

Investigation of Cognitive, Psychological and Physical Factors Affecting Academic Performance of University Students by Principal Component Analysis During the Covid-19 Pandemic

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ABSTRACT

Purpose: The Covid-19 Pandemic has significantly affected the physical activity levels, psychosocial status, cognitive skills, and academic performances of university students in the health field. The aim of this study is to examine the factors affecting the academic performance of university students with principal component analysis.

Methods: 151 University students (aged 21.83±1.88 years; 125 female, 26 male) participated in the study. The CogniFit Cognitive Assessment Program, the International Physical Activity Questionnaire Short Form, Academic Self-Efficacy Scale, Pittsburg Sleep Quality Index, Beck Depression Inventory, and Beck Anxiety Inventory were administered to the students via the Google Form. The Principal Component Analysis was used to evaluate the data.

Results: The Principal Component Analysis (PCA) yielded three principal components (PC) that together account for 93% of the variation in the data set and represent new and distinct patterns. Thus, 11 variables affecting the subject were reduced to three components. These 3 components include all the cognitive functions evaluated. In addition, sleep and depression variables are also included.

Conclusion: The cognitive, emotional, and physical factors affecting the academic performance of university students have been systematically classified and made easier to prioritize and understand. In this way, the parameters that need improvement were laid out.

Keywords: University students, principal component analysis, academic performance, cognitive functions, pandemic

Covid-19 Pandemisi Sürecinde Üniversite Öğrencilerinin Akademik Performansını Etkileyen Bilişsel, Psikolojik ve Fiziksel Faktörlerin Temel Bileşenler Analizi İle İncelenmesi

ÖZET

Amaç: Covid-19 Pandemisi, sağlık alanında eğitim görmekte olan üniversite öğrencilerinin fiziksel aktivite düzeylerini, psikososyal durumlarını, bilişsel becerilerini ve akademik performanslarını önemli ölçüde etkilemiştir. Bu çalışmanın amacı, üniversite öğrencilerinin akademik performansını etkileyen faktörleri temel bileşenler analizi ile incelemektir.

Yöntem: Araştırmaya 151 üniversite öğrencisi (21.83±1.88 yıl; 125 kadın, 26 erkek) katılmıştır. Öğrencilere Google Formu aracılığıyla CogniFit Bilişsel Değerlendirme Programı, Uluslararası Fiziksel Aktivite Anketi Kısa Formu, Akademik Öz-yeterlik Ölçeği, Pittsburg Uyku Kalitesi İndeksi, Beck Depresyon Envanteri ve Beck Anksiyete Envanteri uygulanmıştır. Verileri değerlendirmek için Temel Bileşen Analizi kullanılmıştır.

Bulgular: Temel Bileşen Analizi, veri setindeki varyasyonun %93'ünü oluşturan ve yeni ve farklı modelleri temsil eden üç temel bileşen (PC) sunmuştur. Böylece konuyu etkileyen 11 farklı değişken üç bileşene indirgenmiştir. Bu 3 bileşen, değerlendirilen tüm bilişsel işlevleri içermektedir. Ayrıca uyku ve depresyon değişkenleri de yer almaktadır.

Sonuç: Araştırmanın sonunda üniversite öğrencilerinin akademik performansını etkileyen bilişsel, duygusal ve fiziksel faktörler sistematik olarak sınıflandırılmış, önceliklendirilmesi ve anlaşılması kolaylaştırılmıştır. Bu şekilde sağlık eğitimi sürecinde iyileştirilmesi gereken parametreler ortaya konmuştur.

Anahtar Kelimeler: Üniversite öğrencileri, temel bileşen analizi, akademik performans, bilişsel işlevler, pandemi

Investigation of the cognitive, psychological, and physical factors affecting the academic success of students during the pandemic is important in terms of effective management of this process. Due to the long isolation period, the relationship between students' stress, anxiety levels, cognitive function, and academic achievement attracts great attention during this period. Determining the factors affecting students' cognitive status and taking necessary precautions, especially making learning-teaching processes more efficient, will be very beneficial for academic success (1).

