KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 11 January 2026
Revised 17 March 2026
Accepted 22 March 2026
Initial Publish 28 March 2026
Final Publish 01 July 2026

Journal of Personality and Psychosomatic Research

Volume 4, Issue 3, pp 1-11

E-ISSN: 3041-8542

Modeling the Influence of Fear-Avoidance Beliefs and Cognitive Biases on Psychosomatic Symptom Maintenance Using Machine Learning

Sophie. Nakamanya[1], Andrei. Dumitrescu[2*], Pascal. Reinert[3]

[1] Department of Psychology, Université de Sherbrooke, Sherbrooke, Quebec, Canada
[2] Department of Applied Psychology, University of Bucharest, Bucharest, Romania
[3] Department of Cognitive Psychology, University of Zurich, Zurich, Switzerland

*** Corresponding author email address**: andrei.dumitrescu@unibuc.ro

A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Nakamanya, S., Dumitrescu, A., & Reinert, P. (2026). Modeling the Influence of Fear-Avoidance Beliefs and Cognitive Biases on Psychosomatic Symptom Maintenance Using Machine Learning. *Journal of Personality and Psychosomatic Research, 4*(3), 1-11.
https://doi.org/10.61838/kman.jppr.5159

A B S T R A C T

This study aimed to model the influence of fear-avoidance beliefs and cognitive biases on psychosomatic symptom maintenance using machine learning techniques. A cross-sectional study was conducted among 512 adults recruited from the general population in Romania. Psychosomatic symptom severity was assessed using the Patient Health Questionnaire-15 (PHQ-15), fear-avoidance beliefs were measured with the Fear-Avoidance Beliefs Questionnaire (FABQ), and health anxiety and cognitive bias related to bodily sensations were assessed using the Health Anxiety Inventory and a cognitive bias measure. Data were analyzed using several machine learning algorithms, including Random Forest, Gradient Boosting, Support Vector Regression, and Linear Regression. Model performance was evaluated using mean squared error (MSE), root mean squared error (RMSE), and the coefficient of determination (R^2), and feature importance analysis was conducted to identify the most influential predictors of psychosomatic symptom severity. After data screening, the final sample consisted of 498 participants (mean age = 36.8 ± 11.4 years). The mean psychosomatic symptom score measured by the PHQ-15 was 10.9 ± 5.7. Significant positive correlations were observed between psychosomatic symptoms and health anxiety (r = 0.61), cognitive bias (r = 0.57), and fear-avoidance beliefs (r = 0.52). Among the machine learning models, the Random Forest algorithm demonstrated the best predictive performance, explaining 68% of the variance in psychosomatic symptom severity (R^2 = 0.68). Feature importance analysis indicated that health anxiety, cognitive bias, and fear-avoidance beliefs were the most influential predictors of psychosomatic symptoms. Fear-avoidance beliefs and cognitive biases play a significant role in the maintenance of psychosomatic symptoms.

Keywords: *psychosomatic symptoms, fear-avoidance beliefs, cognitive bias, machine learning, health anxiety, chronic pain*

1. Introduction

Psychosomatic symptoms—defined as physical symptoms that are strongly influenced, maintained, or exacerbated by psychological mechanisms—represent a major challenge for contemporary clinical, psychological, and rehabilitation sciences. Mounting evidence suggests that individuals experiencing persistent bodily complaints often engage in maladaptive cognitive-emotional processes that amplify symptom perception, sustain physiological arousal, and contribute to avoidance of activities that might otherwise facilitate recovery. Across diverse chronic pain and psychosomatic conditions, one of the most influential explanatory frameworks is the fear-avoidance model, a model that has undergone substantial refinement and empirical elaboration over more than two decades. Originating as a model for musculoskeletal pain, it has expanded into a broader conceptual system for understanding symptom persistence in both pain-related and medically unexplained syndromes. At its core, the model proposes that catastrophic interpretations of bodily sensations trigger fear responses, leading to avoidance of movement or normal activity, ultimately resulting in physical deconditioning, heightened vigilance to symptoms, and sustained or escalated distress. Foundational theoretical contributions established the now widely accepted trajectory from catastrophizing to fear, avoidance, and chronicity (Vlaeyen & Linton, 2000). Subsequent updates have emphasized the interconnectedness of these cognitive-behavioral factors and their broader applicability across symptom domains (Vlaeyen & Linton, 2012).

A substantial body of empirical research has corroborated many elements of this framework in clinical populations. For instance, fear-avoidance beliefs have consistently been shown to contribute to pain persistence and disability, particularly among individuals with musculoskeletal disorders (Linton & Shaw, 2018). Research on chronic low back pain, one of the most prevalent and disabling conditions worldwide, consistently highlights the central role of catastrophic thinking and avoidance behaviors. Doménech and colleagues demonstrated that patients with chronic low back pain often exhibit elevated levels of catastrophizing and fear-avoidance beliefs, which together shape pain persistence and functional impairment (Doménech et al., 2025). These findings are echoed in multiple randomized controlled trials and intervention studies. Emotion-focused exposure interventions, for example, have shown notable efficacy in reducing fear and avoidance while simultaneously addressing comorbid anxiety and depressive symptoms in chronic pain patients, suggesting that targeting fear-driven processes yields clinically meaningful improvements (Boersma et al., 2019).

