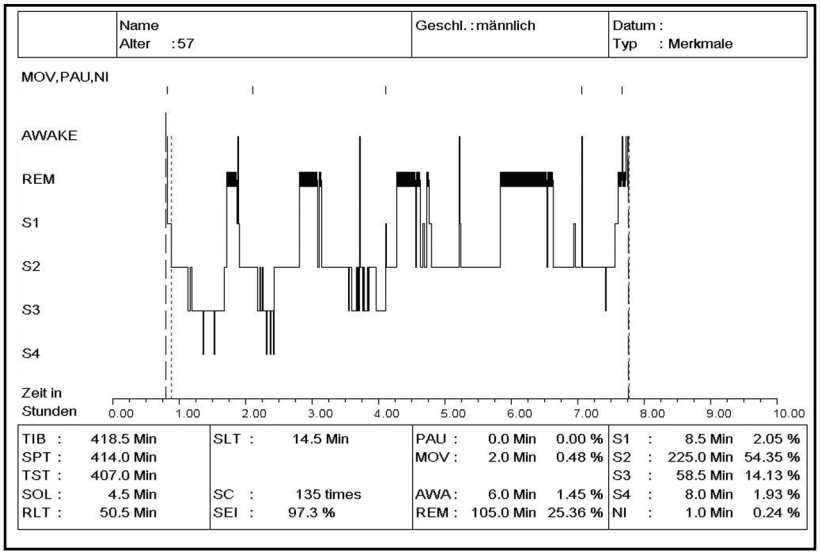

Fig. 2. Sleep-profile and data-print of a registration during night with an ambulatory, automatic electrophysiological sleep-analyser, criteria for a normal status are the sleep-phases after Rechtschaffen and Kales [20].

sure, requires measuring under absolute reproducible conditions, for real diagnosis and treatment. This is not only possible in a sleep-laboratory, but with an ambulatory automatic electrophysiological sleep-analyser (AAESA) in common sleep environment, that means in the own bed room. This device — AAESA — is a microcontroller remote controlled working sleep-analyser. Neuronal networks take over the classification of the sleep-phases. The registration of the ECG occurs with only three electrodes on the frontal region, the patient can apply them himself after instruction before going to bed. He only needs to switch on the device after going to bed, and to switch off after awakening. The transmission or taking of data from the device occurs with a computer, which is taking over then with special software the analysis of the sleep-phases. From taking the data until printing the ready somnogram it takes about 3 minutes. The device can be used at home, in the bed room or in the patient's room of a clinic.

What shows the sleep-profile?

The sleep-profile consists of the electrophysiological data EEG, EMG, and EOG together. There is an international agreement for the classification after Rechtschaffen and Kales [20].

The normal sleep-profile is characterised by the REM-NON-REM-cycles. In the fig. 2 you can see a sleep-profile and data-print of a registration during night from an out-patient, automatic, electrophysiological sleep-analyses. Criteria for a normal status and sleep-phases after Rechtschaffen and Kales [24] are shown.

From the functional hierarchy of these oscillations the sleep-profile is built up. The main rhythm of the sleep-profile is the REM-sleep-cycles. They are classified as long ultra diane rhythm. In 1953 Aserinski and Kleitmann [4] discovered with sleep-polygraphical examinations that during sleep-phases occurred rapid eye movements [4]. They called them REM-phases (Rapid-Eye-Movement). Today, this sleep-phase, which can occur cyclical 4—6 times during a sleep-night in healthy people, is called REM-sleep-phase.

The time from beginning of a REM-sleep-phase to the beginning of the next one is called a REM-cycle. The REM-cycles will be assessed as criteria for sleep-quality at their relative regularity, and at a disturbed or reduced occurring, as criteria for sleep-disorders. The second part of sleep is called NON-REM-sleep (NONREM) and parted into 4 NON-REM-sleep-phases due to EEG-, EMG- and other parameters: NON-REM S1 = half asleep, NON-REM S2 = superficial sleep, S3 and S4 = deep sleep.

