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Research article

# Subjective and objective evaluation of alertness and sleep quality in depressed patients

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## Abstract

**Background:** The reliability of the subjective statements reports on disturbed night sleep and alertness in the daytime was assessed by their correlation to the objective indicators in patients with mild deprsssion.

**Method:** Among patients with depression, altogether 28 patients with insomnia were examined. Their answers to typical questions, as they are used during a psychiatric interview, were scored. In parallel, night sleep quality and alertness level in the daytime were objectively estimated by means of polygraphic recording.

**Results:** The subjective statements on the type of insomnia, the estimated time of falling asleep, frequent awakenings and occurrence of disturbing dreams seem to be unreliable. Similarly, the results were disappointing when the patients were asked about alertness disturbances in the daytime. An unexpected finding was the lack of any significant correlation to the scores obtained by means of Epworth's scale. Among the factors possibly influencing the patients' reports, age, sex, coffee intake and also chronic administration of sedatives or hypnotics showed a low correlation with the sleep and alertness indicators.

**Conclusion:** The statistical evaluation indicated rather poor agreement between the subjective and objective items. The statistical evaluation suggested that anxiety and depression significantly influence reports on sleep quality and alertness disturbances in the daytime.

## Background

The symptoms which are associated with alertness level and sleep belong to the usual complaints in depression [1]. Besides insomnia, many patients suffer from fatigue and sleepiness in the daytime, others report "nervousness" and inability to relax. The common denominator of these symptoms is the fact that they reflect subjective feelings which are only vaguely defined. It is possible to show that even healthy individuals use expressions like "fatigue" and "tiredness" in various senses [2] and the

content varies still more in psychiatric patients [3]. In contrast, alertness and sleep level can be objectively measured by means of neurophysiological methods. Sleep polygraphy belongs today to the routine medical examinations (a review can be found e.g. in Broughton 1999 [4]) and the conventional sleep indicators are well established [5]. Although diagnostic application has not been generally used, the EEG changes during a superficial fluctuation of alertness have also been reported in early studies [6] and used in many studies, mostly for research purposes. There

are, thus, rather reliable methods which can be applied in order to examine sleep quality and alertness disturbances in psychiatric patients. However, these methods are only rarely employed in the examination of psychiatric patients and diagnosis is mostly based on the psychiatric interview. The patient is asked to describe the subjective symptoms and the result of the interview is then decisive for the diagnosis and treatment.

The literature investigating the relationship between objektive and subjective sleep in depressed patients is limited and the results are inconsistent [7,8]. The aim of the present study was to contribute to the studies on the reliability of patients' statements regarding sleep and alertness. The study is characterised by the following:

- sleep disturbances in minor, and not in major depression were considered,

- the role of co-existing anxiety symptoms was investigated, and

- the alertness disturbances in the daytime were also included.

## Methods
### Patients
The study was based on 28 patients with minor depression, complaining of insomnia. Patients with psychotic disorder, bipolar disorder, chronic alcoholism, dementia or organic brain disorders were not included in the study. The diagnosis was based on Structured Clinical Interview according to DSM III. A special attention was paid to the occurrence and intensity of anxiety symptoms. The medication on a stable level (two weeks or more) was contin-

ued. More details can be found in Table 1. All the patients gave their informed consent to inclusion in the study.

### Clinical examination and scoring
The clinical examination consisted of a psychiatric interview and somatic examination which were enlarged by a part concerning sleep quality and possible alertness disturbances in the daytime. The answers to a set of standardised questions were registered in a semiquantitative form, using scores from 0 (not present) to 4 (prominent symptoms). The list of relevant items can be found in the Tables (see Results). Further, the patients were asked to estimate their sleep latency and their total sleep time in minutes and hours, respectively. As a separate part of the clinical scores, those obtained by means of Epworth's sleepiness scale [9], Beck/anxiety and Beck/depression scales were also used.

### Measurement of alertness level in the daytime
The measurement was done in connection with the EEG recording in the late morning of the day preceding the night polygraphy. The recordings were performed with the patients in a semi recumbent position, with their eyes closed. Immediately before the start of the recording, a short mental task was performed in order to ensure full alertness. Afterwards, the patient was left undisturbed, avoiding any noise or movement in the examination room, during the first 10 min when the signal was stored for off-line analysis. The examination was then continued in a routine manner, with eye openings and hyperventilation.