The evidence base also extends beyond musculoskeletal conditions to other domains of chronic pain and psychosomatic health. Research on chronic pelvic pain, for example, underscores the mediating role of fear, avoidance, and attentional biases in shaping symptom perception and distress (Payne et al., 2021). Similar patterns are observed in headache disorders, where fear and avoidance are strongly implicated in disability and symptom maintenance (Rogers et al., 2020). The consistency of these findings across diverse clinical conditions demonstrates the transdiagnostic relevance of cognitive-emotional processes in shaping symptom trajectories. This reinforces the need for more refined theoretical and empirical tools to map these complex interactions more precisely.

Despite the extensive research on this topic, it is well recognized that fear-avoidance beliefs and avoidance behavior do not always align perfectly. De Baets and colleagues highlighted notable discrepancies between individuals' reported fear of movement and their actual avoidance behavior, suggesting that subjective fear is only one component of a broader constellation of factors influencing behavioral choices (De Baets et al., 2023). This discrepancy points toward cognitive biases, attentional tendencies, and individual differences in emotional processing as additional mechanisms that may contribute to psychosomatic symptom maintenance. Related research on personality factors in fibromyalgia further underscores the importance of stable traits that modulate fear-avoidance processes, demonstrating that personality characteristics influence how strongly the fear-avoidance model manifests in clinical populations (Pilar Martínez Narváez-Cabeza de et al., 2011).

Intervention research reinforces the significance of these cognitive-emotional mechanisms. Randomized controlled trials examining mind-body and movement-based therapies have documented changes in fear-avoidance beliefs alongside improvements in pain self-efficacy and coping skills. For example, studies comparing yoga, physical therapy, and educational interventions for chronic low back pain demonstrate that improvements in self-efficacy and reductions in fear-avoidance beliefs play a crucial role in the therapeutic process (Marshall et al., 2022). Likewise, systematic reviews of cognitive behavioral therapy interventions show that CBT reliably improves pain, reduces

fear-avoidance beliefs, and enhances self-efficacy in chronic low back pain patients (Yang et al., 2022). These findings align with earlier work on acceptance- and mindfulness-based interventions, which further suggest that acceptance and values-based action reduce anxiety sensitivity and counteract avoidance tendencies, thereby helping patients disengage from maladaptive cycles of symptom monitoring and catastrophic interpretation (McCracken & Keogh, 2009).

This convergence of evidence strongly supports the central role of cognitive biases—such as attentional bias toward bodily sensations, threat amplification, and catastrophic thinking—in reinforcing fear-avoidance patterns. Indeed, Payne and colleagues demonstrated that attentional bias plays a mediating role between fear, avoidance, and chronic pelvic pain symptoms, highlighting the importance of cognitive processing styles in maintaining pain and distress (Payne et al., 2021). These findings are consistent with broader psychological and clinical science literature, which emphasizes that unhelpful interpretive styles and maladaptive attention patterns are robust predictors of symptom persistence across conditions.

Recent research has also identified additional psychological constructs that modulate the fear-avoidance pathway. For example, investigations in sports medicine demonstrate that mental toughness beliefs play an intermediary role between pain self-efficacy and fear-avoidance behaviors in elite injured athletes, suggesting that resilience-related constructs can either buffer or amplify fear-driven responses to pain (Tawil et al., 2025). Meanwhile, research on perfectionism, affect, and mental performance reveals that cognitive-behavioral interventions can improve emotional and cognitive functioning more broadly, suggesting that psychological flexibility and emotional regulation capacities may serve as important moderators in fear-avoidance processes (Rajaeinia, 2022). Together, these findings underscore the multifaceted psychological architecture underlying the maintenance of chronic pain and psychosomatic symptoms.

Despite the extensive theoretical and clinical literature, traditional statistical methods often struggle to capture the full complexity of interactions among cognitive biases, fear-avoidance beliefs, attentional tendencies, individual differences, and psychosomatic symptoms. Linear approximations, while informative, typically fail to reflect nonlinear relationships, variable interactions, and heterogeneous patterns that characterize psychosomatic presentations. Moreover, patient populations often exhibit substantial variability in symptom expression, cognitive patterns, emotional tendencies, and behavioral responses. This produces a multivariate landscape in which traditional regression models may overlook subtle yet meaningful predictive relationships.

Machine learning has emerged as a powerful set of tools capable of modeling complex, nonlinear relationships among psychological variables in ways that surpass traditional statistical approaches. Unlike classical methods, machine learning models can detect intricate patterns, interactions, and nonlinearities without imposing restrictive parametric assumptions. This positions machine learning as an ideal analytic framework for investigating the combined influence of fear-avoidance beliefs and cognitive biases on psychosomatic symptoms. Yet, despite the theoretical promise, the application of machine learning to fear-avoidance research remains limited, particularly in European samples and general community populations. Most machine learning studies in pain science have focused on biomedical or neuroimaging predictors, leaving psychological predictors relatively underexamined.