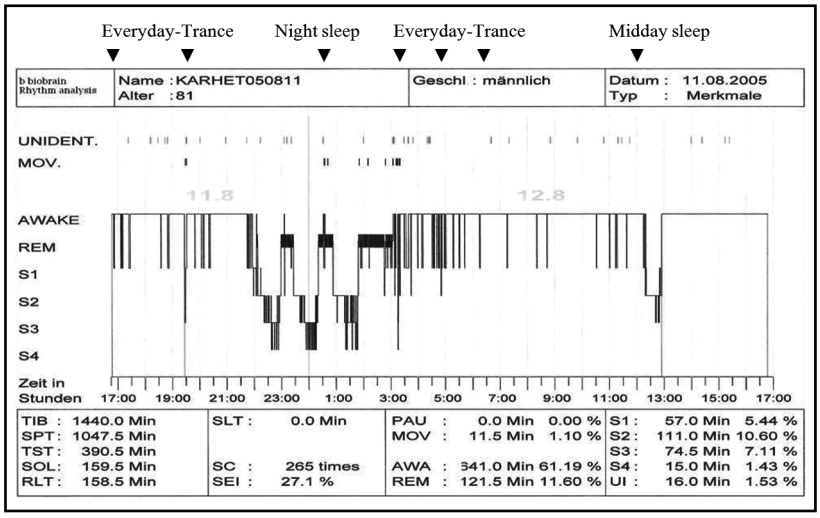

Fig. 3. 4h- record of awake-sleep-passage as a rhythm-profile after Rechtschaffen & Kales 1968.

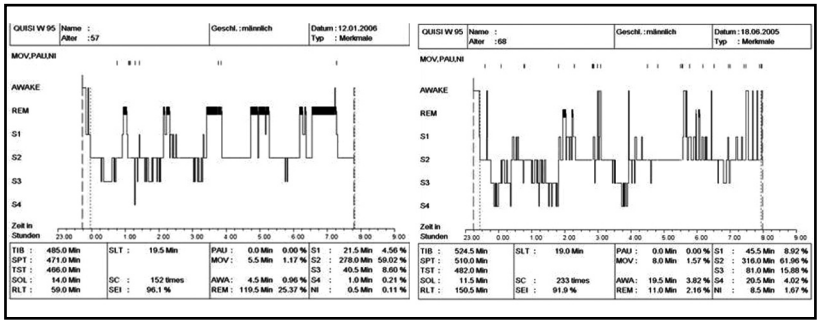

Fig. 4. Comparison of sleep-profiles between a healthy and a sleep-disordered person.

Table 1. Characterisation of the both examined groups

Healthy persons			Ill persons		
NN	Age	Sex	Age	Sex	Diagnosis
1.	14	♂	15	♀	Irregular sleep-awake-rhythm
2.	22	♀	20	♀	Neurodermitis
3.	25	♀	26	♂	Personality disorders
4.	34	♂	35	♂	Struma/Hypothyreosis
5.	42	♀	42	♀	Posttraumatic fears
6.	48	♂	42	♀	Brain stem insult/Depression
7.	50	♀	50	♀	Somatoforme pain
8.	57	♀	62	♂	Condition after commotio cerebri
9.	67	♀	70	♂	Restless legs syndrome
10.	70	♀	73	♂	Dementia/Alzheimer's disease
11.	77	♀	78	♀	Sleep-apnea (untreated)
12.	82	♂	81	♂	Substance-abuse

Regarding the aspect of electrophysiology sleep is a dynamic, active neurophysiologic process, which Koella [16] described following: «The sleep is not a condition of general, motor, sensory, vegetative and psychic rest. Sleep is characterised by a co-existence of high activity and/or stand-by-activity with singly moderate with low to complete missing activity and/or stand-by-activity in all systems. Furthermore the grade of activity and stand-by-activity do not remain constant in a given system; they vary in each different system systematically during a sleep-phase. Sleep is qualitative, and regarded to its behavior concerning time, a polymorphic phenomena» [17].

The functional polymorphism of the brain during the sleep is given further because vegetative-adaptive activities of behavior commonly depend on constellation of stimuli, on the sense of stimuli and on the availability of stored information from memory during the night-sleep [16].

