RESEARCH ARTICLE

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# Evaluation of the Process of Acute Treatment for Depression in Terms of Monitoring Activity and Sleep Efficiency with Actigraphy

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## ABSTRACT

**Background:** This study aimed to evaluate and follow-up the process of acute treatment for depression in terms of activity and sleep efficiency using actigraphy, and thus increase the opportunities for objective measurement in the monitoring of treatment.

**Methods:** A total of 20 patients with depression, and 22 and age- and gender-matched healthy volunteers were included in the study. All subjects were evaluated using a sociodemographic data form, the Hamilton Depression Rating Scale (HDRS), and actigraphy for measurement of motor activity and sleep efficiency.

**Results:** The activity levels and sleep efficiency of the controls were significantly higher than the pre- and post-treatment activity levels and sleep efficiency of the patients. After the treatment process, both motor activity and sleep efficiency were found to be significantly increased in the patients. A highly significant negative correlation was found between the HDRS scores and average activity counts for active intervals ($r = -0.779$, $P < .001$), and between the HDRS scores and sleep efficiency ($r = -0.616$, $P < .001$). On the other hand, a significant negative effect was found between depression and average activity counts for active intervals (RR:0.880; 95% CI:0.782-0.991).

**Conclusions:** Actigraphy is a useful technique for quantifying physical activities and sleep efficiency in depressed patients. Furthermore, it may provide objective follow-up data in assessing the effects of treatment for depression.

## ARTICLE HISTORY

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**KEYWORDS:** Depression, treatment, activity, actigraphy, monitoring, sleep efficiency

## INTRODUCTION

In psychiatric disorders, mood changes are reflected in behaviors and activities. Therefore, the observation of the patient's behaviors and activities is important in descriptive psychopathology. The careful observation of behaviors and activities helps both in the diagnosis and in the assessment of treatment monitoring.[1] Generally, a visible slowing of body movements and speech is defined as psychomotor retardation. Depression is the most important psychiatric disorder in which a reduction in psychomotor activities is observed. In the older nomenclature, depression in which such a reduction in psychomotor efficiency was predominant, was defined as "retarded depression," while this symptom is currently included in the diagnostic criteria.[2,3]

Among behavioral changes, however, the presence of psychomotor retardation at a level observable by others has diagnostic value. In addition, it is a major symptom in melancholic depression.[3] Although the symptom of psychomotor slowing is common in depression, the characteristics and clinical importance of this symptom have not been fully clarified. Psychomotor retardation may occur in different forms during depression. It may occur as a general slowing of movement in the body and head as well as in the extremities, and this may be accompanied by a hunched shoulders posture.[4] On the other hand, marked changes are also observed in neurovegetative functions such as sleep, eating and sexual activity in depressive disorders. Sleep disorder is one of the most common symptoms in patients with depression. In clinical samples, at least one of the symptoms of insomnia has been reported in approximately three-quarters of all depressive patients. The links between sleep and depression are strong, and sleep is one of the important determinants of treatment response. Therefore, sleep disorder associated with

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depression should be addressed separately and managed in a more efficient way.[5,6]

The aim of treatment in the acute phase of depression is to achieve an alleviation of symptoms and a return to functionality in social and professional life.[7] With antidepressant treatment, the onset of efficiency is frequently expected in 2-4 weeks. Prioritization of the leading symptoms such as insomnia, psychomotor retardation, and decreased appetite may increase treatment compliance. An improvement in the level of symptoms by half or more with the treatment, is called a response. The aim of the current treatment protocol is the full recovery of symptoms and the persistence of recovery with maintenance treatment.[8] The treatment process is assessed with clinical interviews and psychological assessment tools, thus ensuring follow-up of the disease and monitoring of treatment efficacy over the course of time. All psychological tests, mainly including scales, aim to enable measurements related to behavior, individual characteristics, or disorders. In addition, they enable an objective comparison of the data obtained. However, assessment and follow-up tools that provide objective measurements in the descriptive structure of psychiatry are currently limited to psychological assessment tools.[3,9] In recent years, devices enabling objective quantitative assessments related to sleep and activity, such as the actigraph, have been used, especially in the diagnosis and follow-up of sleep disorders. The actigraph unit is a measurement device in the form of a wristwatch, which can sensitively perceive motor activities using an embedded accelerometer. The data recorded are transferred to the computer and analyzed. The device also provides statistical measurements and data belonging to daily activity, and objective information measuring and assessing sleep continuity or sleep disorders.[10] With actigraphy, it is possible to monitor motor activity and sleep efficiency during treatment for depression.