The need for nuanced computational modeling is underscored by the substantial variation in participants' belief systems, cognitive tendencies, motivational factors, and behavioral responses, as highlighted in recent clinical and rehabilitation research. Studies on musculoskeletal pain rehabilitation have emphasized the necessity of capturing individual-level differences in fear-avoidance and avoidance behavior to design tailored interventions (De Baets et al., 2023). Similarly, research on in vivo activity among individuals with whiplash injuries observed that fear of movement was strongly associated with reduced physical activity, indicating that fear-avoidance tendencies exert real and measurable effects on behavior (Pedler et al., 2018). These empirical findings highlight the importance of developing predictive models that integrate both cognitive-emotional and behavioral dimensions within a unified analytical framework.

At the same time, emerging evidence suggests that interventions targeting cognitive-emotional mechanisms may produce broader changes in psychological functioning, thereby influencing symptom severity. For example, transdiagnostic emotion-focused exposure treatments have been found to reduce avoidance behaviors across multiple anxiety- and pain-related disorders, offering insight into the generalized mechanisms underlying symptom improvement (Boersma et al., 2019). Interventions that strengthen psychological flexibility, reduce catastrophic thinking, and

JPPR
E-ISSN: 3041-8542

promote adaptive engagement with physical activity may serve as powerful approaches for addressing psychosomatic symptom maintenance. Understanding which cognitive-emotional factors most strongly predict symptom severity—and how these factors interact—can therefore inform more personalized and effective treatment strategies.

Collectively, this literature demonstrates that fear-avoidance beliefs, cognitive biases, attentional tendencies, emotional regulation processes, and individual differences interact dynamically to shape the experience and maintenance of psychosomatic symptoms. Yet no study to date has integrated these psychological factors using advanced machine learning methods in a Romanian population. Addressing this gap has both theoretical and practical importance, offering the potential to refine the fear-avoidance model and to identify the most influential predictors of psychosomatic symptom severity at an individual level.

In light of these considerations, the present study aims to model the influence of fear-avoidance beliefs and cognitive biases on psychosomatic symptom maintenance using machine learning techniques.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional observational design to investigate how fear-avoidance beliefs and cognitive biases contribute to the maintenance of psychosomatic symptoms through machine learning modeling. The research was conducted in Romania and targeted adult participants from the general population as well as individuals reporting persistent psychosomatic complaints. Data were collected between March and July 2025 through both university-affiliated recruitment channels and community outreach. Participants were recruited using a combination of online invitations, advertisements distributed through Romanian academic networks, and announcements in outpatient psychosomatic and general medical clinics.

A total of 512 participants from different regions of Romania took part in the study. Eligibility criteria required participants to be at least 18 years of age, fluent in Romanian, and able to provide informed consent. Individuals with diagnosed severe neurological disorders, active psychotic disorders, or cognitive impairments that could interfere with questionnaire completion were excluded from participation. The final sample included participants with varying levels of psychosomatic symptom severity, enabling the modeling of a broad spectrum of symptom experiences. Demographic information such as age, gender, education level, employment status, and prior medical or psychological diagnoses was collected to control for potential confounding variables in the analysis.

2.2. Measures

Data were collected using a battery of validated self-report psychometric instruments designed to assess psychosomatic symptoms, fear-avoidance beliefs, and cognitive biases associated with symptom perception and health anxiety. Psychosomatic symptom severity was assessed using the Patient Health Questionnaire Somatic Symptom Severity Scale (PHQ-15), a widely used instrument that measures the frequency and severity of common somatic complaints such as fatigue, pain, gastrointestinal problems, and cardiovascular symptoms. The PHQ-15 provides a continuous score reflecting overall somatic symptom burden and has demonstrated good reliability and validity across multiple cultural contexts, including European populations.

Fear-avoidance beliefs were measured using an adapted version of the Fear-Avoidance Beliefs Questionnaire (FABQ), which assesses the extent to which individuals believe that physical activity or daily functioning may worsen their symptoms or lead to injury or illness exacerbation. The questionnaire captures both activity-related and work-related fear-avoidance beliefs and has been widely used in research on chronic pain and psychosomatic conditions. Higher scores on this instrument indicate stronger fear-avoidance tendencies, which are hypothesized to contribute to symptom maintenance through behavioral avoidance and increased bodily monitoring.

Cognitive biases related to symptom interpretation and health threat perception were assessed using the Health Anxiety Inventory (HAI) and a modified Cognitive Bias Questionnaire for Somatic Interpretation. These instruments evaluate patterns of catastrophic interpretation, attentional bias toward bodily sensations, and exaggerated beliefs regarding illness consequences. The measures collectively capture key cognitive mechanisms proposed in cognitive-behavioral models of psychosomatic symptom persistence, including selective attention to bodily sensations, threat amplification, and misinterpretation of benign physical signals.

In addition to these psychometric instruments, participants completed a brief demographic and medical history questionnaire that gathered information on age, gender, educational attainment, current occupation, history of chronic medical conditions, and prior mental health diagnoses. All questionnaires were administered electronically using a secure online survey platform to ensure standardized data collection and minimize missing data. Internal consistency of the instruments within the present sample was evaluated using Cronbach's alpha coefficients prior to the machine learning analysis.