### Night polysomnography
The examination was done after an adaptive, simulated examination. The EEG, ECG, respiration registered by a nasal thermistor, chest movements, eye movements and

**Table 1: Basic data on the patient group, the number of patients with the respective symptoms and the mean scores in three scales.**

| | | |
|---|---|---|
| No. of patients | 28 (6 males and 22 females) | |
| Age | 18 to 72 y. (mean 43.22, s.d. 14.27) | |
| Diagnoses | Minor depression, no prominent anxiety | 9 |
| | Minor depression, prominent anxiety | 19 |
| Duration of the disorder | 5 to 480 months | |
| Medication ** | Antidepressants (SSRI type) | 16 |
| | Benzodiazepines | 21 |
| | Hypnotics (>3 times/week) | 16 |
| Night sleep disturbance ** | Difficult to fall asleep | 26 |
| | Frequent awakenings | 14 |
| | Too early awakening | 16 |
| Sleepiness in the daytime | 25 | |
| Mean scores | Epworth | 10.39 (s.d. 5.02) |
| | Beck: depression | 10.11 (s.d. 4.81) |
| | Beck:anxiety | 17.11 (s.d.10.65) |

** More than one type could occur in the same patient.

EMGs from the submandibular and thoracic muscles were recorded. The time to switch the light off was chosen by the patient. The recording was then started and continued until spontaneous awakening in the morning.

### Visual analysis

Conventional sleep scoring of both types of recordings was done in all 10 s epochs. In the recordings which were obtained in the daytime, the scores were refined by means of a modified version of the method of Roth (1963 [6]). The sleep stages 0 and 1 were divided into altogether 10 substages, using an arbitrary visual scale with various proportions of alpha and theta activity. The night polygraphic recordings were scored in the conventional way [5], estimating the sleep stages according to Dement and Kleitman [10]. In both types of recordings, the scores obtained in the individual epochs were used to calculate the mean, standard deviation and trend (regression to the time) for the whole 10 min recording.

### Spectrum analysis

The stored 10 min segments obtained in the daytime were processed. The activities from 16 EEG derivations (Fp1, Fp2, F3, F4, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2, Cz, and Pz, using a common reference) were digitised with a sampling frequency of 200Hz. The subsequent artefact-free segments of 10 s duration were subjected to spectrum analysis after filtering (0.5 to 35 Hz). To reduce the effect of a non-Gaussian distribution, the power values were transformed into amplitude values (i.e., the square roots of the power values) before further processing. For the purpose of the study, only the alpha frequency band (7.5–12.5 Hz) in the parietal derivation was considered. The results of the analysis of the individual 10 s epochs were then used to calculate the mean, standard deviation and trend (regression to the time) for the whole 10 min recording.

### Statistical analysis

To determine the relationship between the clinical and EEG variables, product-moment correlations were calculated. To avoid possible interference with a third variable, the partial correlation coefficients were also employed. The comparison between the subgroups was done by means of t-tests.

## Results

### Patients' estimates regarding their night sleep

The subjective estimates were obtained in the morning, the day after the night polygraphy. The answers to standard questions were registered by means of five-point scores (no symptoms...0, well pronounced symptoms...4). Besides that, the patients estimated the sleep latency and total sleep length in time units (minutes, hours). The polygraphic recordings were visually assessed in order to construct the hypnograms and to calculate the sleep indicators. The indicators obtained in this way were then correlated to the patients' subjective scores.

The correlations between the subjective items and the objective indicators, based on of whole-night polygraphy, are displayed in Table 2. As it will be seen, the results were rather disappointing: the patients were not able to correctly estimate the sleep latency or length of sleep. In contrast, the scores for "well-rested in the morning" and "total sleep quality" correlated significantly with some of the objective indicators. All the results of the statistical processing, including the remaining items, are displayed in Table 2.

**Table 2: Correlations between the subjective scores (lines) and results of whole-night polygraphy(columns). The scores were obtained by an interview after polysomnography. Except the estimated sleep latency and length of sleep, which were expressed in minutes and hours, respectively, the patients' estimates were registered by scores between zero (no symptoms) and four (pronounced symptoms). Only statistically significant (p < 0.05 or p < 0.01 marked by asterisks) coefficients are displayed.**

| NIGHT RECORDING | Sleep latency | Sleep st. 0 | Sleep st. I | Sleep st. 2 | Sleep st.3+4 | REM sleep | Sleep efficacy | SPT/TIB ** | Total sl. time |
|---|---|---|---|---|---|---|---|---|---|
| Estimated sl. latency (min.) | | | .63* | | | | | | |
| Estimated sl. length (h) | | | | | | | | | |
| Frequent awakenings | .49* | | | | | | | | -.49* |
| Disturbed night sleep | | | | | | | -.70* | | |
| Disturbing dreams | | | | | | | | | |
| Satisfactory depth of sleep | | | | | | | | .73* | |
| Woke up too early | | .68* | | | | | | | |
| Well-rested in the morning | | | | .82* | .85* | .73* | .69* | .70* | |
| Estimated total sl.quality | | -.78* | | .78* | | | | .73* | |