In our study, we aimed to monitor and evaluate the process of acute treatment for depression in terms of actigraphy parameters such as average active activity counts and sleep efficiency, and to compare these parameters with those of healthy individuals, and thus contribute to objective measurement opportunities in monitoring treatment. Thus, it can be demonstrated that smart tools such as an actigraph device may supplement the psychiatric descriptive approach to diagnosis.

**MAIN POINTS**

- The activity levels and sleep efficiency of healthy controls were significantly higher than the pre- and post-treatment activity levels and sleep efficiency of the patients.
- A significant improvement was observed in activity and sleep efficiency in the patients after treatment compared to the period before treatment.
- A significant negative relationship was found between depression and average active activity counts.
- Actigraphy may serve as an objective assistive tool for treatment monitoring in depression by simultaneously taking into account the 2 parameters of average active activity counts and sleep efficiency.

## METHODS

### Study Sample

Patients diagnosed with major depressive disorder according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, who presented to the outpatient and inpatient psychiatry clinic at Canakkale Onsekiz Mart University Training and Research Hospital, were invited to participate in the study. Twenty of the major depression patients with motor retardation who voluntarily accepted to participate in the study were included. Patients aged between 18 and 65 years were picked with the consecutive sampling technique. A total of 22 healthy individuals with similar age and gender distributions, who were eligible according to the research protocol, were included in the study as the control group. The comparison group of controls mainly consisted of people who admitted for a general-purpose psychiatric assessment for the health board report, did not have any clinical psychopathology, and had no history of any psychiatric disease.

The control group provided reference data for comparison with the cases. Sleep hygiene psychoeducation was given to all participants before study participation, and compliance to the sleep hygiene was monitored by a sleep diary. The actigraph device was placed on the non-dominant wrist and data were recorded for at least 3 consecutive days. Recording with the actigraph was applied again after the 4-week treatment period.

Our study was approved by the local Clinical Research Ethics Committee of Canakkale Onsekiz Mart University Faculty of Medicine (Approval Date: July 25, 2018; Approval Number: 2018-15). All procedures were in accordance with the ethical standards of the Declaration of Helsinki. A written informed consent form was obtained from all subjects. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee, and with the Declaration of Helsinki and its later amendments or comparable ethical standards.

Of the patients with unipolar depression, those who agreed to participate in the study were included in the case group. The exclusion criteria were: age below 18 years, illiteracy, schizophrenia and other psychotic disorders, mental retardation, alcohol or substance addiction, or neurodegenerative diseases such as Alzheimer's disease or Parkinson's disease. Volunteers without any neurological disorder, psychiatric disorder, and alcohol or substance addiction were included in the control group.

### Data Collection Tools

**The Sociodemographic Data Form:** A semi-structured interview form that evaluated the patients' sociodemographic and clinical properties was applied. This form included questions related to age, gender, education, marital status, and morbidity.

**The Hamilton Depression Rating Scale (HDRS):** The HDRS is commonly used to assess depression and to measure the severity of symptoms in depression. The original scale, which was developed by Hamilton, includes 17 items, and the Likert-type rating system is used for assessment. The total score ranges between 0 and 53. The higher the total score, the more severe the depression.[11] The scale has a practical value in assessing outcomes related to treatment. The validity and reliability study on its Turkish version was conducted by Akdemir et al.[12]

**Actigraph Device and Program:** The patients' data related to activity and sleep were obtained using motion-sensitive (32 Hz), portable, and wristband-type actigraph devices (Actiwatch-Spectrum; Philips Respironics). Recording for activity, resting, and removal of the device from the wrist were performed using the device's automation mode program. The data obtained from the patients were transferred to the computer and analyzed with the Philips Actiware (Version 6.0.2) program. Sleep efficiency (SE%) and average physical activity counts (AvgAC/min; for daily and active intervals) were assessed to evaluate each patient. Sleep efficiency is the percentage of time spent in bed sleeping. Scored total sleep time divided by [interval duration minus total invalid time (sleep/wake)] of the given rest interval, multiplied by 100. The Avg AC/min is the average of all valid physical activity counts for all epochs for the given interval (e.g., active and daily intervals) divided by the epoch length in minutes. Active intervals are periods of time when the subjects' activities indicate that they are alert and moving. The devices were operated by following the clinical practice guidelines of the American Academy of Sleep Medicine .[13]

### Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analyses. The distribution of the scores of the sample was decided by evaluating the histogram, skewness, kurtosis values, and the Shapiro–Wilk test results together. The analytical test (Shapiro–Wilk test) results of the distribution of each parameter according to the groups are not given in the text and tables, because they may cause data confusion. The descriptive statistics were expressed as mean ± standard deviation or median [first quartile (Q1) – third quartile (Q3)] for the continuous variables, and as case number and percentage (%) for the categorical variables. Pearson's chi-square test was used to compare categorical variables between 2 groups. The Student's *t*-test was used to compare the mean values between 2 groups when the assumptions of parametric tests were met. In cases where the assumptions of parametric tests could not be met, the Mann–Whitney *U*-test was used for independent variables (actigraphy data and HDRS scores of the pre-treatment depression group and the control group). The Wilcoxon test was used to compare the change in the actigraphy data and the HDRS scores of the patients between pre-treatment and post-treatment. In the correlation analyses, the Spearman's correlation test was used according to the distribution characteristics of the continuous variables. The regression analysis planned for the HDRS score change could not be performed, because it did not meet the linear regression assumptions. Logistic regression analysis (the enter method) was applied to investigate the effect of various variables on depression. As dependent variables, the control group was designated as 0 and the depression group was designated as 1. Model fit was assessed by the Hosmer–Lemeshow test. Conditions with a type 1 error rate below 5% were considered statistically significant.

## RESULTS

### Sociodemographic Characteristics of the Sample

The depression group consisted of 20 subjects (12 women, 8 men) and the healthy control group consisted of 22 subjects (11 women, 11 men); the groups were similar in terms of gender ($\chi^2$ = 0.423, $P$ = .516). The mean age was found to be 45.55 ± 9.5 years (min = 26, max = 63) in the depression group and 42.64 ± 7.2 years (min = 28, max = 60) in the control group; the difference was not significant ($t$ = 1.124, $P$ = .268). In the depression group, 75% of the patients ($n$ = 15) were using SSRI antidepressant, 20% ($n$ = 4) were using SNRI antidepressant, and 5% ($n$ = 1) were using SSRI and SNRI antidepressants in combination.

### Comparison of Actigraphy Data Between the Depression and the Control Group

The Mann–Whitney *U*-test was used to compare actigraphy data between the case and the control groups. In the case group, sleep efficiency and average daily and active activity counts before treatment were found to be significantly lower compared to the control group. The median values, distribution, and comparisons related to the groups' actigraphy data are shown in Table 1. Furthermore, sleep efficiency after treatment (79.58%) was found to be significantly lower compared to the control group (84.1%) (Z = −1.977, $P$ = .048).

### Pre- and Post-Treatment Comparison of Actigraphy Data and HDRS Scores

The Wilcoxon test was used for the comparison of HDRS scores and actigraphy data before and after treatment in the depression group. In the depression group, the median HDRS score was found to be 22 (Q1: 17, Q3: 24)

**Table 1.** Comparison of Actigraphy Data of the Pre-Treatment Depression Group and the Control Group

| Actigraphy Data | Depression Group Median (Q1–Q3) (*n* = 20) | Control Group Median (Q1–Q3) (*n* = 22) | Z* | *P* |
|---|---|---|---|---|
| SE (%) | 76.41 (70.87-81.58) | 84.1 (77.6-87.5) | −2.972 | .003 |
| AvgAC/min (A) | 142.7 (111.7-174.5) | 264.1 (212.5-302.8) | −5.415 | <.001 |
| AvgAC/min (D) | 96.5 (57.8-140) | 178.6 (142.1-212.9) | −4.206 | <.001 |

*Mann–Whitney *U*-test.
SE (%), Sleep efficiency (percentage); AvgAC/min (A), Average activity counts for active intervals; AvgAC/min (D), Average activity counts for daily intervals.

before treatment and 10 (Q1: 4.75, Q3: 13.5) after a 4-week treatment period; the difference was statistically significant (Z = −3.927, *P* < .001). Sleep efficiency before treatment (76.41%) was found to be statistically significantly lower compared to sleep efficiency after treatment (79.58%) (Z = −3.173, *P* = .002) in the depression group. In the depression group, an increase was observed in sleep efficiency in 17 patients, in average daily activity counts in 17 patients, and in average active activity counts in 18 patients after treatment, compared to the period before treatment; the score variabilities in these indexes before and after treatment were found to be statistically significant. The actigraphy data and HDRS scores obtained before and after treatment are summarized in Table 2.