2.3. Data Analysis

Data analysis was conducted using a machine learning framework designed to model complex relationships between psychological variables and psychosomatic symptom severity. Prior to analysis, the dataset underwent preprocessing procedures including data cleaning, missing value handling, normalization of continuous variables, and encoding of categorical demographic variables. Cases with excessive missing data were excluded, while isolated missing responses were handled using multiple imputation techniques to preserve statistical power.

The primary analytical approach involved supervised machine learning algorithms aimed at predicting psychosomatic symptom severity based on fear-avoidance beliefs, cognitive bias measures, and demographic variables. Several algorithms were evaluated to identify the most accurate predictive model, including Random Forest, Support Vector Machines, Gradient Boosting Machines, and regularized regression techniques such as LASSO regression. These algorithms were selected because of their ability to detect nonlinear relationships and interactions between psychological predictors.

To ensure robustness and generalizability of the models, the dataset was divided into training and testing subsets using an 80–20 split. Model training was conducted on the training subset, while predictive performance was evaluated on the unseen test data. In addition, k-fold cross-validation procedures were implemented during model development to reduce overfitting and improve reliability of the predictive estimates. Model performance was assessed using multiple evaluation metrics, including mean squared error, root mean squared error, and coefficient of determination (R^2) for regression models.

Feature importance analysis was performed to determine the relative contribution of fear-avoidance beliefs, cognitive bias variables, and demographic factors to psychosomatic symptom prediction. In tree-based models, feature importance scores were extracted to identify the most influential predictors, while in regularized regression models, standardized coefficients were examined to evaluate predictor strength. This approach allowed for both predictive modeling and interpretative insight into the psychological mechanisms associated with psychosomatic symptom maintenance.

All statistical and machine learning analyses were conducted using Python programming language with relevant scientific computing libraries, including Scikit-learn, Pandas, NumPy, and Matplotlib. Significance thresholds for complementary statistical analyses were set at $p < 0.05$. The analytical framework was designed to combine psychological theory with data-driven modeling, enabling the identification of patterns that may not be easily detectable using traditional statistical methods.

3. Findings and Results

The final dataset included responses from 512 participants after data screening and preprocessing. Cases with extensive missing values exceeding 10% of questionnaire items were removed prior to analysis, resulting in the retention of 498 complete cases for the machine learning and statistical analyses. The mean age of participants was 36.8 years (SD = 11.4), with ages ranging from 18 to 67 years. Women comprised a slightly larger proportion of the sample than men. Educational attainment varied across participants, with the majority having completed at least undergraduate education. Approximately one third of the participants reported a previous diagnosis of a chronic medical condition, while a smaller proportion reported a prior psychological or psychiatric diagnosis.

The overall level of psychosomatic symptom severity, as measured by the PHQ-15, indicated a wide distribution of symptom burden within the sample. The mean PHQ-15 score was 10.9 (SD = 5.7), indicating a moderate average level of somatic symptom severity across participants. Fear-avoidance beliefs and cognitive bias measures also showed substantial variability, allowing for meaningful predictive modeling.

JPPR
E-ISSN: 3041-8542

Table 1

Demographic characteristics of the study sample (N = 498)

Variable	Category	n	Percentage (%)
Gender	Female	292	58.6
	Male	206	41.4
Age Group	18–29	128	25.7
	30–39	164	32.9
	40–49	121	24.3
	50+	85	17.1
Education Level	High School	124	24.9
	Bachelor's Degree	241	48.4
	Master's/Doctorate	133	26.7
Chronic Medical Condition	Yes	169	33.9
	No	329	66.1
Prior Psychological Diagnosis	Yes	91	18.3
	No	407	81.7

Descriptive statistics for the main psychological variables are presented in Table 2. The PHQ-15 scores ranged from 1 to 28, indicating that some participants reported minimal symptoms while others reported high levels of psychosomatic distress. Fear-avoidance beliefs demonstrated moderate average levels in the sample, with some individuals reporting particularly strong avoidance attitudes toward physical activity and daily functioning. Measures of cognitive bias also showed variability, particularly in the domains of catastrophic interpretation and attentional focus on bodily sensations.

Table 2

Descriptive statistics for psychological variables

Variable	Mean	SD	Minimum	Maximum
PHQ-15 Somatic Symptom Score	10.9	5.7	1	28
Fear-Avoidance Beliefs Total	34.6	11.2	7	63
Fear-Avoidance (Activity Subscale)	17.3	6.1	3	32
Fear-Avoidance (Work Subscale)	17.3	6.5	4	31
Health Anxiety Inventory	20.7	8.9	4	43
Somatic Cognitive Bias Score	24.5	9.4	5	46

Internal consistency analyses demonstrated satisfactory reliability for all scales used in the study. The PHQ-15 showed a Cronbach's alpha of 0.88, indicating strong internal consistency. The Fear-Avoidance Beliefs Questionnaire demonstrated an alpha of 0.91 for the total scale, while the activity and work subscales showed alphas of 0.87 and 0.85 respectively. The Health Anxiety Inventory showed a reliability coefficient of 0.89, and the somatic cognitive bias measure demonstrated an alpha of 0.86. These reliability indicators suggested that the instruments performed consistently within the Romanian sample.

