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Stress and Drug usage in Young Adults: Efficacy of Self-Report Measure and Wearable Device in Predicting Stress Levels

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Abstract

Background: Stress is a complex and multifaceted process encompassing physiological and psychological dimensions. Young adulthood represents a critical developmental period marked by increased vulnerability to both stress and substance use. Integrating wearable technologies with psychological tools may enhance early detection and prediction of stress-related substance use. This study aimed to examine stress levels among young adults, comparing drug users and non users, and evaluated the congruence between self-reported stress and electroencephalography (EEG)-based physiological indicators.
Methods: A descriptive study with an experimental component was conducted. Two groups; 33 healthy controls with no reported substance use and 37 individuals undergoing rehabilitation for substance use disorders; were examined within an experimental framework using wearable electroencephalography (EEG) headbands. The sample size of 70 participants was determined. Perceived stress was measured using the Perceived Stress Scale (PSS-10), and substance use severity was assessed using the Drug Abuse Screening Test (DAST-20). Results: A positive significant relationship was observed between self-reported stress levels and EEG based physiological stress indicators, suggesting that self-report measures provide valid assessments of perceived stress, while EEG provides an objective, real-time physiological measure of stress. The group comparison was statistically significant and EEG based stress classification achieved an accuracy of 84.8% for healthy controls and 89.1% for substance users, indicating demonstrated high classification performance of wearable neurophysiological data in stress detection. Conclusions: Findings highlighted the value of integrating neurophysiological and psychological measures for comprehensive stress assessment. Wearable EEG combined with machine learning provides a capable neuropsychiatric tool for objective stress assessment and early risk identification in young adults.
Keywords: Stress, Drug Usage, Young Adults, Self-Report Measures, Wearable Devices, EEG, Mental Health

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Introduction

Young adulthood is a complex developmental stage, which is usually associated with fundamental changes and difficulties. (Wood et al., 2018). It is a stage of life when one tries to find his/her way through the intrigues of studying, professional choice, social interactions, and identity formation. Together with the demands to find their own ground and set their independence and growing academic loads, these difficulties may result in greater stress levels. Unmanaged or poorly managed stress may lead to an extensive number of psychological and physical health issues, such as anxiety, depression, and heart disease. Regrettably, most young adults find it difficult to formulate constructive coping skills at this stage, and most of them use dysfunctional coping skills such as substance use to relieve their pressure.

One form of such a coping mechanism is substance use which includes the consumption of alcohol, tobacco, and marijuana as well as other illicit drugs. Firstly, drugs can give short-term relief from the stressful factors of reality, helping individuals escape overwhelming emotions either anxiety or depression. Nonetheless, stress alleviates such as substances can also result in dependency and addiction. Over time, the patient will develop some dependence on drugs to cope with stress, this will worsen the mental health challenge and add more stress, including lack of friendship, economic hardships, and legal complications. This rotational relationship between stress and drug use can considerably influence the living of any particular individual and it is quite alarming to young adults, who are not much developed emotionally and psychologically.

The relationship between substance and stress is twofold. Substance use can be provoked by stress, people want to forget about their emotional and physical problems and get temporary shelter. (Zvolensky et al., 2020) The more stress is accumulated, the more people can be tempted to relieve negative emotions by means of some substances, and the greater their danger of becoming addicted can be. On the other hand, the perpetual use of drugs will impair the performance of the body in controlling stress. Drug use may disrupt the normal reward system of the brain by deciphering stress systems and building up a loop in which a heightened level of stress intensifies the desire to take drugs and the utilization of drugs in turn leads to the increment of the level of stress. The mutual effect between back-and-forth stress and substance use creates a cycle, in and out of which individuals find it hard to escape coining a vicious cycle of addiction and inability to deal with stress effectively.

The use of self-report instruments for measuring stress (perceived stress scale, PSS) has been used widely in traditional research in measuring the levels of stress. (Chan & La Greca, 2020) These are self-report measures where the person has been requested to consider his or her own experiences and how he or she experiences the stress over a certain period of time. An example of common clinical and psychological measures is the PSS which is used to gauge the perceptions of individuals towards the stressfulness of their lives. Although self-reports may be utilized as a rich source of information about the mental and emotional welfare of a particular person, they possess implicit limits. Self-reported data are subject to many kinds of bias, such as social desirability bias (when the participants might report their levels of stress to be socially acceptable) and recall bias (when the participants might be unable to recollect and report both past experiences with stress well). There is also the chance of people over-reporting or under-reporting their level of stress depending on how they feel at that given moment and this can bring about inconsistency in data.

It is against these shortcomings that researchers have been increasingly using more objective measures of stress e.g., physiological stress indicators to supplement self-reports. An emerging device is a wearable Electroencephalography (EEG) that can measure your brain activity instantly. (Casson, 2019) EEG technology functions based on documenting the electrical current produced by neural action in the brain that is able to be used to test the reaction to stress. Whenever a person is stressed, certain electrical activities occur in the brain, and these brain reads can be measured through electroencephalogram (EEG) sensors. These gadgets have the capability of observing these cycles on a consistent and naturalistic basis giving readings as to the real-time effects of physiological stress levels on the individual. With the help of the EEG, researchers have a possibility to obtain more objective data which may be added to the subjective reports of stress collected through self-reporting, increasing the reliability and validity of stress measurements.

EEG devices that can be worn like other wearable electronics have been popular in stress studies because they offer continuous non-invasive monitoring of the stress levels of an individual. (Wu et al., 2022) Such devices have a number of benefits over conventional stress assessment techniques. They can be used to take data in real-time, thus obtaining measures of stress as it happens, instead of self-report methodology that comes with retrospective bias. Moreover, the mobile EEG tools can also be applied in several different environments and the researchers have been able to measure the stress in the real-life context, say during studying, on the job, or socializing. This versatility means that they are a potent instrument for making sense of stress under more realistic circumstances and investigating how stress and substance use interact in a more realistic setting.

This research is aimed at investigating the applicability of self-report and wearable EEG devices to tell about the degree of stress in young adults. In particular, the study aims to discuss the contrast between the rates of stress among young adult drug users and non-users. The study will give a deeper insight into the nature of stress among young adults by comparing the self-reported data in regard to stress levels (using the PSS questionnaire) with the physiological data measured by EEG equipment. The given comparison will provide qualitative information regarding the effects of substance use on the stress response and the possibilities of using physiological measures in the improvement of sensitivity of stress tests.

Besides these are the existence of various stress levels in drug users and non-users, this research will also examine how wearable gadgets, such as EEG, can enhance the prediction of stress levels. When wearable EEG machines become more affordable and convenient to wear on a daily basis, they may contribute to the process of diagnosing people who are at risk of developing substance use disorders. Wearable devices might help develop more effective and personalized interventions, which is achieved through the potential results of determining the pattern of stress in real time. Young adults are at much risk of not being able to cope with stress; the interventions may allow them to cope with these stress factors more efficiently and lessen their use of substances as a coping measure.