### Correlation and Regression Analysis Results

Spearman's correlation test was used to investigate the relationship between depression, sleep efficiency, and physical activity. A highly significant negative correlation was found between the first HDRS scores and the first average active activity counts ($r = -0.779$, $P < .001$), and between the first HDRS scores and the first sleep efficiency ($r = -0.616$, $P < .001$) (Table 3). The relationship between the differences before and after the treatment in the patient group was investigated. The rate of change in HDRS scores (first HDRS – second HDRS/first HDRS), rate of change in sleep efficiency (second SE – first SE/first SE), and the rate of change in average active activity counts (second AvgAC – first AvgAC/first AvgAC) were calculated for the relationship of the differences. A highly significant positive correlation between the HDRS change rate and the activity change rate was found ($r = 0.708$, $P < .001$), but there was no significant relationship between HDRS change rate and sleep efficiency change rate ($r = 0.211$, $P = .372$).

According to the results of logistic regression analysis in which the dependent variable was the presence of depression and the independent variables were age, gender, sleep efficiency, and average active activity counts, a significant negative effect was found between activity and depression (Table 4).

## DISCUSSION

In our study, activity levels and sleep efficiency were found to be significantly higher in the healthy individuals compared to the activity levels and sleep efficiency in the patients, both before and after a 4-week treatment period. A significant improvement was observed in activity and sleep efficiency in the patients after treatment compared to the period before treatment. A significant negative correlation was found between the HDRS scores and the average active activity counts, and between the HDRS scores and sleep efficiency. On the other hand, a significant negative relationship was found between depression and the average active activity counts.

In current studies in the literature, actigraph monitoring devices are being used to measure and evaluate gross motor activity in different psychiatric disorders. These studies show some methodological and technical differences.[14] In some studies on depression, diurnal activity variabilities or 24-hour circadian activities have been reviewed and evaluated in certain periods of time. Ueda et al. followed up circadian activity rates in a 24-hour period using

**Table 2.** Pre- and Post-Treatment Comparison of Actigraphy Data and HDRS Scores of the Patients

| Actigraphy Data | Before Treatment Median (Q1–Q3) (*n* = 20) | After Treatment Median (Q1–Q3) (*n* = 20) | Z* | *P* |
|---|---|---|---|---|
| SE (%) | 76.41 (70.87-81.58) | 79.58 (74.18-83.97) | −3.173 | .002 |
| AvgAC/min (A) | 142.7 (111.7-174.5) | 169.24 (130.7-207.7) | −3.099 | .002 |
| AvgAC/min (D) | 96.5 (57.8-140) | 118.3 (110.1-196.7) | −2.539 | .011 |
| HDRS Score | 22 (17-24) | 10 (4.75-13.5) | −3.927 | <.001 |

*Wilcoxon test.
SE (%), Sleep efficiency (percentage); AvgAC/min (A), Average activity counts for active intervals; AvgAC/min (D), Average activity counts for daily intervals
HDRS, Hamilton Depression Rating Scale.

**Table 3.** Correlation Analysis of the HDRS Score and Actigraphy Data

| | HDRS | SE (%) | AvgAC/min (A) |
|---|---|---|---|
| HDRS | 1 | | |
| SE (%) | −0.616** | 1 | |
| AvgAC/min (A) | −0.779** | 0.484* | 1 |

Spearman's correlation, *$P$ = .001,**$P$ < .001.
SE (%), Sleep efficiency (percentage); Avg AC/min (A), Average activity counts for active intervals.
HDRS, Hamilton Depression Rating Scale.

**Table 4.** Results of Logistic Regression Analysis Regarding the Effect of Various Variables on Depression

| | Unstandardized Coefficient B (Std. Error) | $P$ | RR | 95.0% CI for B Lower-Upper |
|---|---|---|---|---|
| Constant | 30.760 (22.523) | | | |
| Gender | −0.353 (2.432) | .885 | 0.703 | 0.006-82.658 |
| Age | 0.020 (0.111) | .856 | 1.020 | 0.820-1.269 |
| SE (%) | −0.085 (0.215) | .691 | 0.918 | 0.603-1.398 |
| Avg AC/min (A) | −0.127 (0.060) | .035 | 0.880 | 0.782-0.991 |

