SIN-CHN SCIENTIFIC PRESS PTE.LTD.

Molecular & Cellular Biomechanics 2024, 21(1), 256.
https://doi.org/10.62617/mcb.v21i1.256

Article

Study on the sports biomechanics prediction, sport biofluids and assessment of college students' mental health status transport based on artificial neural network and expert system

Haixia Yue[1], Jun Cui[2,*], Xiaoxue Zhao[3], Yin Liu[3], Hao Zhang[3], Mingyi Wang[4,*]

[1] Department of Physical Education, Xi'an University of Science and Technology, Xi'an 710054, Shaanxi, China
[2] Solbridge International School of Business, Woosong University, Daejeon 34613, Republic of Korea
[3] Xi'an Physical Education University, Xi'an 710068, Shaanxi, China
[4] Guangzhou Institute of Applied Science and Technology, Guangzhou 511370, Guangdong, China
*** Corresponding authors:** Jun Cui, jcui228@student.solbridge.ac.kr; Mingyi Wang, 154401204@qq.com

CITATION

Yue H, Cui J, Zhao X, et al. Study on the sports biomechanics prediction, sport biofluids and assessment of college students' mental health status transport based on artificial neural network and expert system. Molecular & Cellular Biomechanics. 2024; 21(1): 256. https://doi.org/10.62617/mcb.v21i1.256

ARTICLE INFO

Received: 22 July 2024
Accepted: 12 August 2024
Available online: 9 October 2024

Abstract: Based on the theories of artificial neural networks and expert systems, this study constructs a model for assessing the sports biomechanics' mental health of college students using artificial neural networks and expert systems. It assesses the sports biomechanics' mental health status of college students who had their yoga classes suspended during the COVID-19 pandemic. Meanwhile, A mobile questionnaire was used to collect information on students' personal circumstances, sport biofluids and yoga exercise routines, as well as data from the Depression Anxiety Stress Scales (DASS-21). This study presents a novel approach to assessing the intersection of sports biomechanics and mental health by employing Artificial Neural Networks (ANNs) and expert systems. Unlike previous research in this domain, this study offers an extensive review of the literature, highlighting both the distinctive contributions of ANNs and expert systems and the existing gaps in current methodologies. Similarly, a univariate analysis method was utilized to quantitatively assess the impact of yoga interventions and other factors on college students' sports biomechanics and mental health. Building on this analysis, an artificial neural network (ANN) model was developed to predict mental health outcomes and sport biofluid conditions. The model focused on evaluating the significance of various variables, with particular attention to the contribution of yoga exercise routines. In short, this approach aims to enhance the understanding and support for utilizing yoga interventions to improve college students' mental health within the context of sports biomechanics, especially in the post-pandemic era. The findings should make an important contribution to the field of integrating ANNs with expert systems and sports biomechanics improves mental health prediction accuracy.

Keywords: college students; sports biomechanics' mental health; sport biofluids; yoga intervention; artificial neural network (ANN); expert system; depression anxiety stress scales (DASS-21)

1. Introduction

Artificial Neural Networks (ANNs) emulate the functioning of human neural networks, effectively simulating the brain's structure and information processing capabilities [1]. These networks consist of numerous processing units, or "neurons," interconnected in specific patterns to create a large-scale, nonlinear, adaptive system capable of executing complex logical operations. ANNs are characterized by their strong adaptability, self-learning capabilities, associative memory, and high fault tolerance, which make them particularly well-suited for handling intricate information, incomplete datasets, and problems that are challenging to describe with traditional mathematical models [2,3]. Expert systems, based on knowledge matching and deep symbolic reasoning, effectively complement ANNs [4]. The integration of expert systems and neural networks can be categorized into hierarchical and hybrid approaches. In the hierarchical approach, expert systems and neural networks form a serial structure, each performing its respective functions in heuristic logic reasoning or data computation and discrimination [5]; in the hybrid approach, neural networks and sports biomechanics are used to implement the functions of expert systems, converting classical symbolic reasoning into numerical computation-based reasoning to enhance the efficiency and learning capabilities of expert systems. This integration method is widely adopted due to its advantages [6,7].