Correlation analyses were conducted prior to machine learning modeling to explore relationships between the main psychological variables. Psychosomatic symptom severity was significantly associated with fear-avoidance beliefs, health anxiety, and cognitive bias scores. Participants who reported stronger fear-avoidance attitudes and greater cognitive bias toward bodily sensations tended to report higher levels of psychosomatic symptoms.

JPPR
E-ISSN: 3041-8542

Table 3

Pearson correlations among psychosomatic symptoms, fear avoidance beliefs, and cognitive biases

Variable	PHQ-15	Fear-Avoidance	Health Anxiety	Cognitive Bias
PHQ-15	1.00	0.52	0.61	0.57
Fear-Avoidance	0.52	1.00	0.46	0.41
Health Anxiety	0.61	0.46	1.00	0.63
Cognitive Bias	0.57	0.41	0.63	1.00

All reported correlations were statistically significant at $p < 0.001$. The strongest association was observed between psychosomatic symptom severity and health anxiety ($r = 0.61$), followed by the relationship between psychosomatic symptoms and cognitive bias ($r = 0.57$). Fear-avoidance beliefs were also moderately correlated with symptom severity ($r = 0.52$), suggesting that behavioral avoidance and fear of symptom exacerbation may contribute to symptom persistence.

Machine learning models were then trained to predict psychosomatic symptom severity using fear-avoidance beliefs, cognitive bias scores, health anxiety levels, and demographic variables as predictors. Several supervised learning algorithms were evaluated, including Random Forest Regression, Support Vector Regression, Gradient Boosting Regression, and LASSO regression. Model performance was assessed using mean squared error (MSE), root mean squared error (RMSE), and the coefficient of determination (R^2) on the testing dataset.

Table 4

Performance of machine learning models predicting psychosomatic symptom severity

Model	MSE	RMSE	R^2
Random Forest Regression	10.84	3.29	0.68
Gradient Boosting Regression	11.37	3.37	0.66
Support Vector Regression	12.95	3.60	0.62
LASSO Regression	14.22	3.77	0.58

Among the evaluated models, Random Forest Regression demonstrated the highest predictive accuracy with an R^2 value of 0.68 on the test dataset, indicating that approximately 68% of the variance in psychosomatic symptom severity could be explained by the included psychological and demographic predictors. Gradient Boosting Regression also performed well, explaining 66% of the variance. The Support Vector Regression and LASSO models demonstrated somewhat lower predictive performance but still accounted for more than half of the variance in symptom severity.

Feature importance analysis derived from the Random Forest model revealed that health anxiety was the most influential predictor of psychosomatic symptom severity, followed by somatic cognitive bias scores and fear-avoidance beliefs. Among demographic factors, the presence of a chronic medical condition contributed modestly to prediction accuracy, while age, gender, and education level had comparatively smaller predictive effects.

Specifically, feature importance scores indicated that health anxiety accounted for approximately 31% of the predictive contribution within the model, cognitive bias variables contributed 27%, and fear-avoidance beliefs accounted for 22% of the predictive variance. Demographic factors collectively contributed the remaining 20% of the model's predictive structure.

Further exploratory analysis showed that participants scoring in the highest quartile of fear-avoidance beliefs reported PHQ-15 scores that were on average 4.3 points higher than those in the lowest quartile. Similarly, individuals with high cognitive bias scores demonstrated significantly greater psychosomatic symptom severity compared with those reporting low levels of cognitive bias.

Overall, the results indicate that both cognitive and behavioral psychological mechanisms play a substantial role in the maintenance of psychosomatic symptoms. Machine learning models were able to capture complex interactions between these variables, highlighting the predictive importance of fear-avoidance beliefs and maladaptive cognitive biases in explaining variation in psychosomatic symptom severity within the Romanian sample.

JPPR
E-ISSN: 3041-8542

4. Discussion and Conclusion

The present study examined the influence of fear-avoidance beliefs and cognitive biases on psychosomatic symptom maintenance using a machine learning framework. The findings demonstrated that psychological variables—particularly health anxiety, cognitive bias related to bodily sensations, and fear-avoidance beliefs—were strongly associated with psychosomatic symptom severity. Correlation analyses revealed moderate to strong relationships between psychosomatic symptoms and the primary psychological predictors, with health anxiety showing the strongest association. Furthermore, machine learning modeling indicated that these cognitive-emotional variables collectively explained a substantial proportion of the variance in psychosomatic symptom severity, with the Random Forest model accounting for approximately 68% of the variance in symptom scores. Feature importance analysis further demonstrated that health anxiety, cognitive bias, and fear-avoidance beliefs were the most influential predictors within the model. These findings support the theoretical proposition that maladaptive cognitive and behavioral processes play a central role in the persistence of psychosomatic symptoms.

One of the most important findings of the study is the strong association between psychosomatic symptom severity and health anxiety. Participants with higher levels of health-related worry and heightened attention to bodily sensations reported significantly greater symptom burden. This finding is consistent with prior psychosomatic research emphasizing the role of cognitive-emotional mechanisms in amplifying physical symptom perception. Cognitive processes such as catastrophic interpretation and attentional bias toward bodily sensations can increase symptom salience and reinforce maladaptive interpretations of normal physiological experiences. Similar patterns have been reported in research examining chronic pelvic pain, where fear, avoidance, and attentional bias were found to mediate the relationship between cognitive processes and symptom severity (Payne et al., 2021). In such models, individuals who interpret bodily sensations as threatening are more likely to experience persistent distress and symptom amplification. The current findings therefore support the growing body of evidence suggesting that health-related cognitive biases contribute substantially to psychosomatic symptom maintenance.

