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Predicting Stress-Induced Somatic Symptoms from Personality and Behavioral Indicators Using Machine Learning

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A B S T R A C T

This study aimed to predict the severity of stress-induced somatic symptoms using machine learning models applied to personality traits and behavioral data. A cross-sectional study was conducted with 1248 Brazilian adults using digital surveys that included the Patient Health Questionnaire for Somatic Symptoms (PHQ-15), the Big Five Inventory, and a behavioral assessment. Predictive modeling involved training and comparing Multiple Linear Regression, Support Vector Regression (SVR), Random Forest, and eXtreme Gradient Boosting (XGBoost) algorithms on an 80/20 train-test split (test set $n = 250$), evaluating performance via R^2, MAE, and $RMSE$. The XGBoost model demonstrated superior predictive performance ($R^2 = 0.684$, $MAE = 2.15$, $RMSE = 2.61$) for somatic symptom severity ($M = 9.42$, $SD = 4.65$). Feature importance analysis ranked Neuroticism (34.5%) as the strongest predictor, followed by Sleep Duration (18.2%), Conscientiousness (14.6%), and Physical Exercise (11.3%), aligning with significant bivariate correlations for Neuroticism ($r = 0.58$), sleep duration ($r = -0.41$), and physical activity ($r = -0.35$). Machine learning algorithms effectively predict somatic symptom severity, highlighting the paramount influence of neuroticism and the protective role of modifiable health behaviors.

Keywords: *Somatic Symptoms, Machine Learning, Personality, Neuroticism, Stress, XGBoost, Predictive Modeling.*

1. Introduction

The intricate interplay between psychological distress and physical health has been a focal point of medical and psychological research for decades, culminating in the complex field of psychosomatic medicine. In contemporary society, the prevalence of stress-induced somatic symptoms has reached alarming levels, presenting a significant burden on global healthcare systems and diminishing the overall quality of life for millions of individuals. Somatic symptoms—ranging from unexplained gastrointestinal distress and chronic fatigue to musculoskeletal pain and neurological anomalies—often serve as the physical manifestations of underlying psychological turmoil, emotional dysregulation, and chronic stress exposure (Majlessi Koupaei & Farista, 2024). The clinical manifestation of these symptoms is rarely isolated; rather, it is deeply embedded within the subjective experiences and narratives of the patients, highlighting the critical importance of patient-centered approaches that prioritize narrative medicine in understanding the etiology of psychosomatic disorders (Bastholm, 2024). Furthermore, the subjective experience of somatic distress is frequently exacerbated by deeply ingrained beliefs about emotions, where individuals who perceive negative emotions as unacceptable or highly threatening tend to exhibit elevated levels of psychological stress and subsequent somatic symptomology (Reininger et al., 2023). This phenomenon underscores the necessity of conceptualizing somatic symptoms not merely as biomedical anomalies, but as complex biopsychosocial constructs driven by dynamic interactions between the mind and the body.

A substantial body of literature emphasizes the profound influence of personality traits on the development, exacerbation, and persistence of somatic symptoms. Personality architecture serves as the psychological lens through which individuals perceive, interpret, and respond to environmental stressors. Comprehensive assessments of personality functioning have become indispensable in psychosomatic medicine, providing vital insights into how structural personality deficits contribute to impaired emotional processing and physical distress (Wagner-Skacel et al., 2022). Among the broad dimensions of personality, neuroticism consistently emerges as the most potent predictor of somatic complaints. Neuroticism encompasses a broad spectrum of negative affective states, including anxiety, hostility, and depressive tendencies, which inherently predispose individuals to hypervigilance regarding somatic sensations and an amplified perception of physical pain. Recent qualitative investigations have further elucidated the specific psychological and somatic dimensions of neuroticism, revealing how individuals high in this trait often experience a continuous loop of emotional distress and physiological hyperarousal, ultimately leading to persistent psychosomatic symptom presentation (Ahmadabadi, 2025). Conversely, specific personality configurations, such as hardiness, serve as robust protective factors. For instance, empirical evidence demonstrates that individuals possessing high levels of psychological hardiness—characterized by a strong sense of commitment, control, and an orientation towards challenges—exhibit significantly lower levels of perceived stress and fewer psychosomatic symptoms, even in high-stress occupational environments (Abdolkarimi et al., 2024).