The physiology and pathophysiology of sleep can be comprehended only under the chronobiological aspect.

The rhythmic sleep-profile is imbedded into the circadian rhythm. During a day being awake is interrupted by short phases of everyday-trance, which frequently and rhythmical appear in 60—120 minutes-intervals. They are called ultradiane rhythms. During the day there are also the BRAC (Base-Rest-Activity-Cycle) and the REM-cycles. There also can appear periods of 7-, 14- and 21-minutes duration, like in fig. 3. in the morning (in following sleep-profile a typical human with low blood-pressure) patients [1, 8, 11—14, 16, 18].

At the rhythmic the not sleep-disordered person and the sleep-disordered person can be distinguished. We regard it ourselves as a task to proceed comparative examinations with the ambulatory, automatic electrophysiological sleep-analyser (AAESA) in patients which show a disorder and in healthy persons under common sleep-conditions.

12 patients (6 female and 6 male) consulting a family doctor or a specialist (neurologist, psychiatrist, dermatologist) with different diseases at the age of 15—81 years which further reported bad quality of sleep were investigated. This group of 12 sleep-disordered patients has been compared with a group of 12 healthy persons (8 female and 4 male) at the age of 14—82 years.

Results and discussion

Sleep-profiles

The important factors which will determine the quality of sleep will be pointed out of the sleep- profile: 1) the rhythmic pass of sleep-cycles sufficient 2) part

of deep- and REM-sleep and their correct distribution of the sleeping- time 3) small part of awake-phase and short times of falling asleep.

Because the sleep underlies individual deviations we want to present the sleep-profiles of both groups to point out the dynamics of the function of sleep.

Sleep-healthy persons

The sleep-profiles of all 12 healthy persons showed the typical cyclic sign of change of NON-REM- and REM-sleep independent on age and gender. The single stages are distributed corresponding the standards of Rechtschaffen & Kales 1968. Considering healthy persons we could not confirm a wide spread opinion that with increasing age the DELTA-sleep (S3 und S4) and the REM-sleep decrease.

Sleep-disordered persons

The sleep-profiles of ill persons showed never a rhythmic passage but showed a disordered sign during the night sleep. Remarkable are restlessness (frequent change of stages) and the frequent shorter or longer awake-times and longer times of falling asleep and mostly a reduced part of the REM-sleep.

There can be identified that ill persons independent from age, gender and the special diagnosis show an arrhythmic, deformed sleep-profile. The sleep-profiles of healthy and ill persons allow a visual demarcation because of the sleep-profiles. This very clear visual assessment could be verified mathematically further by a slight clearness through examination of the function of autocorrelation. An illness dependent specification of the sleep-profile is not recognizable.