Finally, the results of the present research could serve as a source of information in developing future stress management and substance use prevention strategies. Self-reported data combined with objective physiological measurements causes researchers to come up with a more comprehensive way of evaluating stress. In turn, this can result in the designing of specific interventions that can cope with the psychological and physiological components of the stress and enable young adults to have healthier and much more balanced lives.

Stress is a necessary predictor of substance abuse, impacting the beginning of drug usage and the possibility of relapse. It points out the fact that stress matters a lot in inducing and sustaining substance abuse, particularly in young adults who experience academic, social, and identity-based pressures. Comparing the two groups in terms of self-reporting and wearable sensors will allow the study to comprehend the impact of drug use on awareness and

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control of stress. The observations can inform specific mental health-related interventions and better therapeutic approaches to drug users.

Literature Review

Stress and substance use have been studied widely, and many studies have revealed that stress is a key factor causing the initiation, escalation, including maintenance of substance use behaviors, especially among young adults. The young adult age is usually characterized by major life changes e.g., enrolling in higher studies, developing career orientations, and gaining financial independence. (Kim et al., 2022) Although these changes are positive, they also may lead to the rise of stress, concerning new responsibilities, pressures, and difficulties. Substance use may also be encouraged by academic pressures, social pressures, family issues, and other stressors in life that people might use to cope with their situations, taking the form of alcohol, tobacco, or illegal drugs. Here, stress can be considered one of the most important triggers, and its role in the emergence of substance use disorders (SUDs) cannot be ignored. (Arsalan & Majid, 2021)

The hassles of life, especially when they occur often and in high doses, have been found to affect drug use. Emotional and psychological discomfort may be presented by stress, and a large number of young adults may use substances to relieve themselves. (Glowacz & Schmits, 2020) Whatever the reason is, academic pressures, issues in personal life, feelings of inadequacy, and fear of not making it in the future, the choice to take substances may seem expedient when compared to the feelings of pressure and the resultant effects of such stress. In the long term, though, the coping strategy may turn counterproductive and precondition the occurrence of substance use disorders. Chronic stress may affect the capacity of a person to cope with day-to-day life effectively, and he or she is more likely to become dependent on the substance when in trouble. (Boucher et al., 2022) Such emotional control through drugs may lead to addiction, as a person caught in the vicious cycle falls into the association between stress and drug use.

The study has also indicated the importance of understanding the role of chronic stress in altering the brain's reward system, which subsequently causes an increased sensitivity towards the reinforcing property of the drugs. The hypothalamic-pituitary-adrenal (HPA) axis of the body goes into action, causing the body to release stress chemicals such as cortisol as a result of stress. (DeMorrow, 2018) These hormones affect many physiological changes in the body, though over a long period of exposure to high levels of cortisol, the brain chemistry can change. In particular, chronic stress may result in brain alteration in the parts of the brain that are implicated in reward processing, including the nucleus accumbens and the prefrontal cortex. The changes render the brain vulnerable in such a way that it can be influenced by the euphoric impact of drugs since drugs can induce the same brain neurotransmission as stress. The outcome is a two-sided knife, in which stress does not only contribute to substance use but also increases the reward- seeking behavior of the brain causing stress and substance use cycle that is hard to break.

The self-report measures have always been used by the researchers to determine the stress levels in the individuals, as it is a kind of tool that requires individuals to think about their perceptions and experiences of stress. (Crosswell & Lockwood, 2020) An example of the most popular self- report measures is the Perceived Stress Scale (PSS) which addresses the way a person sees certain situations in his/her life as stressful. The PSS requires the respondents to revert back to their thinking and feelings over the last month and rate their experience of stress on a scale of low to high. (Gamonal-Limcaoco et al., 2022) Although the PSS and other self-report tests are very useful for gaining an understanding of self-perception and coping with stress by individuals, they have their limitations. (Zimmer-Gembeck et al., 2018) Self-reporting too is subjective and highly susceptible to biases, including social desirability bias (where the participant is pressured to report stress that corresponds to the expectations of society), or recall bias (where the participant is unable to properly recall or report on past stress experiences). In addition, some people can either underestimate or overestimate the amount of stress depending on their emotions or the current situation they are facing.

Due to these constraints, researchers have, of late, increasingly resorted to wearable devices as a substitution technique for measuring stress. Portable technologies have emerged as a method of measuring real-time physiological reactions to stress, i.e., electroencephalography (EEG) headbands. (Affanni et al., 2022) EEG is used in measuring the electrical activity of the brain and that gives objective records that represent the response of the brain to stress. In contrast to self- report outcomes, which involve subjective measuring variables, EEG has the direct measure of brain activity that is related to stress given that it measures changes in basic brainwave patterns. (Katmah et al., 2021) Research studies have revealed that EEG devices can identify mental stress very precisely and correctly and are therefore a more accurate and objective way of measuring it since it is not always that people can self-report accurately.

A continual measure of stress in real-time data is one of the giant benefits of wearable EEG devices as they offer data under natural conditions. (Lazarou & Exarchos, 2024) This leads to continuous tracking which is a major improvement as compared to the static self-report measures which are dependent on what the individual recalls about his or her past stress experiences. Stress responses might be measured by the use of wearable EEG due to continuous measurement across the day, including brain activity alterations that are difficult to self-report. The continuous behavioral monitoring of the stress levels of the participants makes it possible to observe the stress when it changes according to the daily activities, including academic, social, or physical activity. Consequently, wearable technologies give more real-time and ecologically valid data with the ability to better represent the experience of stress in a real-life situation.

Moreover, such use of wearable devices and machine learning has led to the creation of stressed classification models. The above models can be used to anticipate stress levels using physiological data taken by the wearable gadgets. As an example, EEG data can be analyzed with the help of machine learning algorithms and various groups of people can be treated as possible categories of stress levels, including low, moderate, and high. These models have depicted good predictive themselves in the prediction of high degrees of stress especially in at-risk individuals of substance use disorders. Physiological markers to predict stress will help the researchers study better the relationships between the levels of stress and substance use at the biological level to offer information on intervention techniques.

Further to stress measurement, wearable EEG devices have been examined with reference to substance use too. Studies have indicated that the activity in the brain of drug users is peculiar to them as compared to other individuals, especially in parts that relate to control of stress and reward. (Volkow et al., 2019) Brainwave patterns of people who are using drugs can present an activity increase in the portion of the brain that contains the dopamine system that contributes to the reward-seeking behavior of the brain. Monitoring of these patterns using EEG provides a new method of describing the interaction of stress and substance use at the physiological level. The examination of those patterns will allow researchers to draw important conclusions about the neural processes that influence addiction and stress response.

Moreover, wearable EEG can bring considerable value in intervention and prevention practice regarding substance use conditions. (Arsalan et al., 2019) These devices can be used to guide the identification of risky people through one aspect as they were able to get objective and real-time readings on the level of stress. As an example, when the wearable device can detect limiting tolerance to stress, it may initiate an intervention, e.g., a mindfulness exercise or a check-up on achieving social support. This initiative to manage stress allows treating this vice that may be used to revive the problem of addiction, in a different perspective of stress prevention.