Hosmer-Lemeshow test: $\chi^2$ : 2.044 ($P$ = .980), Cox & Snell $R^2$ : 0.669, Nagelkerke $R^2$ : 0.893.
SE (%), Sleep efficiency (percentage); Avg AC/min (A), Average activity counts for active intervals.
RR, relative risk.

actigraphy in 4 periods of time in patients with melancholic depression. They proportioned activity as a percentage for each period of time. In the method, they compared the activity rates in these periods of time before and after treatment.[15] Toddler et al. evaluated locomotor activity analysis in depression separately for daytime and night-time activity.[16] In their study, the increase in daytime motor activity intensity was found to be significant in patients with depression who showed clinical improvement; while Ueda et al. observed an increase in activity rates only between 6 PM and 12 AM after treatment. Our study discussed the physical activity during active periods when the individuals were alert and in motion. In this way, it was attempted to minimize activity differences that might arise from rest intervals or chronotypical features.[17] In our study, the average active activity counts were found to be markedly lower in our patients with depression compared to healthy controls. Although a significant improvement occurred in activity levels after the acute treatment process, these levels were significantly lower compared to the healthy controls. In addition, the negative correlation between depression and activity levels was also notable, and the data obtained were compatible with previous studies.[16,18,19] However, these findings partially contradict with a study conducted by Volkers et al. It has been stated that the change in motor activity pattern does not occur at the expected level despite clinical improvement with antidepressant treatment.[20] On the other hand, there are also studies showing that actigraphy is not determinative in showing the effect of depression on motor activity. In a study conducted by Razavi et al. using actigraphy involving 76 major depression patients, no correlation was shown between the HDRS total score and quantitative motor activity.[21] In another study that aimed to measure motor activity in unipolar depression, activity parameters were investigated in 2 patient groups who did and did not have motor retardation. The fact that the patients were divided into 2 groups in terms of presence of motor retardation was regarded as one of the limitations of the study, and the differences in actigraphy results were examined. In this study, a notable finding was that actigraphy findings in the patients who did not have motor retardation were similar to the actigraphy findings in the hospitalized patients who had mania.[22,23] These findings indicate that actigraphy may show different findings in certain subgroups of depression or in depression patients with certain clinical features.

In our study, improvement was also observed in sleep efficiency after treatment in the patients. However, sleep efficiency was poorer compared to healthy controls, despite treatment. Although a negative correlation was found between sleep efficiency and HDRS scores, it was found that sleep efficiency had no effect on depression in the logistic regression model. In some previous studies, it was also reported that sleep efficiency was poor in depression, but sleep complaints reduced and sleep efficiency increased after treatment.[18, 24] In this regard, the sleep efficiency parameter in actigraphy may be a notable monitoring tool, but it cannot be determinative by itself, because there is very little evidence indicating the effect of efficient treatment on sleep disorder, despite abundant evidence indicating that efficient antidepressant treatment may successfully lead to significant responses in depression. On the other hand, sleep disturbance may sometimes occur before a depression period, though it is one of the typical characteristics of depression. Bidirectional relationships between insomnia and depression increase the difficulty in differentiating the cause–effect relationship.[6, 25] Therefore, expectations and outcomes related to sleep disorder may show variance in antidepressant treatment.

Our study should be evaluated considering some limitations. Firstly, the small sample size reduced our study's statistical power, though comparison with control groups was made. Different psychotropic drugs and potential comorbidities in the case group may limit the generalization of measurement results obtained by actigraphy in terms of activity and sleep efficiency. The study does not have the power to examine the effect of the antidepressant drugs used on activity parameters. In addition, the fact that some patients were hospitalized might have resulted in a condition that limited activity. Activity differences between the patients who were hospitalized and the healthy individuals living in the community might also be explained by hospital and living environments rather than emotion levels.[26]

In summary, this study shows that actigraphy contribute to objective treatment monitoring in depression by way of activity levels and sleep efficiency. Our results indicate that actigraphy may serve as an objective assistive tool for treatment monitoring in depression by taking account of the 2 parameters including average active activity counts and sleep efficiency simultaneously. We think that future studies confirming these preliminary findings and investigating the effect of depression treatment on sleep and activity levels using actigraphy and similar mobile devices, will be valuable.

**Ethics Committee Approval:** Ethical Committee Approval was received from the ethics committee of Canakkale Onsekiz Mart University Faculty of Medicine (Approval Date: July 25, 2018; Approval Number: 2018-15).

**Informed Consent:** Written informed consent was obtained from all participants who participated in this study.

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