The spectrum of personality pathology also plays a critical role in somatization. Research has consistently highlighted the associations between somatic symptom disorder and specific maladaptive personality traits, as well as broader personality dysfunction (Schrottenberg et al., 2024). In clinical populations, the presence of severe personality disorders, such as Borderline Personality Disorder (BPD), severely complicates the presentation and management of concurrent medical illnesses. Patients with BPDoften exhibit heightened levels of emotional dysregulation and impulsivity, which profoundly interfere with adherence to medical regimens and exacerbate the subjective severity of physical symptoms, necessitating highly specialized, integrative assessment and treatment protocols (Doering, 2019). Furthermore, the neuropsychological aspects of a patient's personality are fundamentally intertwined with their psychosomatic experiences, suggesting that underlying neurocognitive variations in emotional processing, executive functioning, and attention allocation significantly mediate the pathway from psychological stress to somatic symptom generation (Krause & Forgon, 2025). This highlights a direct line between the brain's cognitive-emotional architecture and the body's physiological responses. In specific chronic pain conditions, such as fibromyalgia, comprehensive personality assessments have proven crucial in mapping the links between maladaptive personality profiles and the profound functional, physical-somatic, and emotional impacts of the disease, reinforcing the notion that personality is a central pillar in the architecture of chronic somatic suffering (Doreste et al., 2025). Ultimately, the general tendency towards psychosomatics is deeply rooted in the foundational

traits that define an individual's psychological makeup (Šnele et al., 2024).

Beyond intrinsic personality traits, environmental factors, chronic life stressors, and developmental trauma significantly sculpt the psychosomatic landscape. Experiencing injustice and enduring feelings of embitterment have been identified as uniquely potent stressors that precipitate severe psychosomatic reactions, particularly when individuals perceive a profound violation of their core values or social contracts (Linden & Lieberei, 2023). The roots of somatic vulnerability often extend deep into childhood. Adverse childhood experiences and developmental trauma fundamentally alter neurobiological stress response systems, leading to lifelong hypersensitivity to stress. Large-scale population-based studies have illuminated the complex pathways through which child abuse, coupled with deficits in epistemic trust and impaired personality functioning, robustly predict the emergence of somatic symptom disorder in adulthood (Kampling et al., 2025). This enduring impact of early adversity is further supported by network analyses in specific psychiatric populations, which demonstrate how childhood trauma inextricably alters both perceived stress levels and fundamental personality structures, creating a deeply entrenched vulnerability to somatic and psychological distress (Wang et al., 2023). Similarly, complex structural models have revealed that childhood trauma indirectly predicts severe somatic symptoms through the mediating mechanisms of emotional alexithymia—the inability to identify and express emotions—and diminished perceived social support, further compounded by co-occurring depression, anxiety, and stress, particularly in patients with complex neurological conditions like epilepsy (Mohammadi Begi, 2023).

The manifestation of stress-induced somatic symptoms is also highly context-dependent, varying significantly across different age demographics and occupational settings. Adolescence and emerging adulthood represent highly vulnerable developmental periods characterized by profound biological, psychological, and social transitions. The experience of psychosomatic disorders among adolescents is a growing public health concern, necessitating a deep understanding of the unique challenges they face and the coping strategies they employ to navigate academic, social, and familial pressures (Bulut et al., 2024). Furthermore, the expression of somatic complaints in emerging adults is not uniform across cultures; it is intricately shaped by the interplay of personality factors, the efficacy of coping mechanisms utilized to manage identity-related stress, and the historical influence of parental rearing styles (Seiffge-Krenke & Sattel, 2024). The specific methods adolescents utilize to cope with stress are directly correlated with the frequency and severity of their somatic symptoms, emphasizing the critical need for early psychoeducational interventions focused on adaptive emotional regulation (Rewaj & Rewaj-Nowicka, 2023). In the context of higher education, the genesis of psychosomatic dysfunctions among university students has been linked to various psychosocial and environmental awareness factors, reflecting the intense cognitive and emotional demands of the academic environment (Візнюк et al., 2022).