Other recent research has also focused on the application of EEG-based devices in clinical practice especially those people going through rehabilitation programs to abuse substances. (Bel-Bahar et al., 2022) These studies indicate that wearable EEG would be utilized in the assessment of the effectiveness of treatment intervention as the change in levels of stress can be observed over the course of time. To give an example, as they advance into the rehabilitation process, the alterations of the brainwave pattern might show positive results in the capacity of the people to resist stress without using substances. Such immediate feedback would potentially allow clinicians to better design their treatment plans, especially for each individual, thereby making the rehabilitation program much more effective.

To sum up, wearable devices and especially EEG technology when applied to stress studies provide a great benefit in comparison to traditional self-reporting measures. EEG devices worn on the body furnish objective, real-time information about brain activity that researchers and clinicians can use to observe stress in less controlled and less artificial conditions. (Mishra et al., 2023) These devices not only help us improve our knowledge about the relationship between stress and substance use on a physiological level but also introduce possibilities for intervention and prevention. With the further development of wearable technology, its potential regarding the study and treatment of stress, especially involving substances, is bound to increase as well, creating a new way of ensuring sound mental health and avoiding the problem of addiction.

Research Question

The central research question underlying this research work is:

What is the prediction value of self-report measures and wearable devices to estimate the levels of stress in young adults and what relation is there between stress and the use of drugs?

The question here is to know the relative effectiveness of self-report instruments, such as Perceived Stress Scale (PSS), and wearable interfaces, such as EEG headbands, to define stress levels. The study is also meant to explore an association between these stress levels and the inclination of the young adults to engage in substance use. This study will help to understand whether stress and the related conditions play a role in substance use disorders since by studying how stress affects drug users and non-users, the research will help to gain additional knowledge regarding the condition.

Secondary questions include:

- *Is there a greater amount of reduced perceived stress among drug users compared with non-users?*
- *What is the relationship between physiological measures of stress, which are obtained by means of EEG, and self-reports of stress?*
- *Are wearable devices able to make stress prediction models more accurate in young adults?*

- These questions are fundamental in deriving the prospect of wearable devices in stress assessment and its contribution in developing personalized intervention of young adults at the risk of substance abuse.

Research Objectives

1. To compare the level of stress among young adults, mainly drug users and non-users, using self-reports and wearable sensors:

The aim of this objective is to compare and evaluate stress between young adults who use drugs and those who do not. It will combine subjective (self-reports) and objective (wearable sensors) in its approach, in order to comprehend how stress varies across these populations. It aims at determining whether there is a pronounced or divergent share of stress among drug users.

2. **To see the degree of congruence between physiological measures of stress and psychological self-report:**

This aims at examining the extent to which the biological measures of stress (such as heart rate variability or skin conductivity given by the sensors) are correlated with the reported stress levels of these people measured by questionnaires. It allows identifying the accuracy of the people in perceiving their stress and whether it is accompanied by a mismatch between their perceptions and their bodily expressions.

Theoretical Framework

Biopsychosocial Model of Stress

This model outlines the generation of stress due to the interrelation of biological, psychological, and social factors. Chronic stress impacts neural circuits that perform decision-making and reward, exposing them to a greater risk of drug use and addiction.

Social Learning Theory

This theory holds that humans acquire behaviors, such as drug use, by modeling what they see done by others around them in society, including peers, family, and the media, which makes a strong force in influencing substance use among young people.

Transactional Model of Stress and Coping

This model focuses on the fact that stress depends on the way that an individual evaluates a situation as well as his/her coping resources. Coping responses are adaptive maladaptive (such as substance use) and maladaptive.

Ecological Systems Theory

This theory looks into the dynamics of several layers of the environment through which an individual is affected by stress and in the process of behaving. It assists in the identification of the role played by the social and institutional factors in drug use among young adults.

The biopsychosocial Model relates most to this study because it combines the social, psychological, and biological components of stress. It fits well with the two-pronged strategy of employing wearable sensors and self-reports in evaluating stress and directly connecting these variables to the patterns of substance use.

Rationale of the Study

The study purports to further understand the relationship between stress and drug use among young adults, and more specifically, men when levels of stress are compared between both drug users and non-drug users. Men are specifically targeted in this research due to their unique stress responses, higher rates of substance abuse, and lower likelihood of seeking help for mental health issues. Identifying accurate, gender-specific stress patterns can inform more personalized interventions. It presents the shortcomings of self-reporting and facilitates the application of wearable sensors to achieve a more precise evaluation. The study also takes into account the social, environmental and neurobiological factors that affect substance use. In the end, what is desired is improved and gender-sensitive interventions as well as stress assessment tools that may help identify at-risk youth early and treat them accordingly.

Research Methodology

The research applied a descriptive experimental paradigm, particularly through relying on the comparison of the two options of self-report measures and wearable EEG gadgets to gauge the effectiveness in forecasting the stress levels among young adults. The design entails two different groups, that is, drug users and non-users. The members were included in rehabilitation centers and five universities in Rawalpindi and Islamabad. The study will focus on finding out the correlation between drug use and stress and also measuring the effectiveness of EEG devices in the precise measurement of stress responses.

The study sample will represent 70 participants between the ages of 18 and 25 divided into two groups 33 healthy participants (non-users) and 37 participants who are rehabilitating against substance abuse. It is this age group that has been selected because this age forms a critical period of development in which people are more likely to experience stress and pressure and thus have a higher likelihood of becoming exposed to substance use. Such participants had been recruited purposively meaning that individuals were subjected to certain inclusion criteria. The inclusion criteria for the participants are as follows:

- **Age between 18 and 25 years**: This population group plays a specific role since it includes the time of young adulthood when the level of stress is usually high, as it is determined by academic and social burdens and career issues.
- **Ability to provide informed consent**: Every participant should be able to comprehend what the study entails and should be willing to volunteer in the study.
- **No history of neurological or cognitive disorders**: This is to remove confounding factors in the data that may influence brain activity and stress response but not drug use.

The study data was obtained with the help of two major measurement tools: self-reports and wearable EEG devices.

HypothesisHypothesis 1

There is a significant difference in self-reported stress levels between young adult drug users undergoing rehabilitation and non-users, with non-users reporting higher levels of perceived stress.

Hypothesis 2:

There is a significant relationship between physiological stress markers, as measured by EEG, and self-reported stress scores in both drug users and non-users.

Hypothesis 3:

EEG-based physiological stress measurements can effectively differentiate between drug users and non-users, achieving high classification accuracy in identifying stress profiles.

Operational Definitions

Stress:

The physiological and psychological reaction to any external or internal stress that upsets the state of an individual.

Substance Use:

The use of drugs or alcohol, whether recreationally or habitual, which potentially impact the mental and physical health.