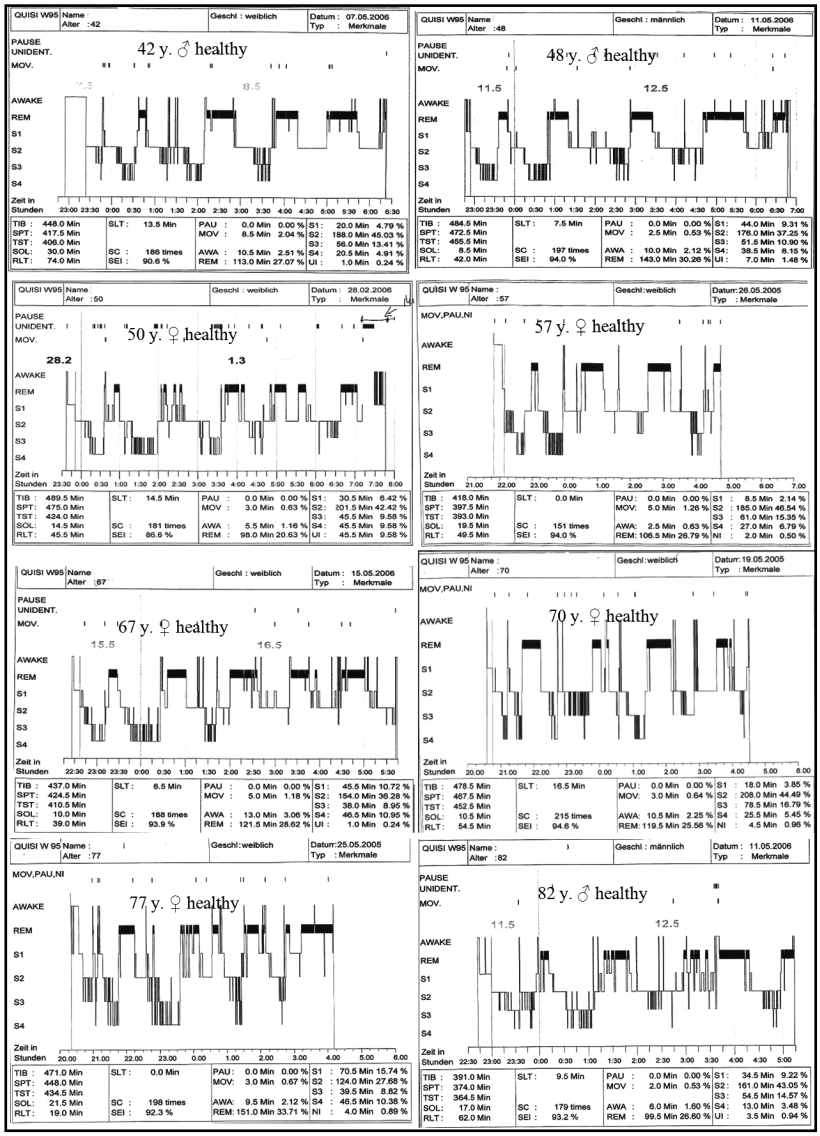

Fig. 5. Sleep-parameters of sleep-healthy persons at different age, measured with the AAESA.

The sleep-duration is a very uncertain parameter to investigate the quality of sleep because it underlies very big individual deviations and a «norm» cannot be established [8]. For adults an effective mean duration of sleep of about 7 hours has been established in the literature. To a mean value always belong the variation of single values and these are very big at this duration of sleep.

Therefore a classification in sleep durance and -types has been taken in the following manner [6, 10, 11, 15, 24]: Short time sleeper < 6h (prevalence about 20%) Long time sleeper > 8h (prevalence about 15%) Median time sleeper 6—8h (prevalence about 65%). To value the quality of sleep only with the duration of sleep is therefore not possible and not permissible.

As our investigations with the out-patient, automatic electrophysiological sleep-analyser show sleep-profiles (even in healthy persons) with big variability which can be much bigger in ill persons because the deformities of the sleep-profiles permit a bigger possibility of intra- and interindividual variables.

The diagnosis «sleep-disorders» requires a very different analysis of rhythmic passage in sleep-profiles to start adequate treatment.

The varieties shown here and the rhythmic passages of particular one still are clear they will be surpassed if healthy persons are examined over weeks and months consecutively.

Afterwards we showed the passage of some sleep-profiles of a 56-years old healthy manager during 250 consecutive follow-up investigations with the AAESA.

In a 56-years old test-person, manager, commonly good condition, over 200 sleep-profiles of following nights in the personal bed room or in Hotel rooms at business travel are taken until now. Therefore the out-patient automatic electrophysiological sleep-analyser is a reliable mea-