The pandemic leads students to a sedentary lifestyle and may negatively affect physical performance, increasing disease and health problems. While physical activity is known to improve cognitive functions, research continues on the consistency and magnitude of its effects, the cognitive areas most affected, and the parameters necessary to achieve the greatest improvements (2). In addition, the increase in the time spent at home with the online education process can cause many problems for university students. While this situation negatively affects the sleep quality of the students, it can increase their depression and anxiety levels (3). Physical activity has been shown to have many positive effects on the body in general. It regulates blood pressure and prevents the formation of hypercholesterolemia, increases bone and mineral density, prevents obesity and has positive effects on mental health problems like depression, and anxiety. In addition, it has been reported that students who do physical activity improve self-confidence, self-esteem, and feelings of competence, increase their energy and reduce the feeling of fatigue. However, studies on the effects of physical activity on cognitive functions such as attention, learning, and memory are limited (4).

"CogniFit" (CogniFit, Inc.), one of the current cognitive assessment technologies, contains validated tasks for the assessment of 23 cognitive skills. The test is used as a professional tool to help detect cognitive changes using neuropsychological assessments. It also provides the opportunity to monitor the development of cognitive skills. At the end of the cognitive assessment, different insights about the cognition of the students are gained and it is determined which ones are strong and which ones need training (5).

Pandemic has been an important process affecting university students' physical activity levels, psychosocial status, cognitive skills, and academic success. CogniFit and

similar applications have started to be used in the evaluations, and such evaluations have gained great importance in this process where face-to-face applications cannot be made together with the pandemic process (6).

This study aims to analyze the factors affecting the academic performance of university students that have been systematically classified and made easier to prioritize and understand. For this purpose, we have used Principal Component Analysis (PCA). While there are many possible variables that can affect students' academic performance, this means a lot of data. Thus, we have reduced a large number of variables to main components. In addition, cognitive functions in our research were carried out through a current technological mobile application. Thus, this technology-based research, it is aimed to evaluate and systematize the factors affecting the academic performance of students during the pandemic with the application of PCA, which is an advanced statistical method.

MATERIALS AND METHODS

This study was carried out on volunteer university students at Biruni University Faculty of Health Sciences between April 2021 and July 2021. Ethics committee approval was received from Biruni University Ethics Committee, dated 09/04/2021, number 2021/50-33.

Based on the literature, considering sleep quality and depression data, the minimum sample size was calculated as 136 people at 95% power (6). Oral and written consent was requested from the participants.

The inclusion criteria are to be a university student, to be between the ages of 18-25, to attend online classes regularly during the pandemic and to be able to read, write and understand Turkish. Exclusion criteria are the presence of orthopedic, neurological, psychiatric, and vision-hearing problems that would prevent participation in the study.

Demographic information form, CogniFit Cognitive Assessment Application, Academic Self-Efficacy Scale (ASES), Pittsburg Sleep Quality Index (PSQI), Beck Depression Inventory (BDI), and Beck Anxiety Inventory (BAI) were administered to the students. The data relating to the physical activity variable of all students were evaluated with the International Physical Activity Questionnaire Short Form (IPAQ-SF). In addition, the students' grade points averages (GPA) were recorded.

Before the cognitive evaluations, necessary permissions were obtained from the company for the software. Later, a mobile application was installed on all students' mobile phones and the features of the application were introduced. Other questionnaires were prepared on google form and applied to all students online. Thus, all the data received from the students were recorded in a completely virtual environment.

Instruments

General Cognitive Assessment Battery (GCAB) by CogniFit™ is a 40-minute online neuropsychological tool designed to precisely evaluate a wide range of abilities and assess cognitive well-being. Using clinically and scientifically validated online cognitive tasks, GCAB identifies strengths and weaknesses in cognition in children 7+ and adults (5). The CogniFit is designed to evaluate a total of 21 cognitive functions divided into five cognitive domains (attention, memory, coordination, perception, and reasoning). Each objective score is derived from raw scores and weights determined by factor analysis (6). The final score is the measure of the current cognitive strength of different cognitive skills.