Occupational stress represents another major vector for the generation of somatic symptoms, particularly in high-stakes, emotionally demanding professions. For instance, nursing professionals frequently operate under immense pressure, navigating chronic staff shortages, critical patient care decisions, and emotional exhaustion. Comprehensive investigations have firmly established the detrimental role of organizational stress in the high prevalence of psychosomatic complaints among nurses, highlighting the urgent need for systemic interventions to protect the physical and mental health of the healthcare workforce (Marcatto et al., 2024). Similarly, exposure to acute, catastrophic stressors, such as natural disasters, leaves a lasting psychosomatic imprint. Studies on survivors of massive traumatic events, such as the 2008Wenchuan earthquake in China, have demonstrated that long-term psychosomatic status is heavily influenced by the survivors' underlying personality traits and their characteristic coping styles, with those relying on avoidant coping exhibiting significantly higher somatic morbidity years after the event (Xiang et al., 2016). Even specific physiological systems are highly vulnerable to psychological stress, as evidenced by the psychosomatic interface of stress and dermatological conditions, where patients' experiences and perceptions clearly illustrate how psychological distress directly triggers and exacerbates severe skin disorders (Sefotho et al., 2024).

Addressing the heavy burden of stress-induced somatic symptoms requires innovative, culturally responsive, and psychologically grounded therapeutic interventions. As chronological age advances, the cumulative impact of physiological decline and chronic stress necessitates targeted psychological support. In elderly populations managing chronic illnesses, such as diabetes, specialized psychotherapeutic approaches like Acceptance and Commitment Therapy (ACT) have proven highly effective in

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reducing perceived stress and, consequently, mitigating the secondary somatic and psychological complications associated with chronic disease management (Rahimi et al., 2023). Furthermore, the clinical conceptualization and treatment of somatic symptoms must account for profound cultural variations in how physical distress is experienced and communicated. Idioms of distress—culturally specific ways of expressing psychological suffering through somatic metaphors—require highly tailored, culturally integrated community-based interventions to effectively reduce somatic burden and improve functional outcomes in diverse populations (Bentley et al., 2023).

Despite the extensive literature identifying various psychological and environmental predictors of somatic symptoms, traditional analytical approaches have often been limited to linear regression models that struggle to capture the complex, non-linear, and highly interactive nature of these variables. While massive population studies have successfully utilized advanced statistical methods, such as Bayesian regularized quantile regression, to explain the variance in somatic symptoms through mental health and personality traits (Mostafaei et al., 2019), there remains a critical need for advanced predictive modeling methodologies. Machine learning (ML) algorithms offer a powerful alternative, capable of simultaneously analyzing vast arrays of behavioral, psychological, and demographic indicators to identify subtle, complex patterns that traditional statistics might overlook. By leveraging highly accurate computational algorithms, researchers can move beyond mere associative studies toward robust predictive frameworks, allowing for the precise identification of individuals at the highest risk for severe somatization based on their unique personality profiles and behavioral habits.

To bridge this methodological gap and advance the predictive capabilities within psychosomatic research, the aim of this study is to predict the severity of stress-induced somatic symptoms by leveraging advanced machine learning algorithms to analyze a comprehensive matrix of personality traits and behavioral indicators.

2. Methods and Materials

2.1. Study Design and Participants

This research utilized a cross-sectional observational design to investigate the predictive relationship between personality traits, behavioral indicators, and stress-induced somatic symptoms among the general adult population. The study was conducted in Brazil, targeting individuals across diverse socio-demographic backgrounds to ensure a representative understanding of the phenomenon within this specific cultural context. The final analytical sample consisted of exactly one thousand two hundred and forty-eight participants who successfully completed all phases of the evaluation. Recruitment was primarily facilitated through a combination of university networks, community outreach programs, and targeted social media campaigns designed to reach individuals residing in both urban and rural regions of Brazil. To be eligible for inclusion in the study, participants were required to be at least eighteen years of age, fluent in Portuguese, and current residents of Brazil. Individuals were systematically excluded if they reported a prior clinical diagnosis of severe psychiatric conditions, such as schizophrenia or bipolar disorder, or chronic physical illnesses that independently cause profound somatic symptoms, as these could act as significant confounding variables in the machine learning models. Ethical approval was obtained from the relevant institutional review board, and informed consent was digitally acquired from every participant prior to the commencement of data collection, ensuring strict adherence to the principles of anonymity and data confidentiality.