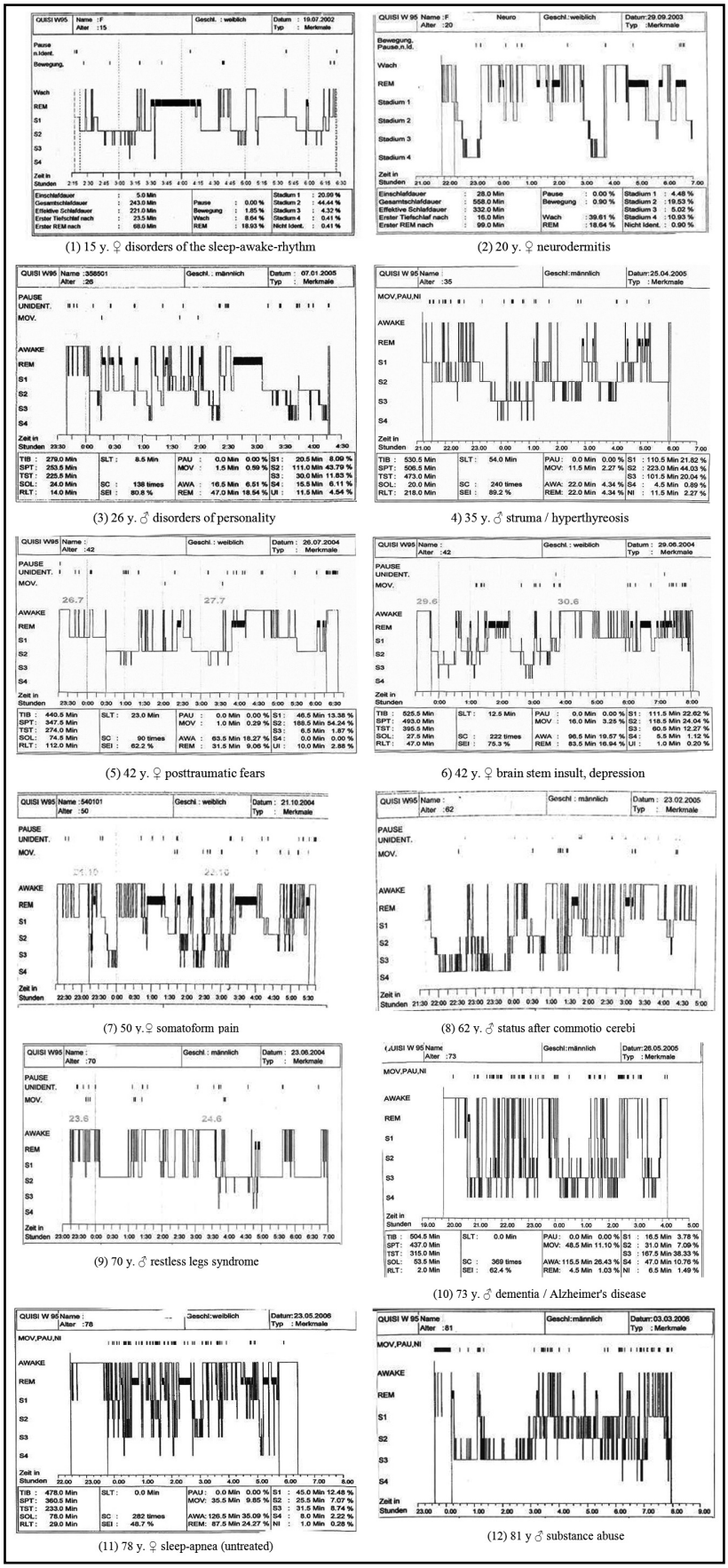

Fig. 6. Sleep-profiles of sleep-disordered persons at different age with different diseases measured with the AAESA.

suring-instrument. The test-person was undergoing stressing run of the day with different intensity. The test-person is non-smoker but was drinking a glass of red wine and black tea. He took daily 0,3 g Glyzin sublingual and 2 x 5 tabl. Spiruptilo in the morning / and in the evening Klinoptilolith-Zeolith/Spirulina, tablets with substances of algae). There was no fall out of data, no erythema or skin-lesions caused by the glue of the electrodes and no other discomforts.

The 250 following recorded sleep-profile showed mostly and particular the configuration of the normal type of Rechtschaffen & Kales with the characteristic delta-sleep-configuration in the first half of sleep and the REM-sleep-parts with their cyclic passage. There is remarkable that the most sleep-profiles showed a strong cyclic activity at which 4—6 REM-NON-REM-cycles changing from night to night are recognizable. At a fine analysis we have seen that no sleep-profile is similar to another. In the sleep-profiles mostly there are imbedded shorter times of awakening which are rarely perceived clearly by the test-persons. They come once to eight times from night to night. If such short times of awakening appear more frequently or/and the sleep-profile shows deformities then these «abnormities» can be related to particular events.