A score between 0 - 200; below the average of your age. The score will be shown in red. Cognitive abilities with this score are considered cognitive weaknesses since they will be below what was expected for people of the same age and sex.

A score between 200 - 400; low scores, although within the average. The score will look yellow, since the cognitive abilities with this score will be within what is expected for people of your age and gender, but they are still improvable.

A score between 400 - 600; high scores within the average. The score will be green since the cognitive abilities with these scores will be in good condition with respect to people of the same age and sex.

Score between 600 – 800; cognitive situations above the average. The score will also look green. The cognitive abilities with this score will be considered strengths or cognitive skills since they will be in a better state than the average for people of your same-sex and age (5).

International Physical Activity Questionnaire - Short Form (IPAQ-SF), determines the types of the intensity of physical activity and sitting time. These are considered

to estimate total physical activity in MET-min/week (1 MET=3.5 ml/kg/min) and time spent sitting. It consists of open-ended questions that involve individuals remembering the last 7 days of physical activity. Turkish versions of the IPAQ SF is reliable and valid in the assessment of physical activity (7).

The Academic Self-Efficacy Scale (ASES) is the individual's perception of being able to perform a given academic task at a specified level of success. The scale consists of three sub-dimensions: social status, cognitive and technical skills. The scale includes 33 items. While the Cronbach Alpha reliability coefficient was found to be 0.86 for the overall scale, it was found to be 0.88 for the social status, 0.82 for the cognitive practices, and 0.90 for the technical skills dimension (8).

Pittsburgh Sleep Quality Index (PSQI) is an 18-item questionnaire that evaluates sleep quality over 1 month period. The items are divided into 7 component scores: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, medication use, and daytime dysfunction. These items are scored on a four-point Likert scale. The component scores provide a total PSQI score that ranges from 0 to 21, with higher scores meaning lower sleep quality (9).

Beck Depression Inventory (BDI) is a 21-item self-report questionnaire. The items are scored between 0 and 3 according to the severity of the depression. The minimum and maximum scores are 0 and 63. Scoring is as follows, 0-9, no depression; 10-16 mild depression, 17-24 moderate depression, 25 and above severe depression. The scale was adapted into Turkish by Hisli (10).

Beck Anxiety Inventory (BAI) evaluates the frequency of anxiety symptoms experienced by the individual. It is a 21-item tool designed to assess the anxiety level that is applicable to the general population [16]. Each item is rated on a four-point Likert scale ranging from 0 =not at all to 3 =severe. The total score ranged from 0 to 63. A score of 0-7 is defined as normal/minimal anxiety, 8-15 as mild anxiety, 16-25 as moderate anxiety, and 26-63 as severe anxiety (11).

After the data collection process was carried out, the statistical analysis process was started.

Statistical Analysis

PCA is a multivariate statistics method. It reduces the multidimensionality of a relevant multivariate data set to a small number of independent main components. Each principal component (PC) contains all variable information and new variables created as linear combinations or mixtures of initial variables.

In this study, PCA was conducted on the assessment scores which applied to university students. For the proper use of PCA, the data were tested with Kaiser-Meyer-Olkin (KMO) and Bartlett tests. These tests were used to examine the adequacy of the selected sample and the independence of each variable, respectively. Firstly, components with eigenvalues > 1.0 were considered. Ten components with eigenvalues > 1 were selected.

Two-sided p values were considered statistically significant at $p \leq 0.05$. All statistical analyses were carried out by using R software/programming (version 3.6.2 (2019-12-12) – Comprehensive R Archive Network (CRAN) (12).

RESULTS

A total of 151 university students (aged 21.83 ± 1.88 years; 125 female, 26 male) participated in our study. The demographic features of the students are shown in table 1.