Mental health issues, including stress, anxiety, and depression, are increasingly prevalent among college students, adversely affecting their academic performance and overall well-being. Traditional prediction and intervention methods often struggle with accuracy and adaptability. Recent advancements in Artificial Neural Networks (ANNs) offer a promising alternative, given their capability to model complex, non-linear relationships and manage incomplete data. This study investigates the potential of integrating ANNs with expert systems and sports biomechanics to enhance prediction accuracy. Meanwhile, by incorporating sports activities such as yoga, this approach aims to provide a more nuanced understanding and management of mental health outcomes, offering a novel solution to improve mental health predictions and interventions [7–9].

In early 2020, the outbreak of COVID-19, caused by the novel coronavirus (2019-nCoV), triggered a global crisis, reshaping the global economy and public safety landscape. Adolescents, being at a critical stage of psychological and physiological development with insufficient self-regulation capabilities, are at a high risk of mental health disorders. College students were among the groups significantly affected during the pandemic. Researchers [10] found in their survey of 405 college students that 44.0% exhibited symptoms of depression, 42.2% experienced anxiety, and 29.4% felt stressed, possibly related to prolonged home isolation and excessive online entertainment [8,9]. Universities play a crucial role in enhancing college students' sports biomechanics mental health literacy, making it vital to adopt necessary interventions to improve their psychological well-being. Accurate prediction and assessment of mental health are essential steps for implementing scientific and reasonable interventions. This paper proposes a concept for a college student mental health prediction, Sport biofluids and assessment system based on neural networks and expert systems, aiming to provide scientific evidence and support for promoting college students' mental health through yoga exercises in the post-pandemic era [10–13].

Despite the advancements in predicting mental health conditions with Artificial Neural Networks (ANNs), existing models often encounter challenges with accuracy, especially in predicting depression. A significant gap exists in integrating ANN predictions with expert systems and sports biomechanics, which could potentially enhance prediction precision. This study seeks to address this gap by combining ANNs with expert systems and incorporating sports biomechanics data, including yoga practices. The goal is to refine the accuracy of mental health predictions and offer a more comprehensive framework for understanding and managing mental health issues among college students [3–5].

This study is structured to provide a thorough exploration of enhancing mental health predictions through advanced computational techniques. It begins with a detailed literature review that examines current research on mental health prediction models and their limitations. The methodology section follows, describing how Artificial Neural Networks (ANNs) are integrated with expert systems and sports biomechanics. In the results section, the accuracy of this hybrid approach is presented, showcasing improvements over traditional models. The discussion then interprets these findings, emphasizing the advancements achieved. The manuscript concludes with a summary of the study's contributions, an acknowledgment of its limitations, and recommendations for future research. This structure ensures a comprehensive examination of how the combination of ANNs, expert systems, and sports biomechanics can significantly enhance mental health predictions [3–6].

2. Literature review

2.1. The comprehensive literature review that contextualizes your study

The application of Artificial Neural Networks (ANNs) in predicting mental health conditions has gained substantial interest due to their flexibility and capacity to process intricate datasets. Modeled after the human neural network, ANNs are adept at managing non-linear relationships and incomplete information, which makes them particularly useful for predicting mental health issues such as stress, anxiety, and depression [7]. These networks function through interconnected nodes or "neurons," which adjust weights and biases during the training phase to refine prediction accuracy. This mechanism endows ANNs with robust self-learning abilities and fault tolerance [7,8]. In the context of mental health, ANNs have been utilized to model a range of psychological conditions with varying degrees of success. Research indicates that while ANNs can effectively predict stress and anxiety, they face challenges in accurately forecasting depression due to its complex and multifaceted nature [8,9]. This underscores the need for incorporating supplementary data sources and methodologies to enhance the precision of mental health predictions. Integrating additional features and leveraging advanced modeling techniques could potentially address the limitations observed and provide more reliable outcomes for mental health assessment.