Instruments:

PSS (Perceived Stress Scale):

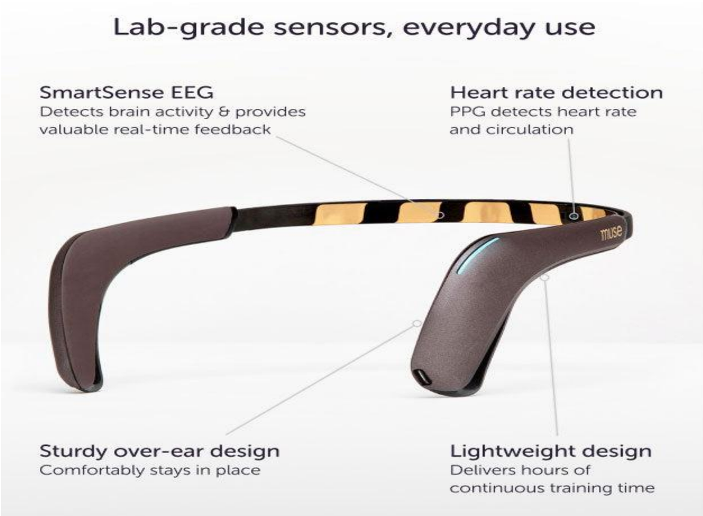
It is a self-report questionnaire that determines the level of stress perceived in life cases. Urdu translated version of the Perceived Stress Scale has been used in the study and the Cronbach's alpha reliability of the translated version is the same as that of the English version. i.e., (.78) (Aneeqa et al., 2011).

DASS-20 (Drug Abuse Screening Test)

The Drug Abuse Screening Test (DAST-20) is a short self-report instrument that has been created by researchers in the domains of population testing, clinical case finding, and treatment evaluation. Urdu translated version of the Drug Abuse Screening Test (DAS-20) has been used in the study and Cronbach's alpha reliability of the translated version is the same as that of English version.
i.e. (0.8) (Skinner et al., 1992).

Muse EEG Headband

It is a wearable device that monitors brainwave activity in real time based on EEG technology and stress management and relaxation.



Demographics

Items on the demographic information include age, education, employment, marital status, accommodation, income, cigarette use, and smoking usage. Other relevant information was also included in the demographic sheet.

Data Collection

1. **Self-report Measures**

In order to evaluate how the participants perceive stress, the Perceived Stress Scale (PSS) was adopted. One of the most common measures is the PSS, which serves as an instrument that allows assessing the levels of perception of unpredictable, uncontrollable, and overwhelmed lives of the people. They also responded to the PSS, which consisted of a sequence of questions on what they felt and thought about stress during the past month. The information included in this self-report instrument was very useful in examining how the participants evaluated their stress levels, which could be compared to the physiological information gathered using wearable device statistics.

Table 1: ***Demographic Table of Individuals with no reported substance use***

This table shows the demographic details for the non-user group from your study.

Demographic Factor	Non-Users (Control Group)
Number of Participants	33
Age Range	18-25
Gender (Male)	18 (54%)

Gender (Female)	15 (46%)
Education Level	Adult with no reported substance abuse
Substance Use History	No reported use of substance

Table 2: ***Demographic Table of Drug Addicts***

This table presents the demographic details for the drug addict group in your study.

Demographic Factor	Drug Users (Rehabilitation Group)
Number of Participants	37
Age Range	18-25
Gender (Male)	20 (54%)
Gender (Female)	17 (46%)

2. Wearable EEG Devices

Muse headband is a wearable, mobile EEG gadget, which was used to collect EEG data according to different tasks, as well as rest intervals. (Godde, 2023) The physiological stress markers were identified with this device, recording the actual brainwave activity in real-time. EEG machines can also measure electrical activities occurring in the brain that change according to the stress levels of the subject. The benefit of using the EEG devices is that they would show precise objective real-time measures of stress level, which could then be compared to the subjective report of stress levels that the person could relate.

Procedure

- Data collection process was conducted in a number of steps in a manner that the self-report measure and physiological measure of stress are coordinated. All the participants of the study were provided with a demographic questionnaire that will allow us to gather demographic information about the background of the person, which includes age, gender, and substance use history. They will additionally be provided with a knowledgeable agreement document, and they are fully aware of what the research is all about and tests and procedures to be administered, and the fact that they are allowed to get out of the research at any time.
- **Stress Measurement**

Out of 50 young adults, 12 were excluded after the initial stage of recruiting by using the screening questions. 38 adults were recruited from various places in Rawalpindi and Islamabad. They had to sign an informed consent declaration. A verbal explanation of the study's goals and assurances that the EEG headset would not expose people to radiation. It was assured to them that the headset wouldn't transmit any data to their brain, just record its electrical activity. 3 people refused to be part of the study, giving the reason that they did not want to wear an EEG headset. After the demographic questionnaire was completed in quiet for a short while, they were requested to stay motionless for 10 minutes so the EEG recorder could work in a focused situation. Following a short 5-minute interval, the participants were then given the Perceived Stress Scale. They were then instructed to wear a headset for 10 minutes again. Eight people were watched for almost four hours using an EEG in just one day. To sum up, one person's recording and data collection took thirty minutes.

- For drug addicts, the same procedure was followed. At first, 40 drug addicts were approached, out of which 37 were selected for the study. They were told about the aim of the research and were first briefed about the EEG headset and how it is attached to the brain. They were asked to fill in the demographic information sheet and DAS-20. After this, their EEG recording for 10 minutes with eyes closed started. After 5 minutes of relaxation, they were given PSS and then, after filling the scale, again, EEG recording for 10 minutes was recorded.

- Wearable devices with long-term use are critical to the measurement of the natural changes in stress levels during various activities throughout the day. (Hickey et al., 2021) By asking participants to perform their normal activities with the device, the study was in a position to get data that is more ecologically valid on the aspect of stress levels.

Data Analysis

Statistical Package for the Social Sciences (SPSS) was used to analyze the data and determine the reliability and validity of the self-reported stress levels to the physiological information observed in the wearable devices that measure the EEG. The grouping was carried out based on the level of stress and was summarized using descriptive statistics involving both groups of people (drug users and non-users).

Also, the machine learning approaches were used to check the data of the EEG. The development of predictive models classifying stress was carried out and had been in the form of machine learning algorithms, which may include Support Vector Machines (SVM) or Random Forest. (Mohamed et al., 2023) These models were then trained using the EEG data to predict the participants into the different levels of stress, e.g., low, moderate, or high stress level. This is intended to determine how far an EEG machine could predict the level of stress from the outcome of the measured self.

The ***t-test for independent samples was*** used to compare the stress levels of addicts with those of individuals with no reported substance abuse. Through this examination, several similarities and differences within the groups were brought to light.

These predictive models were evaluated on their accuracy using conventional measures that include accuracy, precision, recall, and F1-score. These measures will aid in identifying the efficacy of the wearable EEG devices in delivering a measure of stress which is reliable and valid.