As a result of the research, 54 (35%) of the students stated that they slept less than 8 hours, 82 (55%) 8-10 hours, and 15 (10%) slept more than 10 hours.

In terms of academic achievement scores, 50% of the students have an average score between 3 and 4, and 47% have an average score between 2 and 3. This shows that the majority of students were successful in their exams during the pandemic.

Cognifit total score average of the participants is 435.34. This value corresponds to low cognitive risk. When the parameters are analyzed one by one, reasoning, and attention have low scores although within average; memory, coordination and perception have high scores within average (Figure 1).

In terms of depression, the mean value of 13.16 points corresponds to mild depression (Figure 2). When the anxiety values are examined, the value of 15.44 indicates moderate anxiety (Figure 3).

The average total met value is 1390 points, corresponding to minimal assets (category 2).

All assessment scores are shown in table 2.

As a result of the principal component analysis, 3 components were obtained. The first principal component (PC1) has a high variance (72%). These 3 components have a high total variance of 93.41% and are shown in table 3.

Table 1. Demographic features of the participants

| | N | Percent | Mean | SD |
|--------------------|-----|---------|-------|------|
| Age | | | 21,83 | 1.88 |
| Gender | | | | |
| Female | 125 | 82.78 | | |
| Male | 26 | 17.22 | | |
| BMI | | | 21.81 | 3.40 |
| Smokers | 27 | 18 | | |
| Non-smokers | 124 | 82 | | |