Such events were: viral influenza, toothache, back pain or articular pain excessive daily stress, strong Summer-/night heat, strong thunderstorm at night or long car rides before sleep. A fine analysis of the 250 sleep-profile could not verify two identical looking sleep-profiles.

The run of the time of the sleep-parameters (Fig. 7) underlie sometimes big deviations during the 250 nights at what you can see very big amplitudes which are changing with parts of balanced, rhythmic fluctuation. Stronger deviations can be related to one or more of the specified events. From the passages there you can see changing relationships between the run of the single stages. So there is a related divergence between S2 and Delta-sleep that means an overlap of S2 and a reduction of Delta-sleep at the same time.

The deviations under extreme conditions can be enormous. The biggest variance showed S2 of 10% until nearly 70%-part of healthy sleep.

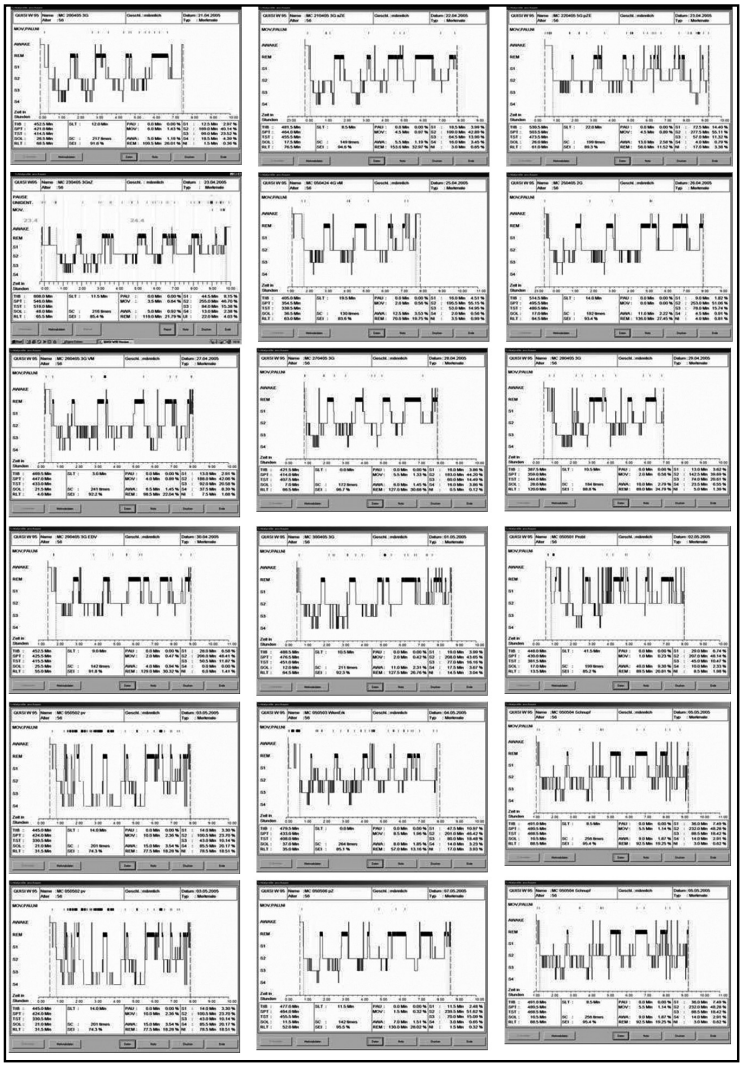

Fig. 7. Run of the time-rows of different sleep-parameter over 250 following nights.