**Total time with sleep activity divided by the total time in bed.

**Table 3: Correlation between the scores, regarding the subjective symptoms in the daytime, and presumptive EEG alertness indicators (see Methods). Note that the decreased alertness is indicated by positive values in the first the columns (occurrence of sleep activity) while the same corresponds to the negative values in the next columns (amplitude of alpha activity). Only statistically significant (p < 0.05 or p < 0.01 marked by asterisks) correlation coefficients are displayed.**

| DAYTIME RECORDING | Sleep stage 0–2 (visual analysis) | | Alpha amplitude (spectrum analysis) | |
|---|---|---|---|---|
|  | mean | trend | mean | trend |
| Not refreshed in the morning |  |  |  | -.67* |
| Low working capacity |  |  | -.43 |  |
| Sleepiness |  |  |  |  |
| "Not in the mood" |  | .45 |  | -.51* |
| Disquiet, anxiety |  |  | .55* | -.62* |
| Epworth's scale |  |  |  |  |

### Patients' estimates of alertness in the daytime

In contrast to night sleep, there are no established indicators of alertness level in the daytime. Therefore, two EEG indicators were considered to be most relevant and used in the study. The first one is based on visual scoring of the sleep stages, similarly as in evaluation of the night polygraphic records. Because of the limited range of alertness changes in the daytime, a refined scale with several substages was used to score the subtle transitions between full alertness (sleep stage 0) and low alertness (sleep stage 1). The second indicator was obtained by spectrum analysis, measuring the amplitude of the dominant activity. In each 10 min recording, all the epochs of 10 s duration were processed and both the visual and automatic values were used to calculate the mean and trend (regression to time, see Methods).

As shown in Table 3, the results of spectrum analysis, particularly those reflecting the unidirectional shift of the respective value during the 10 min recording, seemed to be more informative than the results of visual analysis. The feelings of being not refreshed in the morning, together with less specific scores of low working capacity, unpleasantness and anxiety, were reflected by the objective alertness indicators. A rather unexpected result was obtained with the scores on the Epworth's scale, which is widely employed to indicate sleepiness in the daytime. As shown, no significant correlation to the objective indicators could be obtained.

### Factors which could influence the patients' stimates

Besides the above-mentioned subjective scores, the factors which could indirectly influence the patients' estimates of sleep quality and alertness in the daytime were studied.

**Table 4: Factors which could influence the patients' estimates of their sleep quality and/or alertness in the daytime. Only statistically significant (p < 0.05 or p < 0.01 marked by asterisks) correlation coefficients are displayed.**

| | NIGHT RECORDING | | | | | | | DAY TIME RECORDING | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sleep latency | Sleep stage 1 (%) | Sleep stage 2 (%) | Sleep st.3+4 (%) | REM sleep (%) | Sleep efficacy | Total sleep time | Sleep stage 0–2 (visual an.) | | Alpha amplitude (spectrum an.) | |
| | | | | | | | | mean | trend | mean | trend |
| Age | | | | -.46 | | | | | | | |
| Coffee (>2 cups/day) | | | | | | | | | | | |
| Smoking (>10 cig./day) | | | | | | | | | | | |
| Alcohol (>0.5 l wine or >0.1 l distilate/week) | .47 | | | | | .46 | | | | | |
| Hypnotics (>3 times/week) | | | | | | | | | | -.68* | |
| Sedatives (>3 times/week) | | | | | | | | | | | |
| Antidepressants (daily) | | | | | | | | | | | |
| Unexpected event last week | | | | | | -.54* | | | | | |
| Too active going to bed | | | | | | | | | | | |
| Disturbed by the examination | | | | | | | | | | | |
| Beck: score for depression | | | | | | | | | | | |
| Beck: score for anxiety | .54* | | | | | -.65* | | | | .55* | -.65* |

The list of these items and their correlations with the neurophysiological indicators can be found in Table 4. As it will be seen, the factor of age, habits such as coffee-drinking as well as intake of drugs, including hypnotics, had little to do with sleep quality and alertness level in the daytime. The factor of sex (not included in the Table) was also negligible, except a tendency toward a diminished portion of deep sleep (stages 3+4) in females (t = 2.29, p < 0.05). Surprisingly, the feeling of being too active when going to bed did not correlate with sleep latency or any other sleep indicator. Among other negative findings, it was of interest to see that the report on discomfort, caused by the polygraphy, did not correlate with any of the objective sleep indicators.