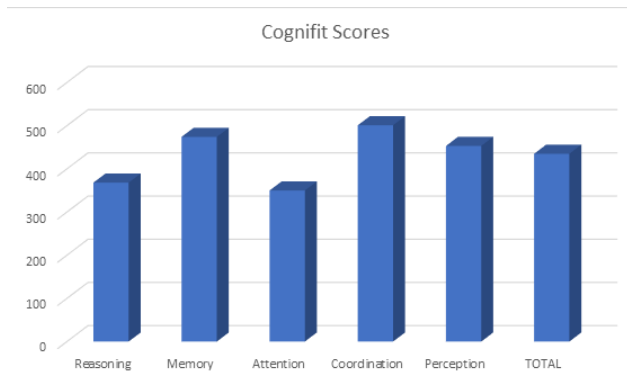


Figure 1. Cognifit scores of the participants

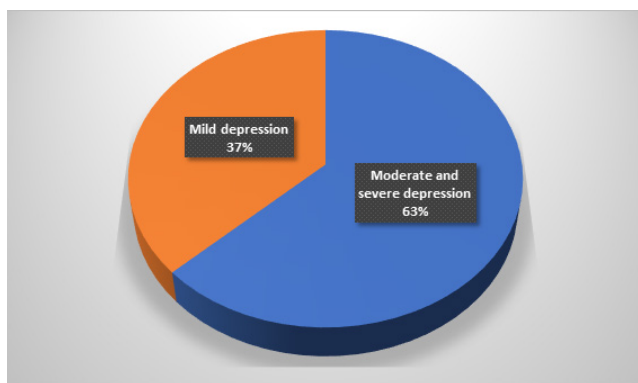


Figure 2. Depression percentages of the participants

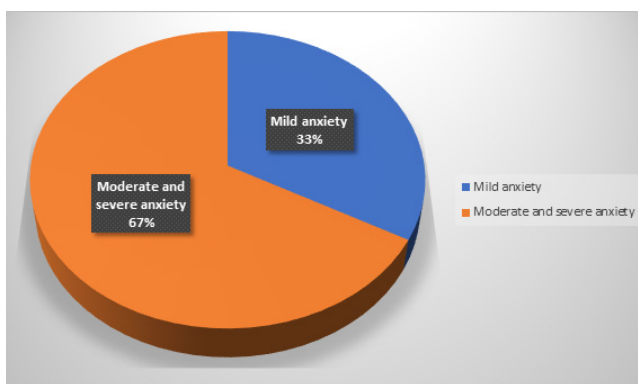


Figure 3. Anxiety percentages of the participants

| | N | Percent | Mean | SD |
|--|-----|---------|--------|--------|
| GPA | 151 | | 2.93 | 0.46 |
| 1.5-2.0 | 5 | 3 | | |
| 2.0-2.5 | 19 | 12 | | |
| 2.5-3.0 | 53 | 35 | | |
| 3.0-3.5 | 61 | 41 | | |
| 3.5-4.0 | 13 | 9 | | |
| ASES | 151 | | 20.28 | 2.64 |
| COGNIFIT TOTAL | 151 | | 435,34 | 35.52 |
| Reasoning | | | 368,2 | 19.60 |
| Memory | | | 474,4 | 23.90 |
| Attention | | | 350,4 | 38.30 |
| Coordination | | | 501,05 | 53.03 |
| Perception | | | 453,29 | 47.06 |
| PSQI | 151 | | 5,74 | 3.33 |
| SLEEP TIME | | | | |
| <8 hours | 54 | 35 | | |
| 8-10 hours | 82 | 55 | | |
| >10 hours | 15 | 10 | | |
| BDI | 151 | | 13,16 | 4.06 |
| BAI | 151 | | 15,44 | 5.14 |
| TOTAL MET | 151 | | 1390 | 201.80 |
| *BMI (Body Mass Index) *GPA (Grade point average) *ASES (Academic Self-Efficacy Scale) *PSQI (Pittsburgh Sleep Quality Index) *BDI (Beck Depression Inventory) *BAI (Beck Anxiety Inventory) *MET (Metabolic equivalent) | | | | |

| | Principal Components | Variance |
|----------|--|----------|
| 1 | Physical activity level walking score Attention Coordination Perception | 72% |
| 2 | Sleep quality Total cognitive level Academic self-efficacy | 15% |
| 3 | Depression Reasoning Memory | 6% |

PC 1: Physical activity level walking score, attention, coordination and perception (72% variance).

PC 2: Sleep quality, total cognitive level and academic self-efficacy (15% variance)

PC 3: Depression, reasoning and memory variables (6% variance)

As a result of the research, the variables applied to the students were reduced to three basic components including the variables related to each other. Interpretation of the data will be done through these components.

DISCUSSION

In this research, we aimed to analyze the factors affecting the academic performance of university students who receive online education in this process by using the principal component analysis and reducing a large number of variables to basic components. In the COVID-19 pandemic, university educators have been asked to bring all their teaching and assessment activities online in a relatively short time. As a result, all lessons, simulations, applications and evaluations were adapted to the online environment and made available for use. From a student perspective, there has been an opportunity to develop and adopt new skills (13). Thus, it is aimed to obtain more systemic and easily interpretable results. With the analysis made in this context, 3 PCs were determined and a high variance value of 93% was reached.

In PC1 (%73 variances), the relationship between the walking parameter of physical activity and attention, coordination, and perception, was revealed. When the cognitive evaluation results were examined, it was seen that the total score was above the average (400-600) and that they were in a similar situation to their peers. When the sub-steps of cognitive assessment were examined, it was concluded that while the memory, coordination, and perception parameters scores were still above the average, the reasoning and attention scores were below the average. In terms of physical activity, it is seen that the physical activity levels of the participants are in the minimal active category and walking activity is at the forefront.

Physical activity in young people is an essential part of healthy aging and maintaining cognitive and cardiovascular functions. Regular physical activity is recognized as an essential attribute of students' academic performances. Sports-related activities strengthen the soul and mind and bring creativity. Young people who are not physically active are more likely to adopt other unhealthy behaviors (such as tobacco, alcohol, and drug use), resulting in poor academic performance. Aerobic activity strongly improves performance on tasks involving executive cognitive functions such as planning, programming, inhibition control, and working memory. Students who have improved physical health show higher memory performance.