Ethical Considerations

Proper ethical considerations were observed in undertaking the study so that the rights and well- being of the participants are safeguarded. Participants will all have to sign informed consent prior to the participation in the study; this consent must certify that they are aware of the aim of the study, are conversant with the study procedures, or the risks involved in the study. During the study the maintenance of confidentiality was ensured and the data analysis will anonymize personal information. Individuals were allowed to withdraw as they pleased and with no repercussion.

Informed Consent

The researcher ensured that participants were sufficiently informed about the use of the electroencephalogram headsets in the study by strictly adhering to informed consent guidelines. All participants were informed in detail about the study, its aims, the use of the EEG headset, potential risks and benefits, confidentiality rules, and the chance to discontinue participation at any time without penalty. They had plenty of opportunities to ask questions, and the instructions, particularly those for connecting the electrodes, appeared very clear. The participants were not obligated to stay in the research if they felt uncomfortable; they were given the option of withdrawing if they so wanted.

Confidentiality and Anonymity

Concerning the subjects of the study, all the data, including their EEG records, remained strictly private. Due to concerns about participant identity disclosure, researchers analyzed the EEG data and made the data accessible to other researchers only with authorization.

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Minimization of Harm

The EEG headset was intended to be as comfortable and as easy to wear as possible to avoid any discomfort to the patient. To alleviate participants' concerns, we explained the procedure of attaching the electrodes in detail. To ensure that the EEG headset was functioning properly and that no technical hitches that would have derailed the experiment were present, the headgear was checked before each session.

Voluntary Participation and Right to Withdraw

Consent was also sought from the participants to leave the study at any time as it was entirely voluntary. They were told that their choice to participate or withdraw would not affect them in any way, including their grades, jobs, or any other aspect. The procedures for withdrawing from the experiment were well explained, together with directions on how to remove the EEG headset.

Transparency and Honesty

The researcher followed the principles of credibility during the study, offering the participants relevant and exhaustive information concerning the EEG headset, its function, and application in the course of the research. The participants were informed about the experimental design of the study, how the headset was linked to a mobile application for data recording. Any technical issues or constraints related to the EEG headset were explained to the participants to avoid any bias and to make sure that the participants are aware of what to expect.

Result Findings

The initial study findings propose that there is a large change between drug users and non-users in regard to stress level on the measure of self-report and physiological markers. The perceived stress levels were higher among non-users, and the measure of subjective stress was assessed with the help of Perceived Stress Scale (PSS). (Belal et al., 2025) This finding is consistent with those made in previous studies, which showed that stress plays a pivotal role in triggering and establishing the progression of substance use. When these young adults are more stressed, they may resort to using substance as a means of coping which subsequently results in substance abuse pattern.

Table : ***Mean, Standard Deviation, and Cronbach's Alpha of PSS-10 & DAS-20) (N=70)***

Scale	Items	M	SD	Range	Skewness	Kurtosis	α
PSS- 10 DAS-20	10	21.80	6.69	28.49	0.48	0.08	.70
	20	29.00	3.96	18.00	0.28	0.04	.78

Table depicts the descriptive statistics and internal consistency for the Perceived Stress Scale (PSS), which assesses perceived stress levels among participants. The mean score on the PSS is 21.80 , reflecting a moderate level of perceived stress in the sample. To check the normal distribution of data skewness and kurtosis were analyzed. The skewness value for the perceived stress scale was 0.48 and the kurtosis was 0.08, which indicated that data is significantly normally distributed. The range of scores is 16.00, representing variability in stress levels among individuals. The *Cronbach's alpha* for the PSS is .70, which depicts a moderate level of internal consistency. The mean score on the DAS-20 is 29.00 , indicating a relatively high level of drug abuse symptoms in the sample. To check the normality of the data, skewness, and kurtosis values were analyzed. Skewness and kurtosis values for the Drug Abuse Screening Test (DAS-20) were 0.28 and 0.04, respectively, showing that data is significantly normally distributed.

The range of scores is 11.00, reflecting the variability in drug abuse symptoms among individuals. The *Cronbach's alpha* for the DAS-20 is .78, which suggests a moderate level of internal consistency.

Comparing the level of stress Among Young Adults, Mainly Drug Users and Non-Users Using Self- report and Wearable Sensors.

Table 4.4

Independent samples t-test Results for Perceived Stress Levels between healthy control group/ Adults with no reported substance abuse and Drug Addicts (N = 70).

	n	M	SD	t	P	df	Cohen's d
Adults with no reported substance use	33	21.03	4.94	1.464	0.014	681	0.45
Drug Addicts	7	18.07	7.84	1.501	0.013	614	0.41

Note: SD=standard deviation, p < 0.05, Cohen's d= effect size

The researcher observed that the levels of stress in young adults who did not abuse substance were higher (M = 21.03) compared with drug addicts (M = 18.07), and the comparison was also considered significant (t = 1.464, p = 0.014). Even though the effect size was smaller (Cohen d = 0.45), the findings claim the hypothesis that stress levels are different in the groups.

EEG DATA RESULTS

EEG measures that have been collected and observed on both the healthy controls and the drug addicts are categorized as two groups depending on the perceived stress scale (PSS) questionnaire. A mean of the PSS scores of the under study in both the groups is calculated. In the healthy controls, the mean value of 21 was achieved whereas in the drug addicts, the mean score was 18. In the case of both of the groups, the people with scores lower than the mean score were assigned with the stressed value of being non-stressed, and the people with scores above the mean value were assigned the stress value of being the stressed participants. According to the mechanism of labeling, in case with healthy participants, 17 became labeled as stressed, and 16 participants became labeled as non-stressed. Figure 1 indicates how the subjects were divided into stressed and non-stressed classes under healthy individuals. Further, the labeling of the drug addicts was as follows, 17 participants as non-stressed and 20 participants as stressed. Figure 2 indicates how the subject was divided into the stressed and non-stressed groups among the drug addicts.

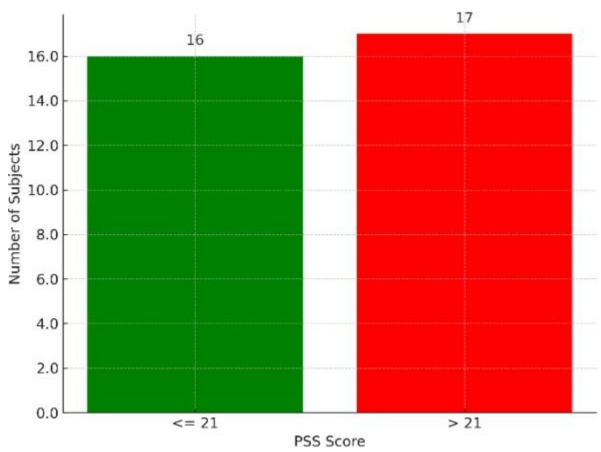

Figure 1: Distribution of subjects into stressed and non-stressed classes for healthy individuals.