In contrast to the preceding items the occurrence and intensity of anxiety, obviously played a more important role. The correlations between the objective sleep/alertness indicators and the scores from the Beck's scale are displayed in the last line in the Table. As it will be seen, a high anxiety score was associated with a long sleep latency, decreased sleep efficacy and also a tendency toward decreased alertness in the daytime. Besides the objective polygraphic indicators, the anxiety and depression score were correlated to the subjective estimates of sleep quality and alertness level in the daytime. It was found that a high depression score correlated significantly with feelings of sleepiness and with low working capacity (correlation coefficients 0.49 and 0.56, p < 0.01 in both cases). Although the scores of anxiety and depression scores were clearly intercorrelated (r = 0.50, p < 0.01), anxiety itself did not significantly correlate with any of the other subjective symptoms.

## Discussion
The aim of the study was to elucidate which parts of the psychiatric interview in patients with depression are most informative regarding night sleep and alertness in the daytime. To validate the patients' subjective estimates, their correlations to the polygraphic indicators of sleep and alertness were evaluated. Trying to interpret the results, the main impression was that many of the subjective complaints could not be verified by the results of objective measurement. If these findings are generally valid, the patients' statements on sleep quality and alertness in the daytime, as routinely examined by a psychiatric interview, are a poor instrument to diagnose this type of symptom. In particular, the statements on the type of insomnia, the estimated time of falling asleep, frequent awakenings and occurrence of disturbing dreams seem to be unreliable. These results are compatible with previously published reports on differences between subjective and objective statements. However, the discrepancies seem to be more pronounced in the present study. A possible explanation can be the fact, that Argyrpoulos et al. [7] and Tsuchiyama

[8] studied patients with major depression while the present study was based on the observations in patients with minor depression. Another confounding factor can be the wide age range as can be seen in the present study. As shown by Lee et al. [11], the subjective assessment of the sleep quality in depression is age-dependent. To estimate the possible influence of various ages in the present study, the statistical processing was enlarged by calculation of partial correlation coefficients, with the age as background variable. However, the results were not substantially changes as compared with the original correlation coefficients. Similarly, the factor of medication was examined by calculating partial correlations with negative results, too.

The results were also disappointing when the patients were asked about alertness disturbances in the daytime. An unexpected finding was the lack of any significant correlation to the scores obtained by means of Epworth's scale, which is generally considered to be an efficient tool in clinical work and research. Of course, the relevance of the individual items varied and some important correlations could be verified. Positive results were also seen in some of the patients' estimates of alertness disturbances in the daytime where simple questions on the feeling of refreshment after sleep, low working capacity, unpleasantness and anxiety gave rather good information.

Besides the age and medication, it was also of interest to study other interfering factors which possibly could influence the patient's alertness and sleep. Among them, alcohol intake seemed to be of more importance than nicotine or coffee intake. On the other hand, the statistical evaluation confirmed that anxiety dominate among possible sources of sleep and alertness disturbances in psychiatric patients [12].

The generally low correlation between the subjective scores and objective in4dicators necessarily evokes a question on the adequacy of the methods applied. As regards the subjective scores, these were obtained during a structured interview, using standardised questions. The symptoms were registered in a semiquantitative form, as a score on an arbitrary five-point scale, or by means of commonly accepted scales (Beck, Epworth).

Doubts can probably be directed against the adeqacy of polygraphic recording. The representativeness of an examination done on one or two occasions under artificial laboratory conditions can be questioned. However, the technical circumstances do not allow us to adapt the patient by repeating the examination during several nights and the discomfort due to the recording equipment cannot be avoided whatever technique is used. A possible solution would be to make the recording at home, using a

portable device. This is certainly available, if only a simple excamination, for example by registering movements during sleep, is desired. However, we did not find a way to get a complete polygram of good quality under such conditions. After all, there is an argument in favour of the technique as it has been used in the study: the patients' estimates of sleep disturbances caused by the examination procedure were not significantly correlated to any of the objective indicators. Thus, no association between sleep quality and patient's discomfort could be proved. The objection that a measurement during a single night does not represent the sleep quality during a longer period is weakened by the fact that the patients' "sleep calender" showed rather stable conditions during the last 2 weeks, including the night of polygraphy.