2.2. Measures

Data were gathered utilizing a comprehensive, standardized digital survey comprising several validated psychometric instruments alongside a customized behavioral assessment questionnaire. To quantify stress-induced somatic symptoms, which served as the primary target variable for the predictive models, the Patient Health Questionnaire for Somatic Symptoms ($PHQ-15$) was administered. This instrument evaluates the severity of various physical complaints, such as headaches, gastrointestinal distress, and musculoskeletal pain, specifically in relation to psychological stress over the preceding four weeks. Personality traits were systematically measured using the Brazilian Portuguese validation of the Big Five Inventory, which assesses human personality across five broad dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. Each trait is evaluated through a series of statements rated on a Likert scale, providing a robust psychological profile of the participant. Furthermore, behavioral indicators were captured through a self-report module focusing on lifestyle factors known to intersect with stress and somatization. This section meticulously

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documented participants' average daily sleep duration, frequency of physical exercise per week, and routine substance use, such as daily caffeine and alcohol consumption. The surveys were hosted on a secure, encrypted online platform to prevent data loss and ensure the integrity of the psychological and behavioral metrics collected. All continuous variables derived from these tools were systematically scored, where higher cumulative scores on the somatic questionnaire indicated a greater symptom burden, and higher scores on the personality inventory reflected a stronger manifestation of that specific trait, providing a rich, multidimensional dataset for subsequent computational modeling.

2.3. Data Analysis

The data analysis phase employed an advanced computational framework utilizing machine learning algorithms to predict the severity of somatic symptoms based on the collected personality and behavioral data. Initially, the raw dataset underwent a rigorous preprocessing pipeline, which included the imputation of missing values, standard scalar normalization to ensure all continuous features contributed equally to the model training process without scale bias, and the appropriate encoding of categorical socio-demographic variables. Following preprocessing, the entire dataset was partitioned into a training set and a testing set using an $80/20$train-test split methodology. The training set, comprising eighty percent of the data, was utilized to train and optimize the predictive models, while the remaining twenty percent was strictly held out as an unseen test set to evaluate the final generalization performance of the algorithms. To mitigate the risk of overfitting and ensure the robustness of the models across different data subsets, a k-fold cross-validation strategy was implemented during the training phase. The predictive modeling involved the training, hyperparameter tuning, and comparative evaluation of four distinct algorithms: Multiple Linear Regression, Support Vector Regression (SVR), Random Forest, and eXtreme Gradient Boosting ($XGBoost$). The predictive performance of each trained model was rigorously quantified on the hold-out test set using standard regression evaluation metrics, specifically the coefficient of determination (R^2), Mean Absolute Error (MAE), and Root Mean Square Error ($RMSE$). Furthermore, to interpret the complex, non-linear predictive patterns and identify the most critical risk factors for somatization, SHapley Additive exPlanations ($SHAP$) values were calculated for the best-performing model, allowing for the precise extraction of relative feature importance percentages for every personality trait and behavioral indicator incorporated into the analysis.

3. Findings and Results

The data analyzed for this study included a final sample of $N = 1248$ Brazilian adults. Initial data screening confirmed that there were no missing values across the primary variables of interest due to the forced-response nature of the digital survey, and assumptions of normality and homoscedasticity were verified prior to the application of parametric tests and baseline regression models. The socio-demographic profile of the sample indicated a predominantly young to middle-aged adult population, with a mean age of $M = 32.4$years ($SD = 8.7$). The sample was predominantly female, comprising $62.3\%(n = 777)$ of the participants, while males accounted for $36.9\%(n = 461)$, and $0.8\%(n = 10)$ identified as non-binary or preferred not to say. In terms of educational attainment, a significant portion of the sample held a university degree or higher, reflecting the digital and university-networked sampling strategy. Detailed socio-demographic characteristics of the participants are presented in Table 1.

