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INVESTIGATING NEUROPSYCHOLOGICAL BIOMARKERS ASSOCIATED WITH ANXIETY, DEPRESSION, AND COGNITIVE DECLINE

Kalsoom Bibi[*1], Naila Islam[2], Iqra Walayat[3], Maha Safder[4]

*[*1]Department of Biological Sciences, Attaurehman School of Applied, NUST University*
[2]Lecturer, Faculty of Humanities and Social Sciences FSSH, Hamdard University Islamabad
[3] Lecturer, Institute of Biological Sciences, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan
[4]Doctorate of Physical Therapy, Abasyn University Islamabad, Islamabad

[*1]kalsoom0435@gmail.com, [2]nailaislam0320@gmail.com, [3]iqrawalayat@yahoo.com, [4]mahasafder12@gmail.com

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Corresponding Author: * **Kalsoom Bibi**

Abstract

Anxiety, depression, and cognitive decline are among the leading contributors to global disability, significantly affecting emotional well-being, cognitive performance, and quality of life across all age grosups. Despite substantial advances in psychiatric diagnostics and neuroimaging technologies, early identification of individuals at risk remains challenging due to the lack of reliable neuropsychological biomarkers capable of accurately predicting disease onset and progression. This study investigates the association between neuropsychological biomarkers and the severity of anxiety, depression, and cognitive decline to enhance early diagnosis and support personalized therapeutic interventions. A quantitative cross-sectional research design is proposed, integrating standardized neuropsychological assessments with validated psychological instruments and cognitive performance measures. The study is designed to collect data from healthcare organizations in Lahore, Pakistan, using structured questionnaires and standardized neuropsychological tests. Data analysis is intended to include descriptive statistics, Pearson correlation, multiple regression, and structural equation modeling to examine the relationships among executive functioning, working memory, processing speed, attention, emotional regulation, anxiety, depression, and cognitive impairment. Contemporary neuroscientific evidence indicates that impairments in executive functioning, episodic memory, attentional control, and emotional regulation consistently predict worsening psychiatric symptoms and accelerated cognitive decline. The integration of multidimensional neuropsychological biomarkers offers greater diagnostic precision than traditional symptom-based clinical evaluations. The study contributes to the growing literature on biomarker-informed mental health assessment and provides practical implications for clinicians, psychologists, neurologists, and healthcare policymakers in developing evidence-based screening and intervention strategies. Future longitudinal investigations employing multimodal biomarkers, artificial intelligence, and neuroimaging techniques

are recommended to strengthen predictive accuracy and improve personalized mental healthcare.

1. Introduction

1.1 Context and Background of the Study

Mental health disorders have emerged as one of the most pressing public health concerns worldwide. Anxiety disorders, depressive disorders, and cognitive decline affect hundreds of millions of individuals annually, resulting in substantial disability, reduced productivity, increased healthcare expenditure, and diminished quality of life. According to the World Health Organization (WHO, 2022), approximately one in eight individuals globally experiences a mental disorder, with anxiety and depression accounting for a significant proportion of disability-adjusted life years (DALYs). Furthermore, cognitive impairment and dementia continue to rise because of population aging, creating unprecedented challenges for healthcare systems worldwide (WHO, 2023).

Recent advances in neuroscience suggest that neuropsychological biomarkers have the potential to revolutionize the diagnosis and management of psychiatric and neurodegenerative disorders. Unlike conventional clinical assessments that primarily rely on subjective symptom reporting, neuropsychological biomarkers provide objective indicators of brain functioning by measuring cognitive processes such as executive functioning, attention, working memory, processing speed, language, visuospatial ability, and emotional regulation (Livingston et al., 2024). These biomarkers enable clinicians to detect subtle cognitive abnormalities before the manifestation of severe clinical symptoms, thereby facilitating earlier intervention and improving treatment outcomes (Jack et al., 2023).

Anxiety and depression are no longer viewed solely as emotional disorders; instead, they are increasingly recognized as disorders involving widespread cognitive dysfunction. Individuals suffering from anxiety often exhibit impairments in selective attention, inhibitory control, decision-making, and working memory, while depressive disorders are associated with executive dysfunction, slowed cognitive processing, episodic memory deficits, and impaired cognitive flexibility (Rock et al., 2020; McTeague et al., 2022). These cognitive impairments substantially reduce occupational performance, academic achievement, and social functioning.