Whole-night polygraphy is a method which is widely used in sleep laboratories for diagnostic purposes. The evaluation of the recordings is based on definitions of sleep stages well established since fifties [10]. The technique, scoring and terminology, as well as a set of sleep indicators, are standardised [5]. Besides the proportion of the individual sleep stages, several other measures such as sleep latency and sleep efficacy are used (see Methods). The sleep indicators were originally developed for diagnostic purposes, in patients with narcolepsy and apnoic syndrome. It was considered of interest to judge the usefulness of the individual indicators in psychiatric disorders. Some information on that can be obtained from the number of significant correlations in Tables II and IV. As it will be seen, the sleep efficacy, or its modification (SPT/ TIB), seem to be more informative than the other polysomnographic indicators.

In contrast to night sleep, the methods of examining the alertness level in the daytime are more disputable. In fact, neither the clinical terminology or every-day language is quite clear in describing various symptoms. For example, as shown in a previous study on patients with mild dementia [2], the expression "fatigue" correlated with the degree of the cognitive defect, without any significant correlation with the sleep and alertness indicators. In the present study, the difficulties are well illustrated by the disappointing results achieved with Epworth's scale. This scale is well established and widely applied in examining the symptoms of sleepiness in the daytime [9] but the scores did not show any relevant correlation to any of the objective indicators. The relevance of the objective indicators could, however, be supported by their significant correlations to other clinical items (Tables III and IV). Moreover, interpretation of the visual indicators is not difficult because they are based, similarly to the indicators of sleep quality, on conventional sleep stages. The only difference is that the assessment has been refined by using several sub-stages in order to register the transitions

between full wakefulness (sleep stage 0) and decreased alertness (sleep stage 1). These transitions are characterised by rather typical EEG patterns [6] and can be defined as typical sub-stages. The method has previously been used in a study on healthy individuals and the significant correlation between the EEG pattern and a subjective score for sleepiness in the daytime could be confirmed [2]. In the previous studies, it was also found that the method was more sensitive in this application than the Multiple Sleep Latency Test, a method of choice for examining patients with narcolepsy [13]. Another procedure, the Maintance of Wakefulness Test [14], is probably more sensitive but it was not tested. The reason was that it requires a degree of cooperation that could not be achieved in psychiatric patients with pronounced anxiety symptoms.

To get another, more accurate indicator than the visual scores, the subtle transitions between sleep stages 0 and 1 were also assessed by means of spectrum analysis. Because the shift from full alertness to sleep 1 stage is mainly characterised by successive disappearence of the dominant alpha activity [6], its amplitude in the individual epochs could be used as an indicator. This type of measurement, based on the calculation of EEG spectra, belongs to relatively well established methods of EEG analysis [15]. Thus, the application of spectrum analysis to estimate the transitions from wakefulness is acceptable and not controversial [16]. More interesting can be the additional data processing, trying to characterise the whole 10 min recording from a set of spectral values as obtained in the individual 10 s epochs. Among various measures, the trend was found to be most contributive. The unidirectional shift in the course of the examination session was presented by means of regression to the time from the start of the recording. A negative regression coefficient means that the alpha amplitudes showed a tendency toward successive decrease. According to the definitions of the sleep stages, this change can be interpreted as a shift from full alertness (sleep stage 0) toward decreased alertness (sleep stage 1). In the present study, the trend was used for the first time as a measure of alertness shifts and the results, in terms of significant correlations to the clinical items, are encouraging. Therefore, the trend was also calculated for the former indicator, based on visual analysis of the curves, and the results are favourable, too (Tables III and IV).

The main objection against the results of the study concerns the great number of correlation coefficients, each of them representing a statistical test. Considering the limited material available, there is a risk of false positive results. Unfortunately, almost all methods of EEG analysis result in such a large numer of variables that the usual statistical methods to compensate for the "alpha overflow"

(e.g. Bonferoni method) cannot be used. The present study certainly belongs to the "exploratory" investigations, requiring a continued "confirmatory" investigation [17]. In any case, the findings can be used to establish new hypotheses.

In conclusion, the study confirms that self-estimation of sleep quality is unreliable in depressed patients. Similarly, there is a discrepancy between the subjective and objective assessment of the alertness changes in the daytime. Of course, the results of the study should not be over-interpreted and the diagnosis should always be based on the clinical examination. However, some kind of "correcting factor" can be considered in this type of patients, particularly in those suffering of anxiety symptoms. The study also demonstrates possible difficulties caused by vague definitions of sleep and alertness disturbances. In uncertain cases, a qualified polygraphic examination is well motivated, anyway.

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