Previous studies have suggested that physical activity helps achieve better academic performance through increased serotonin secretion, improved cerebral circulation, changes in hormone levels, and increased self-esteem (14). Other researchers have also found a positive correlation between the physical activity level and cognitive functioning, especially the working memory (15, 16).

A moderately significant relationship between physical health and academic performance was found among Nigerian university students. This was also in line with other findings, which showed a positive relationship between physical activity level and academic achievement. Comparably, another researcher found that students who were physically inactive and have lower physical activity levels reported lower academic levels (17, 18).

PC2 revealed the relationship between university students' sleep quality, total cognitive level, and academic self-efficiency variables. Sleep, the variable with the highest variance in this component, is a concept that deserves special attention. It is recommended that young

adults get 8 hours of sleep. However, most young adults sleep less than this period (19). Sleep disturbance is common among university students who live in an environment that promotes sleep reduction due to the burden of academic work and social pursuits. It often causes depression and poor academic performance. Decreased sleep time has been associated with poor academic performance (20-22).

It was observed that 35% of the students included in our study sleep less than 8 hours. Studies show that poor sleep habits have a negative impact on academic performance and mental health complaints. The effect of sleep disturbance on cognitive performance has also been documented previously with a correlation between sleep quality and GPA in university students (23,24). As revealed in our study, sleep and cognitive skills are closely related. High-quality and optimal duration of sleep helps maintain concentration, executive cognitive functions, sensorimotor integration, memory and learning (25). When the GPA values of the students participating in our research were examined, it was seen that 50% of them were very successful and 12% had a sufficient grade point average. In higher education, student selection procedures reduce the variation in intelligence scores, especially in selective faculties. At this level, factors other than intelligence can be important to precisely predicting performance. GPA is the main criterion for post-graduate selection and graduate employment and predicts professional status.

The relationship between cognitive skills and academic self-efficacy in PC2 is also extremely important. The perceived academic self-efficacy and performance are factors that are correlated. Students with high academic self-efficacy displayed more cognitive skills that helped them organize themselves better (26, 27).

Along with depression, reasoning and memory variables, are involved in PC3. During times of enormous uncertainty, such major lifestyle changes are associated with mental health issues such as a higher risk of depression during the pandemic. Depression is a major mental disorder with symptoms such as exaggerated and persistent sadness, cognitive impairments, and a tendency to negative teasing, as well as fatigue and insomnia. It has been shown that about one-fifth of college students suffer from existing mental health problems. In Sweden, between 25% and 50% of students show symptoms of these problems. Mental health problems are the biggest barrier

to academic performance and can affect students' motivation and concentration (28).

In our study, the mean of depression was found to be 13.13, which indicates the presence of mild depression. The result of the anxiety assessment indicates moderate anxiety with an average value of 15.44. It has been observed that about one-fifth of the students suffer from mental health problems. This population was at high risk of experiencing anxiety, depression, and panic attacks during the pandemic. Depression levels among students reported in recent studies range from 29% to 38%, which may indicate an increase in pandemic-related depressive symptoms among college students in China (29).

Both difficulties concentrating and changes in sleeping habits are associated with depression.

The American College Health Association reported that faced with the pandemic situation, Turkish and American university students, respectively, had a high risk of suffering anxiety, depression, and panic attacks (30).

General threats posed by the pandemic include increased sedentary behavior, mental health effects, and impacts on daily life and work. Students often followed public health advice during the pandemic, but many reported significant negative results regarding academic self-efficacy and mental health status. In order to prepare for the pandemic and similar future crises, online education options should be developed to increase cognitive skills, build resilience and alleviate students' suffering (27, 28).

The individual approach, which takes into account the strengths and weaknesses of each participant, is one of the most important advantages of web-based platforms for cognitive training and screening. We used the CogniFit application, which is a valid cognitive assessment tool, in our research. Thus, we evaluated the young generation, which is intertwined with technology, with a modern method.