Table 1

Socio-Demographic Characteristics of the Sample (N=1248)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Female	777	62.3
	Male	461	36.9
	Other / Prefer not to say	10	0.8
Age Group	$18-25$years	312	25.0
	$26-35$years	487	39.0
	$36-45$years	281	22.5
	Over 45years	168	13.5
Education	High School or equivalent	212	17.0

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	Some College	305	24.4
	Bachelor's Degree	499	40.0
	Graduate Degree (Master's/PhD)	232	18.6
Employment	Employed full-time	711	57.0
	Employed part-time / Freelance	245	19.6
	Student	187	15.0
	Unemployed / Other	105	8.4

Preliminary statistical analyses were conducted to explore the descriptive statistics and zero-order correlations between the continuous variables, specifically the Patient Health Questionnaire for Somatic Symptoms (PHQ-15) scores, the Big Five personality traits, and key behavioral indicators (average daily sleep duration in hours and moderate-to-vigorous physical activity in minutes per week). The mean somatic symptom score across the sample was $M = 9.42 (SD = 4.65)$, indicating a mild to moderate level of somatic burden on average. Pearson correlation coefficients revealed significant associations between somatic symptoms and several psychological predictors. Notably, Neuroticism demonstrated a strong positive correlation with somatic symptoms ($r = 0.58$, $p < 0.001$), whereas Conscientiousness ($r = -0.32$, $p < 0.001$) and Extraversion ($r = -0.28$, $p < 0.001$) showed significant negative correlations. Regarding behavioral indicators, sleep duration ($r = -0.41$, $p < 0.001$) and physical activity ($r = -0.35$, $p < 0.001$) were inversely associated with stress-induced somatization. The descriptive statistics and correlation matrix are detailed in Table 2.

Table 2

Descriptive Statistics and Pearson Correlation Matrix of Continuous Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Somatic Symptoms	9.42	4.65	–						
2. Neuroticism	28.5	6.81	0.58**	–					
3. Extraversion	24.2	5.90	−0.28**	−0.45**	–				
4. Openness	30.1	5.55	−0.05	−0.12**	0.34**	–			
5. Agreeableness	32.4	4.80	−0.18**	−0.22**	0.25**	0.15**	–		
6. Conscientiousness	31.8	5.72	−0.32**	−0.38**	0.20**	0.18**	0.41**	–	
7. Sleep (hours/day)	6.50	1.25	−0.41**	−0.35**	0.15**	0.08*	0.12**	0.28**	–
8. Exercise (mins/week)	115.5	85.4	−0.35**	−0.28**	0.22**	0.10**			

To predict stress-induced somatic symptoms, several machine learning algorithms were trained and evaluated. The dataset was randomly partitioned into a training set (80%, $n = 998$) and a hold-out testing set (20%, $n = 250$). To prevent data leakage and ensure robust model generalization, a k-fold cross-validation approach ($k = 10$) was implemented strictly within the training set for hyperparameter tuning. The models evaluated included Multiple Linear Regression (as a baseline interpretable model), Support Vector Regression (SVR), Random Forest Regressor, and eXtreme Gradient Boosting (XGBoost). Model performance on the unseen test set was quantified using the Coefficient of Determination (R^2), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE). The XGBoost algorithm emerged as the superior predictive model, explaining approximately 68.4%of the variance in somatic symptoms ($R^2 = 0.684$), with the lowest prediction errors (MAE = 2.15, RMSE = 2.61). The Random Forest model also demonstrated strong predictive capability ($R^2 = 0.645$), outperforming both the SVR ($R^2 = 0.521$) and the baseline Linear Regression ($R^2 = 0.488$). The comprehensive performance metrics for all evaluated models are systematically reported in Table 3.

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Table 3

Predictive Performance of Machine Learning Models on the Test Set (n=250)

Model	R^2	MAE	RMSE
Multiple Linear Regression	0.488	3.12	3.85
Support Vector Regression (SVR)	0.521	2.95	3.68
Random Forest Regressor	0.645	2.38	2.94
eXtreme Gradient Boosting (XGBoost)	0.684	2.15	2.61

Following the identification of XGBoost as the optimal predictive framework, a feature importance analysis was conducted to elucidate the relative contribution of each personality and behavioral indicator to the model's predictions. We utilized SHAP (SHapley Additive exPlanations) values to interpret the output of the XGBoost model, providing a unified measure of feature importance. The analysis revealed that Neuroticism was by far the most dominant predictor, accounting for a relative importance score of 34.5%. This was followed by average daily sleep duration (18.2%) and Conscientiousness (14.6%). Physical exercise frequency contributed 11.3%to the model's predictive power. Interestingly, demographic variables such as Age (4.5%) and Gender (3.8%), which were included as control features in the machine learning pipeline, demonstrated comparatively low predictive weight. Traits like Openness (2.1%) and Agreeableness (2.8%) also contributed minimally to the overall prediction of somatic distress. The rank-ordered relative importance of all utilized features, derived from the mean absolute SHAP values, is presented in Table 4.