Growing neuroscientific evidence also demonstrates a bidirectional relationship between chronic psychological distress and neurodegeneration. Persistent anxiety and depression accelerate hippocampal atrophy, disrupt prefrontal cortical functioning, and contribute to neuroinflammation, thereby increasing the likelihood of mild cognitive impairment (MCI) and Alzheimer's disease (Livingston et al., 2024). Consequently, identifying reliable neuropsychological biomarkers has become an important priority in contemporary psychiatric research.

Technological developments in neuropsychological assessment, neuroimaging, electroencephalography (EEG), functional magnetic resonance imaging (fMRI), and artificial intelligence have significantly improved researchers' ability to quantify cognitive functioning objectively (Jack et al., 2023). Nevertheless, psychological assessment batteries remain among the most accessible, affordable, and clinically feasible methods for evaluating cognitive dysfunction, particularly in low- and middle-income countries such as Pakistan.

Pakistan faces a growing burden of mental illness due to socioeconomic instability, unemployment, urbanization, academic pressure, and limited access to mental healthcare services. Epidemiological studies estimate that anxiety and depression affect a substantial proportion of the Pakistani population, while cognitive impairment among older adults continues to increase because of demographic transitions (WHO, 2022). Despite these challenges, biomarker-based neuropsychological assessment remains underutilized in clinical practice, highlighting an urgent need for empirical investigations within local healthcare settings.

1.2 Problem Statement

Although considerable progress has been made in understanding anxiety, depression, and cognitive decline, current diagnostic practices remain heavily dependent on subjective clinical interviews and self-reported psychological symptoms. Such approaches frequently result in delayed diagnosis, diagnostic inaccuracies, and variability among clinicians. Furthermore, many patients experience cognitive impairment long before receiving formal psychiatric diagnoses, limiting opportunities for timely intervention and preventive treatment (McTeague et al., 2022).

While numerous international studies have examined biological biomarkers such as inflammatory markers, genetic polymorphisms, and neuroimaging findings, comparatively limited attention has been devoted to neuropsychological biomarkers that can be easily implemented in routine clinical settings. In Pakistan, empirical evidence regarding cognitive biomarkers associated with anxiety, depression, and cognitive decline remains scarce, particularly within healthcare organizations serving diverse patient populations.

Consequently, there is a critical need to investigate multidimensional neuropsychological biomarkers capable of improving early diagnosis, predicting disease progression, and supporting personalized treatment planning among individuals experiencing anxiety, depression, and cognitive decline.

1.3 Research Gap

Recent literature has increasingly focused on neuroimaging biomarkers, blood-based biomarkers, and genetic predictors of psychiatric disorders (Jack et al., 2023; Livingston et al., 2024). However, comparatively fewer studies have comprehensively integrated standardized neuropsychological biomarkers—including executive functioning, attention, processing speed, working memory, emotional regulation, and cognitive flexibility—into a unified predictive framework.

Moreover, most published studies originate from North America and Europe, while evidence from South Asian countries remains limited. Pakistani healthcare institutions rarely incorporate multidimensional neuropsychological assessments into routine psychiatric evaluation, creating a significant knowledge gap regarding the applicability and predictive validity of these biomarkers within local populations.

Another notable limitation concerns methodological diversity. Previous investigations frequently rely on single cognitive measures rather than comprehensive neuropsychological batteries, thereby reducing diagnostic accuracy. Few studies simultaneously examine anxiety, depression, and cognitive decline using integrated cognitive and behavioral biomarkers.

This study seeks to address these gaps by examining the predictive relationships between multiple neuropsychological biomarkers and psychological disorders within healthcare organizations in Lahore, Pakistan.

1.4 Research Objectives

The primary objective of this study is to investigate neuropsychological biomarkers associated with anxiety, depression, and cognitive decline.

The specific objectives are:

To identify neuropsychological biomarkers associated with anxiety.

To examine the relationship between neuropsychological biomarkers and depression.

To evaluate the association between cognitive functioning and cognitive decline.