The integration of expert systems with Artificial Neural Networks (ANNs) offers a promising avenue for improving predictive performance in mental health modeling. Expert systems utilize knowledge-based reasoning and symbolic logic to provide structured decision-making frameworks, which complement the data-driven nature of ANNs [8,9]. This can be achieved through hierarchical integration, where expert systems and ANNs are combined sequentially, or through a hybrid approach that merges symbolic and numerical reasoning by converting symbolic rules into quantitative data. Such integration enhances the learning capabilities and efficiency of ANNs, addressing some of the limitations inherent in using ANNs alone. Additionally, incorporating sports biomechanics into mental health modeling has garnered attention, with research indicating that physical activities, such as yoga, significantly influence mental health outcomes [7–9]. By combining these insights with the methodologies of ANNs and expert systems, the proposed framework provides a robust approach for predicting and managing mental health issues, particularly in populations like college students. In short, this study advances existing literature by integrating ANNs, expert systems, and sports biomechanics, offering an innovative approach to addressing psychological challenges through advanced computational methods. This combination aims to enhance the accuracy and applicability of mental health predictions, reflecting a significant development in the field.

2.2. Compare your study to existing research to highlight its novelty and contribution

This study distinguishes itself from existing research by integrating Artificial Neural Networks (ANNs), expert systems, and sports biomechanics to predict mental health states. While previous research has established the effectiveness of ANNs in predicting stress and anxiety, their application to depression has shown limited precision. Many studies focus solely on ANNs, often neglecting the potential benefits of combining these models with expert systems [7].

Our approach introduces a hybrid methodology that merges the symbolic reasoning capabilities of expert systems with the numerical prowess of ANNs, thereby enhancing prediction accuracy [8]. Furthermore, by incorporating data on sports biomechanics—such as yoga practices—this study offers a novel perspective on the impact of physical activities on mental health outcomes, an area that has received less attention in current literature [9]. This integrated framework not only addresses the limitations of existing models but also provides a comprehensive approach that leverages diverse data sources for improved mental health predictions. Besides, this innovative methodology contributes new insights and practical applications in the field, offering a more nuanced understanding of the relationship between physical activities and mental health.

2.3. The multi-theoretical framework

Neural network theory: This theory underpins the use of Artificial Neural Networks (ANNs) to model complex data patterns. Inspired by the structure and function of the human brain, ANNs consist of interconnected processing units or neurons that capture non-linear relationships and adapt to incomplete data. This allows for nuanced understanding and prediction of mental health conditions.

Expert systems theory: To improve prediction accuracy, Expert Systems Theory integrates symbolic reasoning with the outputs of ANNs. This approach combines rule-based decision-making with data-driven models, enhancing the interpretability and precision of predictions by incorporating structured knowledge.

Sports biomechanics theory: This theory is applied to examine how physical activities, such as yoga, influence mental health. By integrating sports biomechanics, the study accounts for the impact of physical interventions on psychological well-being, providing a more holistic view of mental health management.

According to above theories, these theories form a comprehensive framework that leverages computational methods and physical activity data to advance the accuracy and effectiveness of mental health predictions [9].

The structure of the paper is organized into six distinct sections to systematically address the research objectives. Part 2 presents a comprehensive review of relevant literature, highlighting existing theories, methodologies, and gaps in the current understanding. Part 3 delves into user knowledge and provides an in-depth exploration of the sports biomechanics and mental health, offering insights into its application. Part 4 details the research methodology and includes data analysis to illustrate the practical implementation of the theoretical concepts. The findings are discussed in Part 5, where the implications of the results are analyzed in relation to the research questions. Finally, Part 6 summarizes the conclusions, acknowledges the study's limitations, and suggests directions for future research to advance the field.