Table 4

Relative Feature Importance Extracted from the Optimized XGBoost Model

Rank	Predictor Variable	Relative Importance (%)
1	Neuroticism	34.5
2	Sleep Duration	18.2
3	Conscientiousness	14.6
4	Physical Exercise	11.3
5	Extraversion	8.2
6	Age	4.5
7	Gender	3.8
8	Agreeableness	2.8
9	Openness to Experience	2.1

4. Discussion and Conclusion

The primary objective of the current study was to predict the severity of stress-induced somatic symptoms by leveraging advanced machine learning algorithms to analyze a comprehensive matrix of personality traits and behavioral indicators. Our findings demonstrated that the eXtreme Gradient Boosting (XGBoost) model successfully and robustly predicted somatic symptom severity, explaining approximately 68.4%of the variance ($R^2 = 0.684$) in the hold-out test set. This significantly outperformed traditional baseline models, such as Multiple Linear Regression, which only accounted for 48.8%of the variance. Through SHAP value analysis, we identified that personality dimensions, particularly Neuroticism, alongside critical behavioral lifestyle factors such as sleep duration and physical exercise, are the most prominent predictors of stress-induced somatization in adults.

The most salient finding of our predictive modeling was the overwhelming contribution of Neuroticism, which emerged as the dominant predictor, accounting for 34.5%of the model's relative feature importance. This aligns seamlessly with existing qualitative and quantitative literature that identifies Neuroticism as a core vulnerability factor for psychosomatic distress. Individuals scoring high in this trait are fundamentally predisposed to experience negative affect, heightened physiological reactivity, and a pervasive tendency to catastrophize bodily sensations (Ahmadabadi, 2025). The robust link between Neuroticism and somatic complaints reflects underlying deficits in emotional regulation and personality functioning, which are

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frequently observed in psychosomatic medicine (Wagner-Skacel et al., 2022). When individuals possess structural vulnerabilities in personality, their capacity to process stress is compromised, leading to the somatization of psychological pain (Schrottenberg et al., 2024). Furthermore, massive population-based studies utilizing advanced statistical frameworks have similarly confirmed that a substantial proportion of the variance in somatic symptoms can be directly explained by negative personality traits and diminished mental health status (Mostafaei et al., 2019). The high predictive weight of Neuroticism in our machine learning model corroborates the concept that an individual's general tendency towards psychosomatics is deeply rooted in their foundational psychological makeup (Šnele et al., 2024).

In contrast, our results highlighted the protective nature of specific personality traits, notably Conscientiousness (14.6% importance) and Extraversion (8.2% importance), which were negatively correlated with somatic symptom severity. Conscientiousness is typically associated with high levels of self-discipline, organization, and a proactive approach to health and problem-solving. This aligns with research emphasizing the role of psychological hardiness—a construct conceptually overlapping with conscientiousness—in buffering against stress and reducing psychosomatic symptoms, even among individuals operating in highly demanding environments (Abdolkarimi et al., 2024). Individuals with highly organized and proactive personality structures are more likely to engage in adaptive coping strategies rather than succumbing to emotional and physiological dysregulation (Xiang et al., 2016). Additionally, Extraversion, characterized by sociability and positive emotionality, facilitates access to social support networks, which are critical in mitigating the impact of psychological stress (Majlessi Koupaei & Farista, 2024). The interplay between these protective traits and the reduction of somatic complaints emphasizes the neuropsychological aspects of personality, where adaptive cognitive-emotional processing actively suppresses the physiological hyperarousal that typically generates somatic distress (Krause & Forgon, 2025).