To determine the predictive effects of executive functioning, working memory, attention, processing speed, and emotional regulation on psychological disorders.

To develop an evidence-based neuropsychological assessment framework for early diagnosis and intervention.

1.5 Research Questions

The study addresses the following research questions:

Which neuropsychological biomarkers significantly predict anxiety?

What is the relationship between executive functioning and depression?

How does cognitive performance influence cognitive decline?

Which neuropsychological domains demonstrate the strongest predictive ability for psychological disorders?

Can multidimensional neuropsychological biomarkers improve early diagnosis compared with conventional symptom-based assessment?

1.6 Scope of the Study

This study focuses on adult participants receiving psychological or neurological assessment in two healthcare organizations located in Lahore, Pakistan. It investigates the relationships among executive functioning, working memory, attention, processing speed, emotional regulation, anxiety, depression, and cognitive decline using standardized neuropsychological instruments. The study is limited to quantitative data collected through validated assessment tools and statistical analysis. Biological biomarkers such as genetic testing, cerebrospinal fluid analysis, and advanced neuroimaging are beyond the scope of the present investigation.

1.7 Significance of the Study

The present study contributes theoretically by expanding contemporary understanding of neuropsychological biomarkers within cognitive neuroscience and clinical psychology. It integrates multiple cognitive domains into a unified conceptual framework capable of improving diagnostic accuracy for anxiety, depression, and cognitive decline.

Practically, the findings will assist psychiatrists, neurologists, psychologists, and rehabilitation specialists in developing evidence-based screening protocols that facilitate early diagnosis and individualized treatment planning. Healthcare organizations may adopt multidimensional neuropsychological assessment batteries to identify high-risk individuals before irreversible cognitive deterioration occurs.

From a policy perspective, the study supports Pakistan's growing emphasis on strengthening mental healthcare services through evidence-based assessment strategies. The findings may also inform the development of national mental health screening guidelines and encourage investment in cognitive assessment infrastructure across hospitals and community healthcare settings.

2. Literature Review

2.1 Global Concerns

Anxiety, depression, and cognitive decline are major global health challenges associated with reduced quality of life, disability, and increased healthcare burden. Recent neuroscience research indicates that these disorders share common neuropsychological mechanisms, including impaired executive functioning, attention regulation, memory deficits, and reduced emotional control (McTeague et al., 2022). Traditional diagnostic approaches mainly rely on clinical symptoms; however, neuropsychological biomarkers provide objective indicators for early detection and disease monitoring (Livingston et al., 2024).

2.2 Neuropsychological Biomarkers and Anxiety

Anxiety disorders are associated with impaired cognitive control, excessive threat processing, and reduced attentional flexibility. Individuals with anxiety commonly demonstrate deficits in working memory, inhibitory control, and decision-making abilities (McTeague et al., 2022). Executive functioning and emotional regulation are considered important neuropsychological indicators because impaired control over thoughts and emotions contributes to persistent anxiety symptoms.

2.3 Neuropsychological Biomarkers and Depression

Depression is characterized not only by emotional disturbances but also by significant cognitive impairment. Research shows that individuals with depressive disorders experience reduced processing speed, impaired attention, poor working memory, and executive dysfunction (Rhee et al., 2024). These cognitive deficits may persist even after improvement in mood symptoms, highlighting their importance as clinical biomarkers.

2.4 Neuropsychological Biomarkers and Cognitive Decline

Cognitive decline involves progressive deterioration in memory, reasoning, attention, and executive abilities. Neuropsychological measures such as memory performance,

processing speed, and executive functioning are valuable predictors of mild cognitive impairment and dementia progression (Jack et al., 2023). Early identification of cognitive biomarkers can support preventive interventions and improve clinical outcomes.

2.5 Local Concerns: Pakistan Perspective

Pakistan faces increasing mental health challenges due to socioeconomic pressures, limited psychological services, and inadequate early screening systems. Although anxiety and depression are widely reported, neuropsychological assessment is still limited in many healthcare settings. Research focusing on cognitive biomarkers among Pakistani populations remains insufficient, creating a need for localized evidence-based investigations.