The results also demonstrated that cognitive bias scores were among the strongest predictors of psychosomatic symptoms in the machine learning model. Individuals who exhibited stronger tendencies toward catastrophic interpretation and attentional bias reported significantly higher somatic symptom severity. This finding aligns with theoretical perspectives suggesting that biased cognitive processing plays a crucial role in maintaining symptom distress. Cognitive biases may lead individuals to selectively attend to bodily sensations, exaggerate perceived threat, and interpret ambiguous physiological signals as signs of illness. These processes reinforce a feedback loop in which anxiety and symptom monitoring increase the perceived intensity of physical symptoms. Similar conclusions have been drawn in cognitive-behavioral research examining pain and psychosomatic conditions, which emphasizes the importance of maladaptive interpretive styles in sustaining symptom distress. Cognitive-behavioral interventions designed to modify such biases have demonstrated significant improvements in pain and functional outcomes among patients with chronic pain conditions (Yang et al., 2022). The present findings reinforce the importance of addressing cognitive biases when designing therapeutic strategies for psychosomatic disorders.

Fear-avoidance beliefs also emerged as a significant predictor of psychosomatic symptom severity. Participants with stronger beliefs that activity or movement might worsen their symptoms tended to report higher levels of somatic distress. This result strongly supports the fear-avoidance model originally proposed to explain chronic musculoskeletal pain. According to this model, catastrophic interpretations of bodily sensations lead to fear of movement or activity, which subsequently results in avoidance behaviors that reinforce disability and symptom persistence (Vlaeyen & Linton, 2000). Over time, avoidance behaviors may reduce physical conditioning, increase bodily vigilance, and reinforce maladaptive beliefs about vulnerability to harm. Later theoretical developments expanded this model by emphasizing the dynamic interplay between cognitive, emotional, and behavioral processes in the maintenance of chronic pain conditions (Vlaeyen & Linton, 2012). The present findings are consistent with these theoretical perspectives, demonstrating that fear-avoidance beliefs remain a powerful psychological factor associated with psychosomatic symptom severity.

The observed association between fear-avoidance beliefs and symptom severity is also supported by a growing body of empirical research across various chronic pain conditions.

Studies examining chronic musculoskeletal pain have consistently demonstrated that fear-avoidance beliefs contribute significantly to pain persistence and disability. For instance, research has shown that individuals who strongly believe that physical activity may worsen pain are more likely to avoid movement and engage in protective behaviors that ultimately prolong their symptoms (Linton & Shaw, 2018). Similarly, cross-sectional studies in chronic low back pain populations have documented strong relationships between catastrophizing, fear-avoidance beliefs, and pain intensity (Doménech et al., 2025). The findings of the present study extend this evidence by demonstrating that fear-avoidance beliefs are not only relevant in musculoskeletal conditions but may also contribute to broader psychosomatic symptom experiences in general populations.

Another important observation from the current study is that the machine learning models captured complex interactions between psychological variables, suggesting that psychosomatic symptom maintenance cannot be explained by any single factor alone. Instead, symptom persistence appears to emerge from the combined influence of cognitive biases, emotional responses, and behavioral avoidance patterns. This interpretation aligns with recent research highlighting discrepancies between reported fear and actual avoidance behavior. De Baets and colleagues noted that individuals may report fear of movement without necessarily engaging in avoidance behavior, suggesting that cognitive-emotional factors interact in complex ways to shape behavioral responses (De Baets et al., 2023). Machine learning methods are particularly well suited to identifying such multidimensional interactions, as they can detect nonlinear relationships and complex predictor combinations that traditional statistical approaches may overlook.

The role of behavioral avoidance observed in the present study is also consistent with research examining physical activity patterns among individuals with pain-related disorders. Studies investigating the fear-avoidance model in people with whiplash injuries have demonstrated that fear of movement is associated with reduced real-world activity levels (Pedler et al., 2018). Such avoidance behaviors can lead to decreased physical conditioning and increased sensitivity to bodily sensations, thereby reinforcing the perception of vulnerability and symptom persistence. The current findings support this behavioral dimension of the fear-avoidance model, suggesting that avoidance beliefs may indirectly sustain psychosomatic symptoms through behavioral restriction and increased bodily monitoring.

The predictive importance of psychological variables observed in the machine learning analysis also highlights the relevance of psychological interventions in managing psychosomatic symptoms. Randomized controlled trials examining treatments for chronic pain conditions have shown that interventions targeting fear-avoidance beliefs and cognitive biases can produce meaningful improvements in both psychological and physical outcomes. For example, studies comparing yoga, physical therapy, and educational interventions for chronic low back pain have found that reductions in fear-avoidance beliefs and improvements in self-efficacy are strongly associated with symptom improvement (Marshall et al., 2022). Similarly, exposure-based and emotion-focused treatments have demonstrated efficacy in reducing fear and avoidance while improving emotional functioning among chronic pain patients (Boersma et al., 2019). These findings support the notion that modifying maladaptive cognitive-emotional patterns can interrupt the cycle of fear and avoidance that sustains symptom persistence.