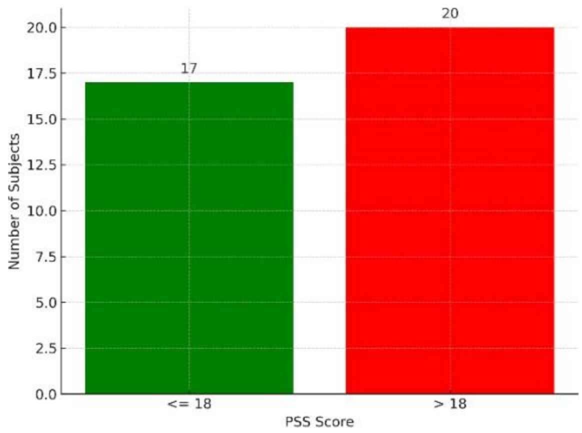

Figure 2: Distribution of subjects into stressed and non-stressed classes for the drug addicts'

Regarding physiological stress index, the stress categorization using the EEG indicated higher correctness of classification among the drug users where the classification correctness was 89.1%, whereas the classification correctness of non-drug users was 84.8. This fact suggests the particular efficacy of using wearable EEG devices to identify stress response among the drug users, possibly because of the specialized physiological markers of stress that this latter phenomenon might reveal. The given findings demonstrate the effectiveness of wearable EEG gadgets in detecting particular stress patterns that are more vivid in drug users.

Moreover, Figure 3 presents confusion matrix achieved in the proposed method. We may note that based on the confusion matrix, 14 out of 16 instances are correctly classified in the stressed and 14 out of 17 are correctly classified in the non-stressed. Such a percentage of the accuracy of prediction characterizes the efficiency of the suggested EEG perceived stress classification technique. Further, the decision boundary identified in Figure 4 after performing the principal component analysis in order to reduce the dimension in the stressed and non-stressed people in the healthy control individuals is indicated in the figure. As noted in the graph, a rather high degree of accuracy can be achieved when assigning the two classes (stressed and non-stressed) and therefore the proposed stress classification scheme is seen to be effective.

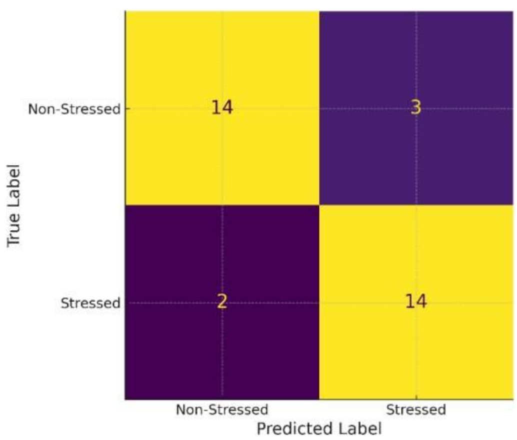

Figure 3: Confusion matrix for the MLP classifier obtained for the perceived stress classification of healthy control group.

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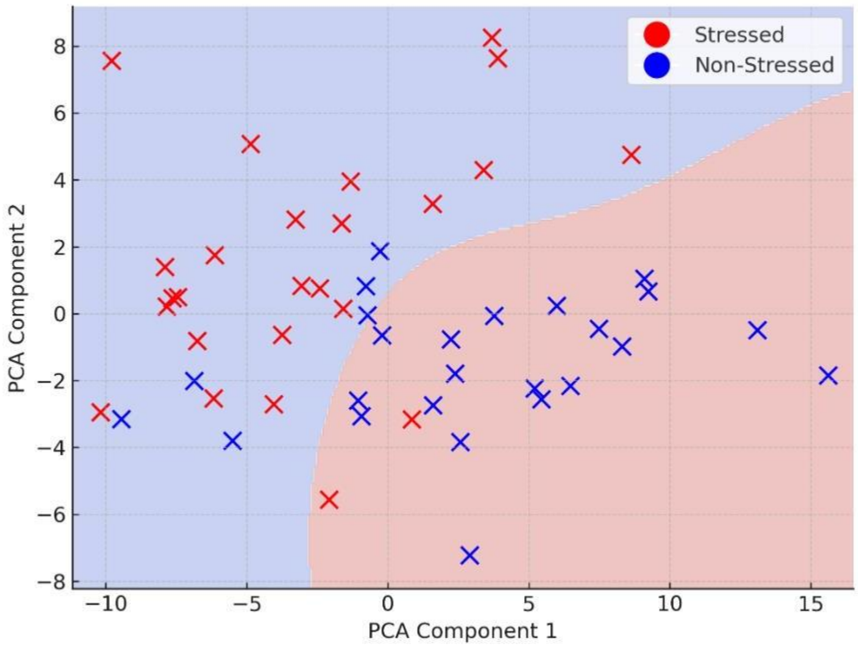

Figure 4: Decision boundary obtained after applying principal component analysis with the MLP classifier for the healthy control group.

Besides, Figure 5 demonstrates the confusion matrix that was obtained in regards to the proposed approach. As can be noted in the confusion matrix, in the case of the stressed class, 85 percent (18/20) were correctly classified, and on the case of the non-stressed class, 88 percent correct (15/17) were correctly classified. In the case of the drug addict's sample, Figure 6 shows the decision boundary attained following an implementation of the PCA using the MLP classifier that illustrates the performance of the proposed EEG based perceived stress classification scheme.

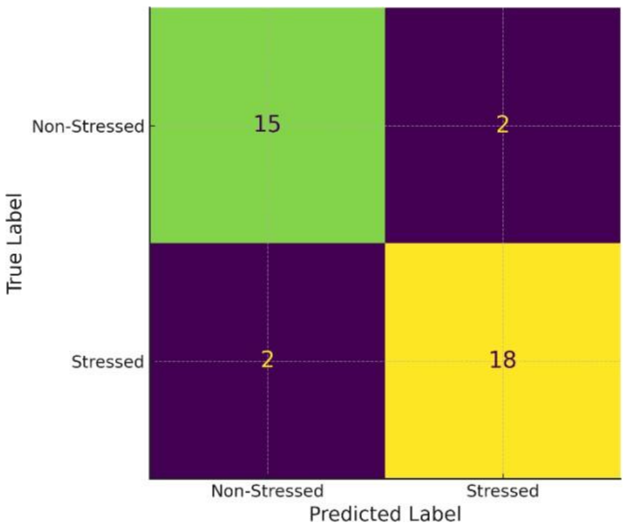

Figure 5: Confusion matrix for the MLP classifier obtained for the perceived stress classification of drug addicts' group.