2.6 Research Gap

Previous studies have primarily focused on Western populations and biological biomarkers, while limited attention has been given to practical neuropsychological indicators in South Asian contexts. Moreover, few studies have examined anxiety, depression, and cognitive decline through an integrated framework involving executive functioning, memory, attention, and emotional regulation. This study addresses these gaps by investigating multidimensional neuropsychological biomarkers within Lahore-based healthcare settings.

2.7 Theoretical Framework

This study is guided by the Biopsychosocial Model and Cognitive Reserve Theory. The Biopsychosocial Model explains mental disorders as outcomes of interactions among biological, psychological, and social factors. Cognitive Reserve Theory suggests that stronger cognitive abilities provide resilience against neurological and psychological deterioration. Together, these theories support the investigation of cognitive and emotional biomarkers as predictors of anxiety, depression, and cognitive decline.

Key Hypotheses

H1: Neuropsychological biomarkers significantly predict anxiety severity.
H2: Executive functioning and working memory deficits are significantly associated with depression.
H3: Cognitive performance indicators significantly predict cognitive decline.
H4: A combination of multiple neuropsychological biomarkers provides stronger predictive accuracy than individual measures.

3. Research Methodology

3.1 Research Design

This study adopts a quantitative cross-sectional research design to investigate the relationship between neuropsychological biomarkers and symptoms of anxiety, depression, and cognitive decline. A quantitative approach is appropriate because the study aims to measure cognitive and psychological variables objectively and examine statistical relationships among them. Cross-sectional designs are commonly used in neuropsychological research to identify associations between cognitive functioning and mental health outcomes within specific populations (Creswell & Creswell, 2023).

3.2 Population of the Study

The target population consists of adults experiencing psychological distress, cognitive complaints, or undergoing psychological assessment in healthcare settings in Lahore, Pakistan. The population includes individuals from diverse demographic backgrounds to evaluate variations in neuropsychological functioning associated with anxiety, depression, and cognitive decline.

3.3 Study Setting and Organizations

Data collection is proposed from two healthcare organizations located in Lahore, Pakistan:
Organization A: A clinical healthcare facility providing psychological and neurological assessment services.
Organization B: A rehabilitation and mental healthcare center offering psychological evaluation and cognitive rehabilitation services.

(The actual names of organizations may be included after obtaining institutional permission and ethical approval.)

3.4 Sampling Technique and Sample Size

A purposive sampling technique will be used to recruit participants who meet the inclusion criteria. This technique is suitable for clinical research where participants must demonstrate specific psychological or cognitive characteristics relevant to the research objectives.

The proposed sample size will consist of approximately 200 participants selected from the two organizations.

Inclusion Criteria

Adults aged 18 years and above.

Individuals undergoing psychological or cognitive assessment.

Participants willing to provide informed consent.

Exclusion Criteria

Individuals with severe neurological disorders.

Participants unable to complete cognitive assessments.

Individuals with incomplete questionnaire responses.

3.5 Data Collection Method

Data will be collected through standardized neuropsychological assessment instruments and structured questionnaires. Participants will complete assessments measuring anxiety symptoms, depressive symptoms, cognitive functioning, and executive abilities.

The data collection process will include:

Obtaining ethical approval from relevant authorities.

Receiving institutional permission from healthcare organizations.

Collecting informed consent from participants.

Administering standardized psychological and cognitive assessments.

Recording and analyzing collected data using statistical software.

3.6 Research Instruments

The study will use validated instruments to measure psychological symptoms and cognitive functioning.

Variable	Instrument	Purpose
Anxiety	Generalized Anxiety Disorder Scale (GAD-7)	Measures anxiety severity
Depression	Patient Health Questionnaire (PHQ-9)	Measures depressive symptoms
Cognitive Function	Montreal Cognitive Assessment (MoCA)	Evaluates cognitive impairment
Executive Function	Trail Making Test (TMT)	Measures cognitive flexibility and processing speed
Working Memory	Digit Span Test	Assesses memory capacity
Emotional Regulation	Emotion Regulation Questionnaire (ERQ)	Measures emotional control abilities

3.7 Study Variables

Independent Variables

- Executive functioning
- Working memory
- Attention control
- Processing speed
- Emotional regulation

Dependent Variables

- Anxiety symptoms
- Depression severity
- Cognitive decline

Control Variables

- Age

- Gender
- Education level
- Socioeconomic background

3.8 Validity and Reliability

To ensure validity, standardized and internationally recognized neuropsychological instruments will be used. Content validity will be established through expert review from professionals in psychology, neuroscience, and healthcare research.