Individual differences may also shape how fear-avoidance processes influence symptom experiences. Research on personality traits in fibromyalgia patients suggests that dispositional characteristics influence the degree to which individuals engage in catastrophic thinking and avoidance behaviors (Pilar Martínez Narváez-Cabeza de et al., 2011). Similarly, resilience-related constructs such as mental toughness have been shown to mediate the relationship between self-efficacy and fear-avoidance beliefs among injured athletes (Tawil et al., 2025). These findings suggest that psychosomatic symptom maintenance may be influenced by broader psychological resources and personality characteristics that either buffer or amplify fear-based responses to bodily sensations.

Furthermore, psychological flexibility and acceptance processes may serve as protective mechanisms against fear-avoidance cycles. Acceptance- and mindfulness-based frameworks emphasize the importance of engaging with meaningful activities despite discomfort, thereby reducing avoidance patterns and emotional distress. Empirical research indicates that acceptance and values-based action can counteract fear and emotional avoidance in chronic pain populations (McCracken & Keogh, 2009). The present findings are consistent with this perspective, as they highlight the central role of cognitive-emotional factors in shaping symptom experiences.

Overall, the results of the present study support a multidimensional conceptualization of psychosomatic

symptom maintenance in which cognitive biases, fear-avoidance beliefs, and emotional processes interact to influence symptom perception and behavior. The application of machine learning methods allowed for the identification of complex relationships among these variables, providing new insights into the psychological mechanisms underlying psychosomatic symptom persistence. By integrating theoretical models of fear-avoidance with data-driven predictive modeling, the study contributes to a more comprehensive understanding of the cognitive-behavioral processes that sustain psychosomatic symptoms.

Several limitations should be considered when interpreting the findings of the present study. First, the cross-sectional design limits the ability to draw causal conclusions regarding the relationships between fear-avoidance beliefs, cognitive biases, and psychosomatic symptom severity. Although strong associations were identified, it is not possible to determine the directionality of these relationships. Longitudinal studies would be necessary to examine how these psychological processes evolve over time and whether they directly contribute to the development or persistence of psychosomatic symptoms.

Second, the study relied exclusively on self-report measures to assess psychological variables and symptom severity. Self-report instruments are vulnerable to response biases, including social desirability and recall bias, which may influence the accuracy of reported experiences. Future research could benefit from incorporating objective behavioral measures, physiological indicators, or ecological momentary assessment techniques to capture real-time symptom experiences and behavioral responses.

Third, although the sample size was adequate for machine learning modeling, the study population was drawn from a single national context. Cultural, social, and healthcare system differences may influence how individuals interpret bodily sensations and respond to symptoms. Therefore, the generalizability of the findings to other populations or cultural contexts may be limited. Replication studies in diverse populations would be necessary to confirm the robustness of the identified relationships.

Future research should prioritize longitudinal designs to better understand the temporal dynamics of fear-avoidance beliefs, cognitive biases, and psychosomatic symptom development. Tracking individuals over time would allow researchers to determine whether these psychological factors predict symptom onset, escalation, or recovery. Such studies could provide stronger evidence regarding causal mechanisms underlying psychosomatic symptom persistence.

Another important direction for future research involves the integration of multimodal data sources into predictive models. Combining psychological assessments with physiological indicators, behavioral activity data, and digital health monitoring could provide a more comprehensive understanding of psychosomatic symptom mechanisms. Machine learning approaches are particularly well suited for integrating these complex datasets and identifying patterns that may not be apparent through traditional analytical methods.

Future studies could also explore moderating variables that influence fear-avoidance processes, including personality traits, resilience factors, coping styles, and social support. Identifying these moderating factors may help explain why some individuals develop persistent psychosomatic symptoms while others recover more rapidly. Such knowledge could inform the development of personalized intervention strategies tailored to individual psychological profiles.

The findings of this study have several implications for clinical and rehabilitation practice. First, clinicians should carefully assess fear-avoidance beliefs and cognitive biases when evaluating individuals with persistent psychosomatic symptoms. Understanding how patients interpret and respond to bodily sensations may provide valuable insight into the psychological processes that maintain their symptoms.

Second, psychological interventions that directly target maladaptive cognitive-emotional processes may be particularly effective in reducing psychosomatic symptom severity. Cognitive-behavioral strategies aimed at modifying catastrophic thinking, reducing attentional bias toward bodily sensations, and encouraging gradual reengagement with avoided activities may help interrupt the cycle of fear and avoidance.

Finally, interdisciplinary treatment approaches that integrate psychological, behavioral, and physical rehabilitation strategies may provide the most effective pathway for managing psychosomatic symptoms. Addressing both cognitive-emotional processes and behavioral patterns can promote functional recovery, improve coping capacity, and reduce the long-term burden of psychosomatic conditions.