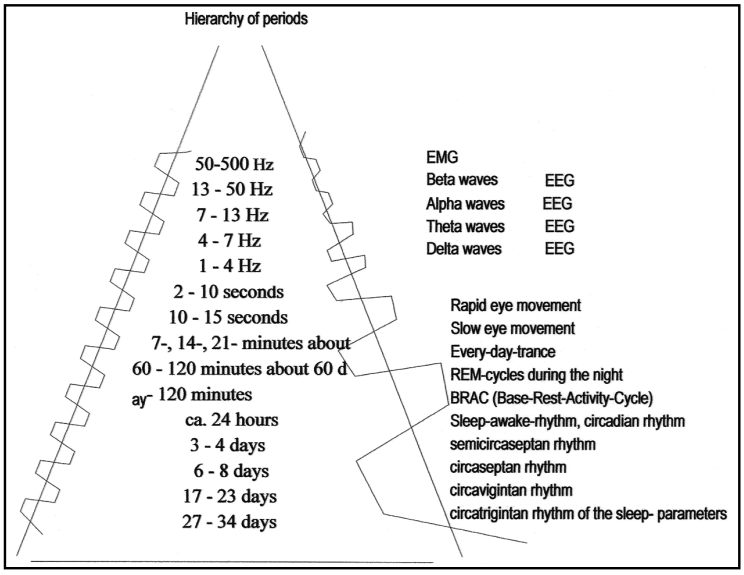

Fig. 8. Hierarchy of frequencies periods joining the physiological processes in sleep functions. In healthy persons this hierarchy of periods in a local-temporal dynamics relatively «synchronized (coordinated)».

The Delta-sleep has extreme values between 10% and 55%, the REM-sleep between 2% and 33%. The smallest difference shows S1 between 3% and 17%.

The time to fall asleep is in the mean between 2 and 20 minutes except some small deviations, one of about 30 minutes and one of about 50 minutes. There also were reached extreme times of over 500 minutes and 300 minutes, too. You can say that the total duration of sleep is about seven hours in the mean. The total times of awakening during the night is about a boarder of 10 minutes and shows extreme values from 0 to 20 minutes.

In the summary we represent the generalised scheme of hierarchical relations in time-and-frequency characteristics of the rhythmic processes defining duration, structure and quality of a human night sleep.

The duration of the periods are given in Hertz (Hz), seconds, minutes, hours and days. We have proofed this periodic hierarchy of physiologic rhythms with the AAESA (ambulatory, automatic electrophysiological sleep analyser).To assess diagnostically this chronophysiological process of sleep only with an interview of about 1—3 minutes duration is not possible.

Final remarks:

1. These result here show that the functions of sleep only have to be verified by measured data and that they only have to be to be assessed by their rhythmic passages so that you have to prefer analysis of time-rows rather than statistic mean values and that the interview related to the quality of sleep has no diagnostic worth.

2. Physiologically sleep shows a functional hierarchy of biologic rhythms their optimal, synchronized cooperation determines the quality of sleep.

3. Further, sleep cannot be regarded as a constant but it has a dynamic function which underlies a big variability even during one night which presents the «plasticity» of the brain functions during sleep and which follows this functional principle over weeks and months.

4. At least we want to postulate that the rhythmic parted sleep function has to be integrated also into the assessment of damages of health due to environmental factors. It is well-known that from noise (Maschke et al. [17]) and electromagnetic radiation [22], a disordered rhythmicity of sleep is the initial sign fort he health damaging effect due to these environmental factors.

5. Further we want to propose that, as long not each doctor has a measuring instrument for the record of the rhythmic, electrophysiolog-

ical process of sleep of his patients as he uses a blood-pressure-device, as long we are far away to make a nature scientific diagnostics of sleep and/or sleep disorders.

6. From the main principle, that a safe diagnostic has always to precede every therapy, the biggest part of today's medicine related to the diagnostics therapy of sleep (except the sleep-laboratories) is at the level of prehistoric time.

Hippokrates used to begin every «inpatient therapy» of a chronic disease with a sleep-therapy for 2—3-weeks. He used a pendulum with a magnet oscillating with the frequency of the breathing — rhythm over the patient's head and medicinal herbs additional to this medicinal sleep treatment. The magnet could have had a frequency of the Alpha rhythm (as we know today).

Eratokles of Trozen, suppurative. As he has done in Trozen to have let burned himself by the doctors, God* appeared in his sleep and directed him not to have let burned himself but to sleep in healing room of the sanctuary of Epidauros. After the time has gone the abscess has opened and he has left healthy.

* Asklepios stands for God.

(Inscription of Epidauros 5/4 century b. C. — Herzog 1931, Wunder 48,22)

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