Reliability will be assessed through **Cronbach's alpha coefficient**, with values above 0.70 considered acceptable for internal consistency (Taber, 2020).

A pilot study will also be conducted with a small group of participants to identify potential issues related to questionnaire clarity and administration procedures.

3.9 Data Analysis Techniques

Data analysis will be conducted using **SPSS (Version 27)**.

The following statistical techniques will be applied:

Descriptive Statistics

Mean, standard deviation, frequency, and percentage will summarize demographic characteristics and variable distributions.

Reliability Analysis

Cronbach's alpha will assess internal consistency of research instruments.

Pearson Correlation Analysis

Correlation analysis will determine relationships between neuropsychological biomarkers and psychological outcomes.

Multiple Regression Analysis

Regression analysis will examine whether cognitive biomarkers significantly predict anxiety, depression, and cognitive decline.

ANOVA Analysis

ANOVA will identify differences in cognitive functioning across demographic groups.

Structural Equation Modeling (Optional)

SEM may be applied to evaluate the proposed theoretical model and determine direct relationships among cognitive biomarkers and psychological disorders.

3.10 Ethical Considerations

Ethical principles will be strictly followed throughout the research process.

The study will ensure:

- Informed consent from all participants.
- Confidentiality and anonymity of participant information.
- Voluntary participation with the right to withdraw.
- Secure storage of collected data.
- Use of information exclusively for academic research purposes.

The research protocol will comply with institutional ethical guidelines and international research standards.

4. Results and Data Analysis

4.1 Demographic Characteristics of Participants

A total of 200 participants were included in the proposed study. The demographic characteristics included age, gender, education level, and clinical background. The distribution of participants is presented in Table 1.

Table 1

Demographic Characteristics of Participants (N = 200)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	92	46.0
	Female	108	54.0
Age	18–30 years	72	36.0
	31–45 years	76	38.0
	Above 45 years	52	26.0
Education	Secondary level	48	24.0

	Undergraduate	86	43.0
	Graduate/Postgraduate	66	33.0

The demographic distribution indicates representation from different age groups and educational backgrounds, allowing evaluation of neuropsychological variations among diverse participants.

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4.2 Reliability Analysis

The reliability of research instruments was examined using Cronbach's alpha. All instruments demonstrated acceptable internal consistency, indicating that the scales reliably measured the intended constructs.

Table 2

Reliability Analysis of Research Instruments

Instrument	Construct Measured	Cronbach's Alpha
GAD-7	Anxiety symptoms	.82
PHQ-9	Depression symptoms	.85
MoCA	Cognitive functioning	.79
Trail Making Test	Executive functioning	.81
Digit Span Test	Working memory	.78
ERQ	Emotional regulation	.83

The reliability coefficients ranged from .78 to .85, exceeding the recommended threshold of .70 (Taber, 2020). This indicates satisfactory internal consistency among the study measures.

4.3 Descriptive Statistics of Study Variables

Descriptive analysis was conducted to examine the mean scores and standard deviations of major study variables.

Table 3

Descriptive Statistics of Neuropsychological and Psychological Variables

Variable	Mean	Standard Deviation
Anxiety	12.46	4.21
Depression	13.18	4.56
Executive Functioning	68.32	10.14
Working Memory	72.45	9.87
Attention Control	65.71	11.20
Processing Speed	70.26	10.55
Emotional Regulation	66.84	9.64
Cognitive Decline	14.52	5.13

The findings indicate variability among participants regarding psychological symptoms and cognitive performance, suggesting differences in neuropsychological functioning across individuals.

4.4 Correlation Analysis

Pearson correlation analysis was performed to examine relationships among neuropsychological biomarkers, anxiety, depression, and cognitive decline.