3. Materials and methods

3.1. Data collection

This study conducted an online survey from 27 May to 30 May 2020. The participants were college students from across the country enrolled in yoga classes, all of whom were in a suspended class status at home and regularly participated in online yoga course exercises and sports biomechanics exercises. The survey was mainly conducted through the "Questionnaire Star" online survey platform, and participants were invited through the WeChat social software by the Yoga Association of Xi'an University of Science and Technology. A total of 2839 students' valid information was collected. Geographically, the vast majority were from regions outside Hubei (about 99.2%), including students from the first to the fourth year of college, with 225 males and 2614 females, aged between 17–23 years. The questionnaire content mainly included basic information, yoga exercise conditions, and mental health status.

A. Personal information and yoga exercise conditions: This section mainly includes basic information, lifestyle habits, and factors related to yoga interventions, as shown in **Table 1**:

Table 1. Personal information and yoga exercise conditions.

No.	Question	Options
1	Your gender	1. Male 2. Female
2	Your major	1. Science and Engineering 2. Literature and History 3. Finance and Economics 4. Sports and Arts 5. Social Sciences
3	Your grade	1. Freshman 2. Sophomore 3. Junior 4. Senior
4	Your age	1. Under 18 2. 18–19 years old 3. 20–21 years old 4. Over 21 years old
5	Your weight	(kg)
6	Your height	(cm)
7	Your current relationship status	1. In a relationship 2. Not in a relationship
8	Your approximate monthly living expenses	1. Below 1 k 2. 1 k–1.5 k 3. 1.5 k–2 k 4. Above 2 k
9	Your average weekly internet usage time	1. Within 1 h 2. 1–3 h 3. 3–5 h 4. More than 5 h

Table 1. (*Continued*).

No.	Question	Options
10	Do you have a habit of exercising	1. Yes 2. No
11	Your exercise frequency	1. Almost never 2. 1–2 times a week 3. 3–4 times a week 4. 5–6 times a week 5. Almost every day
12	Your purpose for practicing yoga	1. To relieve psychological stress 2. For physical fitness 3. Both of the above
13	Your form of yoga practice	1. Mindfulness training 2. Asanas 3. Combination of mindfulness training and asanas
14	Your frequency of yoga practice per week	1. Once 2. 2–3 times 3. 3–5 times
15	Your duration of each yoga session	1. About 30 min 2. About 60 min 3. About 90 min

Note: Source: Author's own creation.

B. Sports biomechanics' mental health level survey: The sports biomechanics' mental health level survey utilized the classic DASS-21 questionnaire to test the mental health levels of the respondents. The DASS-21 is widely used internationally, and its reliability and validity have been well verified. Gong et al. [11] first introduced this scale to China and tested it among college student populations. The results indicated that the DASS-21 test could scientifically reflect the characteristics of depression, anxiety, and stress levels among college students in Chinese universities [10,11]. The Depression Anxiety Stress Scale (DASS) comprises three subscales (see **Table 2**), each assessing an individual's perceived level of typical negative emotions: depression, anxiety, and stress. Each subscale contains 7 items, totaling 21 items, as detailed in the following **Table 2**. For each item, respondents are required to choose the option that best matches their recent true feelings. Meanwhile, each item is scored on a 0–3-point scale, where 0 indicates does not apply, 1 indicates applies some of the time, 2 indicates applies often, and 3 indicates applies most of the time. The scoring formula is: Subscale score = Sum of scores for the 7 items × 2. Based on the scores and referring to the DASS-21 subscale grading standards [12,13], the levels of depression, anxiety, and stress emotions are classified, as shown in **Table 2**. Higher scores indicate more severe levels of depression, transport, anxiety, and stress.

Table 2. Classification of depression, anxiety, and stress levels.

	Normal	Mild	Moderate	Severe	Extremely Severe
Depression	≤9	10~13	14~20	21~27	≥28
Anxiety	≤7	8~9	10~14	15~19	≥20
Stress	≤14	15~18	19~25	26~33	≥34

Note: Source: author's own creation.

3.2. Analysis methods

A. Questionnaire reliability and validity test: Reliability analysis uses the internal consistency coefficient method, calculating Cronbach's alpha coefficient as the reliability evaluation. Structural validity testing employs exploratory factor analysis, with factor loading >0.50 as the criterion for questionnaire item exclusion. The maximum variance method is chosen for factor rotation, calculating the KMO value and performing the Bartlett's test of sphericity.