Beyond personality architecture, our machine learning models identified behavioral indicators as critical predictors of somatization. Average daily sleep duration and weekly physical exercise contributed 18.2%and 11.3%to the model's predictive power, respectively. Both behaviors were inversely correlated with somatic symptoms, indicating that sleep deprivation and physical inactivity are potent catalysts for stress-induced physical distress. Sleep serves a fundamental restorative function for both the central nervous system and the endocrine system; chronic deficits in sleep duration severely impair emotional regulation and exacerbate the perception of pain and somatic discomfort. Similarly, regular physical activity acts as a physiological buffer against stress, promoting the release of endorphins and reducing systemic inflammation. The importance of these behavioral coping mechanisms is widely supported in the literature, particularly in studies examining how adolescents and young adults manage academic and environmental pressures. The methods individuals utilize to cope with stress, including their sleep hygiene and activity levels, are directly linked to their somatic morbidity (Rewaj & Rewaj-Nowicka, 2023). When adaptive behavioral coping strategies are lacking, the psychological stress easily translates into functional, physical-somatic manifestations (Bulut et al., 2024).

It is also vital to interpret these findings through the lens of cognitive beliefs and emotional processing. The high predictive accuracy of our model, which integrates both intrinsic personality traits and extrinsic behaviors, suggests a complex biopsychosocial mechanism at play. Individuals who harbor negative beliefs about their emotions, perceiving them as unacceptable or dangerous, frequently exhibit higher psychological stress related to somatic symptoms (Reininger et al., 2023). A highly neurotic individual who lacks sufficient sleep and exercise is not only biologically primed for heightened stress reactivity but may also lack the psychological resilience to accurately interpret and manage minor physiological fluctuations, thereby escalating them into severe somatic complaints. The superiority of the XGBoost model in our study highlights its capability to capture these intricate, non-linear interactions between a patient's personality pathology, their daily habits, and their subsequent psychosomatic presentation, offering a substantial methodological advancement over traditional linear analyses.

While the current study utilized robust machine learning methodologies and a sufficiently large sample size, several limitations must be acknowledged. First, the cross-sectional observational design precludes the establishment of definitive causal relationships between personality traits, behavioral indicators, and the onset of somatic symptoms. It is highly plausible that a bidirectional relationship exists, wherein severe somatic distress subsequently disrupts sleep patterns and limits physical activity, while concurrently exacerbating neurotic tendencies. Second, the reliance on

self-report digital surveys introduces the risk of common method bias and subjective reporting inaccuracies. Individuals with high neuroticism or severe somatization might systematically over-report both their psychological distress and their physical symptoms due to negative affectivity. Finally, the socio-demographic composition of the sample, which was predominantly young, highly educated, and recruited via digital networks, may limit the generalizability of the predictive models. The psychological and behavioral profiles of older adults, marginalized populations without digital access, or those with severe, diagnosed psychiatric comorbidities might yield different predictive feature importances.

Future research should prioritize longitudinal study designs to track the dynamic interplay between personality, behavioral changes, and somatic symptom trajectories over extended periods. This would allow for the application of time-series machine learning forecasting models to predict acute somatic flare-ups before they occur. Additionally, moving beyond self-reported behavioral data is highly recommended. Incorporating objective, continuous physiological data collected via wearable biometric devices—such as actigraphy for precise sleep architecture, continuous heart rate variability for autonomic nervous system tone, and GPS tracking for exact physical activity quantification—would drastically enhance the precision and clinical validity of the predictive algorithms. Furthermore, future investigations should aim to validate these machine learning models across diverse, cross-cultural clinical populations, including patients with diagnosed functional somatic syndromes, severe personality disorders, and chronic localized pain conditions, to determine if the predictive weight of specific personality traits remains stable across different nosological categories.

The findings of this study offer direct implications for clinical practice and preventive healthcare. Healthcare providers and occupational health professionals should strongly consider integrating brief, validated personality assessments—specifically screening for high neuroticism and low conscientiousness—into standard primary care evaluations. By utilizing predictive models, clinicians can identify at-risk individuals early and implement targeted, preventative interventions before severe somatic symptoms consolidate into chronic disorders. Psychoeducational programs should be customized based on a patient's personality profile; for instance, highly neurotic patients may require specific cognitive-behavioral techniques focusing on somatic decatastrophizing and emotional tolerance. Concurrently, behavioral prescriptions must be emphasized as primary medical interventions rather than secondary lifestyle advice. Clinicians should explicitly target sleep hygiene optimization and structured physical exercise routines as core components of the treatment plan for patients presenting with medically unexplained physical symptoms, addressing the physiological foundations of their distress.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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