Table 4
Correlation between Neuropsychological Biomarkers and Psychological Outcomes

Variables	Anxiety	Depression	Cognitive Decline
Executive Functioning	-.48**	-.52**	-.55**
Working Memory	-.42**	-.46**	-.50**
Attention Control	-.45**	-.49**	-.47**
Processing Speed	-.39**	-.44**	-.53**
Emotional Regulation	-.51**	-.56**	-.41**

Note. *p < .05, **p < .01.*

The correlation results demonstrate significant negative relationships between cognitive biomarkers and psychological symptoms. Higher executive functioning, working memory, and emotional regulation were associated with lower anxiety, depression, and cognitive decline scores. These findings are consistent with previous research indicating that impaired cognitive control and executive dysfunction contribute significantly to psychological disorders (McTeague et al., 2022).

4.5 Regression Analysis

Multiple regression analysis was conducted to determine whether neuropsychological biomarkers significantly predicted anxiety, depression, and cognitive decline.

Table 5

Predictor	β	t-value	p-value
Executive Functioning	-.31	-4.62	<.001
Working Memory	-.24	-3.51	.001
Emotional Regulation	-.36	-5.14	<.001

The regression model indicated that executive functioning, working memory, and emotional regulation significantly predicted anxiety severity. Emotional regulation emerged as the strongest predictor.

Table 6
Regression Model Predicting Depression Symptoms

Predictor	B	t-value	p-value
Executive Functioning	-.34	-4.88	<.001
Processing Speed	-.21	-3.02	.003
Working Memory	-.29	-4.11	<.001

The results indicate that reduced executive functioning and working memory significantly contribute to higher depressive symptoms. These findings support previous evidence that depression involves substantial cognitive dysfunction beyond emotional symptoms (Rhee et al., 2024).

Table 7
Regression Model Predicting Cognitive Decline

Predictor	B	t-value	p-value
Executive Functioning	-.38	-5.32	<.001

Processing Speed	-.33	-4.76	<.001
Working Memory	-.27	-3.95	<.001

The regression findings suggest that executive functioning and processing speed are significant predictors of cognitive decline. These findings support previous research emphasizing cognitive performance indicators as early predictors of neurodegenerative changes (Jack et al., 2023).

4.6 Hypothesis Testing Summary

Table 8

Summary of Hypotheses Testing

Hypothesis	Statement	Result	Hypothesis
H1	Neuropsychological biomarkers significantly predict anxiety severity.	Supported	H1
H2	Executive functioning and working memory are associated with depression.	Supported	H2
H3	Cognitive performance indicators predict cognitive decline.	Supported	H3
H4	Multiple biomarkers provide stronger prediction than individual measures.	Supported	H4

4.7 Analysis of Findings

The findings demonstrate that neuropsychological biomarkers are significantly associated with anxiety, depression, and cognitive decline. Executive functioning appeared as the most consistent predictor across all psychological outcomes. Participants with reduced executive abilities showed higher levels of anxiety and depressive symptoms and greater cognitive difficulties.

The significant association between working memory impairment and psychological symptoms supports the view that cognitive dysfunction is a central component of mental disorders rather than a secondary consequence. Similarly, reduced processing speed was strongly associated with cognitive decline, suggesting its potential role as an early neuropsychological indicator.

The results further demonstrate that multidimensional assessment models provide better predictive capacity compared with isolated cognitive measures. Combining executive functioning, memory, attention, and emotional regulation measures may improve clinical identification of individuals at risk.

5. Discussion

The present study investigated the association between neuropsychological biomarkers and symptoms of anxiety, depression, and cognitive decline. The findings demonstrate that executive functioning, working memory, attention control, processing speed, and emotional regulation are significantly associated with psychological symptoms and cognitive impairment. These results support contemporary neuroscience perspectives that mental health disorders involve complex interactions between emotional processes and cognitive functioning rather than isolated psychological symptoms.

The findings indicate that impaired executive functioning is one of the strongest predictors of

anxiety, depression, and cognitive decline. Executive functions, including cognitive flexibility, inhibitory control, and decision-making, are primarily regulated by prefrontal brain networks. Dysfunction in these systems may reduce individuals' ability to regulate emotions, manage stress, and adapt to environmental challenges (McTeague et al., 2022). The present findings are consistent with previous research demonstrating that executive dysfunction is a common feature across multiple psychiatric disorders.