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.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

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

References

Boersma, K., Södermark, M., Hesser, H., Flink, I. K., Gerdle, B., & Linton, S. J. (2019). Efficacy of a transdiagnostic emotion–focused exposure treatment for chronic pain patients with comorbid anxiety and depression: a randomized controlled trial. *Pain*, *160*(8). https://journals.lww.com/pain/fulltext/2019/08000/efficacy_of_a_transdiagnostic_emotion_focused.6.aspx

De Baets, L., Meulders, A., Van Damme, S., Caneiro, J. P., & Matheve, T. (2023). Understanding Discrepancies in a Person's Fear of Movement and Avoidance Behavior: A Guide for Musculoskeletal Rehabilitation Clinicians Who Support People With Chronic Musculoskeletal Pain. *Journal of Orthopaedic & Sports Physical Therapy*, *53*(5), 307-316. https://doi.org/10.2519/jospt.2023.11420

Doménech, J., Angulo, A. E., Peñalver-Barrios, L., Rio-González, E. D., Herrero, R., García-Palacios, A., Díaz, M. M., Garreta-Catalá, I., Díez-Ulloa, M.-A., & Baños-Rivera, R. M. (2025). Catastrophizing and Fear Avoidance Beliefs in Chronic Low Back Pain: A Cross-Sectional Study. *European Journal of Physical and Rehabilitation Medicine*, *61*(2). https://doi.org/10.23736/s1973-9087.25.08419-9

Linton, S. J., & Shaw, W. S. (2018). Impact of fear-avoidance beliefs on pain persistence: Implications for rehabilitation interventions. *Pain Management*, *8*(6), 405-415. https://doi.org/10.2217/pmt-2018-0032

Marshall, A., Joyce, C. T., Tseng, B., Gerlovin, H., Yeh, G. Y., Sherman, K. J., Saper, R. B., & Roseen, E. J. (2022). Changes in Pain Self-Efficacy, Coping Skills, and Fear-Avoidance Beliefs in a Randomized Controlled Trial of Yoga, Physical Therapy, and Education for Chronic Low Back Pain. *Pain Medicine*, *23*(4), 834-843. https://doi.org/10.1093/pm/pnab318

McCracken, L. M., & Keogh, E. (2009). Acceptance, mindfulness, and values-based action may counteract fear and avoidance of emotions in chronic pain: an analysis of anxiety sensitivity. *The Journal of Pain*, *10*(4), 408-415. https://doi.org/10.1016/j.jpain.2008.09.015

Payne, R. T., Holloway, D., & Mercer, L. (2021). Cognitive-emotional mechanisms in chronic pelvic pain: The mediating role of fear, avoidance, and attentional bias. *Journal of psychosomatic research*, *145*, 110473. https://doi.org/10.1016/j.jpsychores.2021.110473

Pedler, A., Kamper, S. J., Maujean, A., & Sterling, M. (2018). Investigating the fear avoidance model in people with whiplash: the association between fear of movement and in vivo activity. *The Clinical Journal of Pain*, *34*(2), 130-137. https://doi.org/10.1097/AJP.0000000000000524

Pilar Martínez Narváez-Cabeza de, V., Sánchez, A. I., Miró, E., Medina, A., & Lami, M. J. (2011). The Relationship Between the Fear-Avoidance Model of Pain and Personality Traits in Fibromyalgia Patients. *Journal of Clinical Psychology in Medical Settings*, *18*(4), 380-391. https://doi.org/10.1007/s10880-011-9263-2

Rajaeinia, A. (2022). Effectiveness of Cognitive Behavior Group Therapy on decreasing perfectionism, increasing positive affect and mental performance in Female Clergies. *International Journal of Education and Cognitive Sciences*, *2*(4), 45-53. https://doi.org/10.22034/injoeas.2022.160688

Rogers, D. G., Protti, T. A., & Smitherman, T. A. (2020). Fear, Avoidance, and Disability in Headache Disorders. *Current Pain and Headache Reports*, *24*, 1-8. https://doi.org/10.1007/s11916-020-00865-9

Tawil, S., Kassis, V., Bassil, T., Farhat, K., Hourani, E., Massoud, L., & Najem, C. (2025). Intermediary role of mental toughness beliefs on the relationship between pain self-efficacy and fear avoidance in Elite injured athletes. *BMC Sports Science, Medicine and Rehabilitation*, *17*(1), 124. https://doi.org/10.1186/s13102-025-01171-w

Vlaeyen, J. W., & Linton, S. J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: A state of the art. *Pain*, *85*(3), 317-332. https://doi.org/10.1016/S0304-3959(99)00242-0

Vlaeyen, J. W. S., & Linton, S. J. (2012). Fear-avoidance model of chronic musculoskeletal pain: 12 years on. *Pain*, *153*(6), 1144-1147. https://doi.org/10.1016/j.pain.2011.12.009

Yang, J., Lo, W. L. A., Zheng, F., Cheng, X., Yu, Q., & Wang, C. (2022). Evaluation of Cognitive Behavioral Therapy on Improving Pain, Fear Avoidance, and Self-Efficacy in Patients with Chronic Low Back Pain: A Systematic Review and Meta-Analysis. *Pain Research and Management*, *2022*(1), 4276175. https://doi.org/10.1155/2022/4276175

JPPR
E-ISSN: 3041-8542