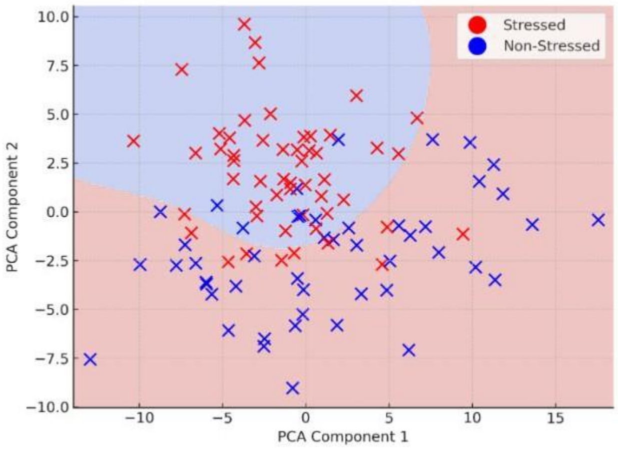

Figure 6 : No table of figures entries found.Decision boundary obtained after applying principal component analysis with the MLP classifier for the drug addicts' group.

These results confirm that wearable EEG technology has a high potential not only as a stress monitoring tool to be employed in real-time but also its ability to be used in addiction prevention efforts, where knowledge of and control over stress would help minimize the danger of substance abuse among young adults.

Discussion

The analysis of this paper offers invaluable information concerning the complicated correlation between stress and substance taking especially among the younger generation. The fact that drug users are more stressed compared to non-users is what creates the need to validate the role of stress as a major contributor to the development and persistence of the developing substance abuse. Precisely, the perceived stress level of drug users was low in this research paper as opposed to non-users. At first, it might seem counterintuitive, but this indicates that chronic stress can be coped with by the use of drugs. Substance abusers might have resulted in maladaptive ways of coping as using drugs is a kind of escape from the stressors experienced by the person. In this regard, drugs serve as a temporary source of relief in stress cases and as the cycle of drug use perpetuates itself, people would be likely to rely on these drugs to cope with their stress and this may increase of addicts and the level of stress that they experience.

On the contrary, the level of perceived stress was reported to be higher among non-users. This may be explained by the fact that non-users, not depending on substances as a coping strategy, might have problems with stress coping which might lack effective coping strategies or support. These people might have greater emotional and psychological distress in the absence of substances to help them calm their stress. High stress levels in non-users may indicate the difficulty of young adults in adapting to life stressors in the absence of maladaptive coping behaviors and a need for alternative, healthy coping practices.

It was also found that wearable EEG devices could demonstrate a lot of higher accuracy in distinguishing stress in drug users, 89.1 % against 84.8 % among non-users. This means that the wearable EEG technology is especially useful in detecting stress-related factors specific to drug users. EEG functions by recording brainwaves and patterns correlated to stress, including greater activation of parts of the brain dealing with emotional processes and of the hypothalamic-pituitary- adrenal (HPA) axis that mediates the stress reaction in the body. This improved accuracy of EEG in drug users implies that data acquired by the EEG devices may present a more representative (and objective) measure of stress in contrast with the data that are self-reported and, therefore, might be subjected to all kinds of cognitive biases including the recall bias and social desirability. Here, wearable EEG technologies provide an effective opportunity for stress evaluation in real- time and can greatly enhance stress management and intervention programs, especially among substance abuse-prone individuals. More so, a combination of Self-report measures, including the Perceived Stress Scale (PSS) and wearable devices offer an in-depth methodology of stress assessment. Self-reports provide useful information concerning the perceived stress on the side of the individual, which is the actual emotional and mental perception of stress. Nevertheless, self-report instruments possess their weakness which include the possibility of bias or reporting inaccuracy. Conversely, wearable/mobile systems, such as EEG, offer objective and real-time records of physiological stress reactions with the possibility of a more subtle and precise characterization of stress. The conglomeration of subjective information on self-report with objective physiological information recorded by the EEG devices provides a more detailed description of stress and its effects on the persons considering the substance abuse as well.

In addition to this, continuous and real-time monitoring of stress can be conducted by using wearable EEG devices. This characteristic is of special merit to the extent that it enables researchers and clinicians to measure stress which varies over time on any day of the day and involves stress responses during different activities, such as during studying, social engagements, or exercising. This regular surveillance gives stress to a dynamic character and actions and events that could not be captured by static self-reports. (Fischer et al., 2019) It also creates new opportunities for customized interventions. In other words, stress could be measured in real-time and clinicians might present instant interventions, in the form of mindfulness practices, cognitive- behavioral techniques, or other coping measures, as soon as the stress levels surpass a particular mark. Such a method might be specifically helpful to those people who are prone to the development of substance abuse, as the timely and individual action may help to eliminate the increased stress to be transformed into substance abuse.

Another conclusion made in the research is the role that wearable EEG devices could have in addiction prevention. Since stress plays a significant role in substance use, the exact physiological way through which stress is expressed in terms of EEG might soothe us with early indicators of the occurrence of stress-related behaviors that contribute to substance abuse. Wearable EEG devices could be applied in the real-time monitoring of stress levels, enabling the resort of intervention strategies before the stress levels turn overwhelming, and therefore, persons will not have to seek solace in substances. Such prevention strategies may prove to be of great help, especially among young adults who are quite susceptible to substance use disorders as they may develop when the levels of stress are high.

Moreover, the results of the present research indicated the necessity of further studies that would determine neurobiological processes regarding the links between stress and drug use. Although this research gave a better understanding of the physiology of stress, a lot of insight is yet to be comprehended into the brain systems and circuits during stress and substance use. Investigations regarding the influence of stress on the reward system in the brain specifically in regions such as the nucleus acumens and pre-frontal cortex may bring an essential clue to the complexity of stress and substance abuse. The neurobiological research into the driver behind stress and drug use could also contribute towards creating more focused interventions that can help eliminate the reason behind substance use disorders. As an illustration, in case a certain part of the brain or neural circuitry is identified to be associated with stress-related use of drugs, treatment may involve the localization of such areas through

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neuro-stimulation or by a pharmacological process.
On the whole, it is possible to note that this paper supports the use of wearable EEG devices as a valuable tool that may enhance our level of knowledge about stress and its connection to substance use. EEG devices provide constant and real-time information on the reactions to stress, which will enable them to faceless subjective measurement compared to self-report of stress. Integration of subjective and physiologic data offers a bright prospect to the area of stress measurement, as the knowledge may be used to create individualized treatments, which are more likely to meet the needs of culture-specific populations who are at risk of substance misuse. In addition, the study indicates the importance of further research work on the neurobiological basis of stress and substance use that would reveal new methods of treatment and prevention.

Conclusion

In summary, the research study is informative with regards to the value of stress in substance use among young adults and it is possible to gauge how potential wearable EEG objects can enhance stress assessment. Self-report measures are more complete together with wearable EEG technology as they provide a better and more accurate representation of the level of stress, especially in those people who have a history of substance use. (Carreiro et al., 2020) The results indicate that wearable EEG technology has the potential to enhance stress-predicting model signatures by a huge margin due to real-time retrieval of physiological parameters that are used to enhance predictability values in stress measures. That is why wearable EEG devices can be used not only to manage stress but also to prevent addiction and treat mental health.