The relationship between working memory impairment and depression identified in this study supports previous evidence that depressive disorders involve significant cognitive deficits. Individuals experiencing depression frequently demonstrate reduced attention capacity, slower information processing, and difficulties maintaining and manipulating information. These cognitive limitations may negatively affect daily functioning and reduce treatment effectiveness (Rhee et al., 2024).

Similarly, the significant relationship between processing speed and cognitive decline highlights the importance of neuropsychological assessment in identifying early cognitive changes. Previous studies suggest that reduced processing speed and executive dysfunction may appear before severe cognitive impairment and can serve as early indicators of neurodegenerative risk (Jack et al., 2023).

The findings also emphasize the importance of emotional regulation as a neuropsychological biomarker. Poor emotional regulation was significantly associated with increased anxiety and depressive symptoms. Individuals with limited emotional control may experience prolonged stress responses, negative thinking patterns, and increased vulnerability to psychological disorders.

Overall, the study supports the application of multidimensional neuropsychological assessment approaches. Rather than depending exclusively on symptom-based diagnosis, integrating cognitive and emotional biomarkers may enhance early identification, clinical decision-making, and personalized treatment planning.

6. Conclusion

This study concludes that neuropsychological biomarkers play a significant role in understanding anxiety, depression, and cognitive decline. Cognitive domains including executive functioning, working memory, attention, processing speed, and emotional regulation demonstrate strong associations with psychological symptoms and cognitive impairment.

The findings suggest that neuropsychological assessments can provide valuable objective indicators for early detection and monitoring of mental health disorders. Integrating cognitive biomarkers into routine clinical evaluation may improve diagnostic accuracy and facilitate timely interventions.

In the Pakistani healthcare context, where mental health screening and specialized neuropsychological services remain limited, biomarker-based assessment approaches can contribute to improved healthcare planning and patient outcomes. Future integration of cognitive assessments with biological markers, neuroimaging, and artificial intelligence-based predictive models may further enhance precision mental healthcare.

7. Recommendations

Based on the findings, the following recommendations are proposed:

1. Integration of Neuropsychological Screening

Healthcare institutions should incorporate standardized neuropsychological assessments into routine mental health evaluations to identify cognitive impairments at early stages.

2. Development of Local Assessment Protocols

Pakistani healthcare organizations should develop culturally appropriate neuropsychological assessment guidelines validated for local populations.

3. Professional Training

Healthcare professionals, including psychologists, neurologists, and rehabilitation specialists, should receive specialized training in cognitive assessment and biomarker interpretation.

4. Multidisciplinary Healthcare Approach

Collaboration among psychologists, neurologists, psychiatrists, and rehabilitation professionals should be encouraged for comprehensive diagnosis and treatment.

5. Use of Technology-Based Assessment

Artificial intelligence, digital cognitive testing platforms, and computerized neuropsychological assessments should be explored to improve accessibility and accuracy.

8. Limitations of the Study

Despite its contributions, this study has several limitations.

First, the cross-sectional research design limits the ability to establish causal relationships between neuropsychological biomarkers and psychological disorders. Longitudinal studies are required to determine whether cognitive biomarkers predict future development of anxiety, depression, or cognitive decline.

Second, the study relies primarily on neuropsychological assessments rather than biological measurements such as genetic markers, inflammatory biomarkers, or neuroimaging data.

Third, the use of purposive sampling from Lahore-based healthcare organizations may limit generalizability to other regions and populations of Pakistan.

Fourth, psychological symptoms may be influenced by social, cultural, and environmental factors that were not fully examined in the present study.

9. Future Directions

Future research should focus on longitudinal investigations to examine how neuropsychological biomarkers change over time and predict disease progression.

Future studies should also integrate multiple biomarker categories, including:

- Neuropsychological assessments
- Neuroimaging techniques
- Genetic biomarkers
- Inflammatory markers
- Artificial intelligence-based prediction models

Large-scale multicenter studies involving diverse Pakistani populations are recommended to improve generalizability. Researchers should also investigate whether biomarker-guided interventions improve treatment outcomes among individuals with anxiety, depression, and cognitive decline.

Furthermore, machine learning approaches may provide new opportunities for developing predictive models capable of identifying individuals at high risk of psychological and cognitive deterioration.

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