It can be predicted that the pandemic will continue for a long time. Technological developments accelerated by this process have also caused the habit of online lessons and meetings to settle. In order to increase students' adaptation to this process, it is of great importance to first find out which factors affect their academic performance and make the necessary improvements. With the PCA method, which we have applied within the scope of our

research, these factors have been systematically analyzed. Thus, it has been demonstrated which education parameters should be improved.

In the future, it is planned to carry out preventive and intervention studies by making use of systematic findings that affect the academic achievement of university students. We believe that the transition to the improvement process by taking these factors into account in the university education will be an effective, efficient and practical solution.

Limitations

Considering that the education styles of each department at the university are different, this situation was not fully detailed in our research and only a sample group was formed as students in the field of health sciences. In future studies, having a structure that includes departmental differences will provide more precise results.

DECLARATIONS

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflicts of Interest

The authors have indicated they have no potential conflicts of interest to disclose.

Ethics Approval

Ethical approval was obtained from Biruni University Non-Interventional Clinical Research Ethics Committee on 09.04.2021, number 2021/50-33.

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This article includes no material from other sources.

Authors' Contributions

BÖ: Conceptualization, review and editing, supervision; RA, BB, BÖ: Conceptualization, investigation, Writing-Original Draft; BB: Review and editing, supervision; YÇ: Methodology, statistical analysis; BÖ, RA: Investigation, review and editing.

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Supplementary Data

| Rotated Component Matrix ^a | | | |
|---------------------------------------|-----------|-------|-------|
| Variable | Component | | |
| | 1 | 2 | 3 |
| SEVERE MET | -,001 | -,019 | ,084 |
| AVERAGE MET | -,090 | ,124 | ,186 |
| GPA | -,039 | ,270 | ,003 |
| DD | -,004 | -,062 | -,002 |
| USP | -,022 | -,042 | ,028 |
| SD | -,017 | -,004 | ,003 |
| HSA | -,016 | ,007 | ,000 |

| | | | |
|--|--------------|--------------|---------------|
| ST | ,004 | ,027 | ,004 |
| SSQ | -,035 | ,009 | -,018 |
| CLASS | ,014 | -,017 | -,006 |
| SL | -,197 | ,819 | ,107 |
| TIB | ,057 | ,001 | -,001 |
| GENDER | -,040 | -,062 | -,039 |
| SITTING MET | -,006 | -,092 | ,014 |
| TOTAL MET | -,021 | -,039 | ,029 |
| BAI | -,011 | -,035 | -,061 |
| BDI | ,037 | ,011 | -38,04 |
| REASONING | ,007 | ,050 | 82,23 |
| PSQI | ,003 | 58,65 | ,039 |
| COGNIFIT TOTAL | 2,78 | 62,51 | 23,870 |
| WALKING MET | 79,45 | -7,958 | 48,609 |
| MEMORY | 75,62 | 1,813 | 94,62 |
| ATTENTION | 90,93 | -3,385 | -43,951 |
| COORDINATION | 48,13 | 27,412 | -32,307 |
| PERCEPTION | 39,91 | 6,693 | -1,726 |
| ASES | -34,496 | 375,5 | -6,069 |
| % of Variance | 72,193 | 15,249 | 5,969 |
| Cumulative % | 72,193 | 87,442 | 93,411 |
| <p>*BMI (Body Mass Index) *GPA (Grade point average) *ASES (Academic Self-Efficacy Scale) *PSQI (Pittsburgh Sleep Quality Index) *BDI (Beck Depression Inventory) *BAI (Beck Anxiety Inventory) *MET (Metabolic equivalent) *SSQ (Subjective Sleep Quality) *DD (Daytime dysfunction) *HSA (Habitual sleep activity) *ST (Sleep Time) *SL (Sleep Latance) *SD (Sleep Disorder) *USP (Use of Sleeping Pills) *TIB (Time in Bed)</p> | | | |