Even though self-reports, including the use of the Perceived Stress Scale (PSS), are crucial in capturing the personal feeling of stress, a limitation exists in that it is biased by social desirability bias and recall bias. (Booth et al., 2022) The self-reports depend on how individuals report the stress they feel hence objections such as cognitive distortions, mood, and social pressures may affect their reporting. On the other hand, wearable EEGs give continuous and objective measures of physiological responses that better reflect the true stress levels of the person. Through the combination of subjective self-reports and objective physiological parameters with wearable EEG machines, the study avoids the limitations of self-reporting in that the measurement of stress uses a combination of both self and physiological reports, leading to an accurate recording of stress levels.

The findings of the present study also stress the significance of individualized interventions among young adults who are risky substance users. Since stress is one of the major causes of substance use, special interventions are important to create an intervention that is sensitive to individual patterns of stress. Wearable EEG products can enable the clinician to measure the stress in real time, giving the option of personalizing the intervention depending on the way that the patient is responding to stress. To give an example, when a young adult person experiences elevated levels of stress, it is possible to apply some interventions shortly through mindfulness, relaxation techniques, or another coping skill to avoid the further development of this issue into the use of substances. This individualized intervention may result in a better course of treatment, given that it targets the cause of stressors that cause substance abuse.

Moreover, the results indicate how wearable EEG models may become part of a larger-scale intervention to address the problem of stress and monitor it. The application of wearable devices through continuous monitoring of stress levels among young adults provides an early prediction to identify people at risk of developing substance abuse so that early treatment can be administered before stress results in harmful behavior of the person. These tools may be used as the intervention mechanism as a prevention measure, particularly, when working with populations at risk of getting stress-related conditions, including students subjected to academic strain and conditions, people with issues in their families, mental problems, etc. The ongoing data represented by these items can assist in revealing the tendencies and risk factors of substance abuse to be recognized by the authorities in charge of the health of the nation and the clinicians to allow more accurate prevention measures to be developed.

There is a lot of potential in using wearable technology to reduce mental health care despite being integrated into stress management plans. With the growing availability and affordability of wearable devices, the ability of such devices to completely transform stress monitoring and management grows as well. They do not only provide real-time information but also give an idea of longer-term patterns of stress, which can be used to predict future mental health crises and suggested temporal slips. Given that they can track stress any time, day or night, wearable devices may facilitate a more active approach to mental health care by eliminating the need to visit a healthcare professional to receive care episodically and instead facilitate ongoing data-driven care.

Proceeding further, future studies are to be devoted to the improvement of stress prediction models based on wearable EEG devices, including more diverse sample populations. Although the study was promising, it had several limitations connected with the rather small size of the sample and the demographic peculiarities. The inclusion of a diverse sample that would comprise people with different cultural, social economic, and geographical backgrounds would give a generalized piece of information on referring to stress and the patterns of substance use. Also, it is hoped that future research studies can find out the effects of the long-term use of wearable EEG technology in reducing stress and whether it can help lower the relapse rates of drug users. The knowledge of the long-term effects of wearable devices on stress levels would assist in narrowing down how to apply wearable devices in substance use disorder therapies.

Lastly, studies would also be needed to look at how wearable EEG options can be combined with other mental health-enhancing interventions, e.g., therapy or counseling, to generate a more comprehensive intervention system. The multidimensional approach to the regulation of stress and substance use may be achieved by combining the EEG data and psychological interventions. This would not only increase the precision with which stress is measured but also permit interventions that would be more specific to individual requirements, which may improve the outcome of the condition of substance use.

To sum up, wearable EEG systems have significant potential in the area of stress measurement and intervention processing, primarily in the case of high-risk young adults vulnerable to the dangers of substance abuse. In a more correct, real-time, and individualized manner of tracking stress, wearable EEG technology has the potential to be critical in ruling out the occurrence of substance use and making people handle stress more favorably. With the gradual development of technology, the use of wearables may win its way in managing mental health, transforming the future practice of stress and substance use prevention, and eventually providing effective and sustainable changes to the issues of mental health in young adults.

Implications of the Study

The main purpose of the study was to compare the level of stress among young adults, mainly drug users and non-users, using self-reports and wearable sensors and to see the 86 degree of congruence between physiological measures of stress and psychological self reports. Generally, researchers have focused on young adults with drug-addicted behaviors and measured their stress levels only by using psychological self-report. i.e. (PSS-10), but this focuses purely on measuring and predicting the stress levels by using psychological and physiological measures. i.e. (by using PSS-10 & EEG headband). Thus, the ability to predict stress levels by using both these measures can give rise to new interventions that can be given on time, especially to susceptible populations like young adults with drug addiction, as well as those having high academic pressures and societal demands. The inclusion of EEG data in the study gives a chance to develop an understanding of the physiological aspect of stress. Future research could extend this by examining the specific patterns of brain waves linked to the various stressors and recovery modalities. **Limitations of the Study**

- The study utilizes a cross-sectional design, which means it gives an insight into the levels of stress at a particular time. This further does not provide the stress levels transformation over time, specifically in drug users' treatment process. Longitudinal studies can help to have an insight into the levels of stress over a longer period.
- Additionally, the duration of the EEG recording sessions may have led to participant fatigue or fluctuations in attention, potentially influencing the data quality. A structured break involving light reading or rest between sessions could have mitigated this effect.
- Moreover, the study did not account for variables such as sleep quality, caffeine intake, or stress levels, which can influence EEG signals. The study emphasizes particularly on young adults, particularly those in universities or rehabilitation centers. Due to this, the results might not be suitable for other populations, such as individuals in organizational settings or other socio economic groups. Future research could examine other socioeconomic groups with different ages and other organizational centers to broaden the scope of the results.
- The use of EEG as a physiological measure of stress also presents limitations. EEG data can be affected by external noise, artifacts from movement, (EMG artifacts) or ocular artifacts (blinking of an eye) can also affect EEG. Thus also incorrect electrode placement, can reduce data accuracy. Moreover, interpreting EEG signals to stress can be complex, as multiple psychological and environmental factors influence brainwave patterns. Therefore, drawing clear conclusions from EEG readings alone requires cautious interpretation and should ideally be combined with other physiological and psychological measures.

EEG signal is non-stationary, So that is why the classification of machine learning models is difficult and it is challenging to handle and train the model.

Recommendations

To improve participant engagement and reduce potential fatigue or mental saturation during EEG recordig sessions, it is recommended that a short cognitive break be introduced. For example, providing participants with a newspaper or light reading material during 5–7-minute intervals between EEG recordings could help maintain alertness and mental balance. This approach may also minimize data variability caused by attention drift or fatigue, potentially enhancing the reliability of the EEG data.

Additionally, controlling for external factors that can influence EEG activity— such as recent sleep quality, caffeine consumption, or emotional stress—would strengthen the internal validity of future studies. Incorporating self-report questionnaires or screening tools before sessions could assist in managing these variables.

Finally, longitudinal or experimental designs should be employed to better understand causal relationships between cognitive or neurological variables and EEG patterns. Including follow-up sessions could also help observe changes over time and improve the interpretability of results.

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