B. Univariate analysis: A univariate analysis using *T*-test or *F*-test is conducted on the Sports biomechanics' mental health levels (depression, anxiety, stress) across different genders, majors, grades, ages, BMIs, relationship statuses, living expenses, internet usage time, exercise habits, exercise frequencies, and yoga exercise conditions [11–13].

C. Prediction of sports biomechanics' mental health levels and analysis of variable importance: An artificial neural network machine learning model is established with the mental health status levels as the target variable and statistically significant influencing factors as input features, using a confusion matrix to evaluate model prediction accuracy [13,14]. A 10-fold cross-validation method is employed to train the model, i.e., the total sample is randomly divided into 10 parts at a 9:1 ratio, with 9 parts used for training modeling (training set) and 1 part used for evaluating model prediction effects (test set). Artificial Neural Network (ANN) Prediction System Design. Artificial neural networks, by simulating the brain's processing of information through extensive neuronal interactions, are a type of abstract mathematical model for distributed parallel information processing. Among the many artificial neural network algorithms, the ANN neural network model with backpropagation algorithm is one of the most commonly used [14]. The architecture of an ANN neural network consists of an input layer, hidden layers, and an output layer, each layer having a set of interconnected nodes (neurons) working in parallel [14].

D. Statistical software: The questionnaire reliability and validity test and univariate analysis are performed using SPSS 22.0, while the prediction of Sports biomechanics' mental health levels and analysis of variable importance are completed using the scikit-learn library in Python.

3.3. Proposed model

Furthermore, the proposed model incorporates Artificial Neural Networks (ANNs) to predict mental health states such as stress, anxiety, and depression by analyzing a range of input variables, including sports participation, yoga practice, and daily internet usage. Methodologically, the model utilizes a multi-layered ANN architecture with backpropagation for training, ensuring high prediction accuracy. Likewise, the implementation process involves several key steps: preprocessing data to normalize and encode input variables, training the model on a designated training dataset, and validating its performance using cross-validation techniques. This comprehensive approach facilitates precise prediction of mental health outcomes and enables the evaluation of how various physical activities impact mental well-being. The proposed model combines Artificial Neural Networks (ANNs) with expert systems to predict mental health states and integrate sports biomechanics. To represent this model mathematically, we can use the following formula:

$$\text{Mental Health Score} = f\left(\sum_{j=1}^{m} w_j \times x_j + b\right) + g(\text{Expert System Output, Biomechanics Data})$$

where x_j are the input features (e.g., sports participation, yoga practice, daily internet usage).

w_j represents the weights assigned to each input, and b is the bias term. And f is the activation function applied to the weighted sum of inputs plus the bias, enabling the network to perform complex logical operations.

4. Result

4.1. Reliability test

The reliability analysis results show that the overall Cronbach's alpha coefficient of the questionnaire is 0.91, indicating that the overall reliability of the questionnaire is acceptable. The structural validity test results show a KMO value of 0.86 and pass the Bartlett's test of sphericity, indicating good structural validity of the questionnaire. Meanwhile, the study employed a multifaceted methodology to enhance the reliability and validity of its findings. Data collection was conducted using standardized surveys and validated questionnaires, aimed at minimizing self-reporting biases. To further ensure accuracy, the study utilized multiple measures of mental health status, including scales for stress, anxiety, and depression. Machine learning models, specifically Artificial Neural Networks (ANNs), were rigorously trained and validated through cross-validation techniques, ensuring precise and reliable predictions. Additionally, the study incorporated consistent monitoring of key variables, such as sports participation and internet usage, which contributed to the robustness and depth of the results.

The brief duration of the survey poses a limitation in capturing the long-term effects of yoga and physical activities on mental health. To overcome this constraint, future research should consider extending the survey period or adopting longitudinal study designs. Such approaches will allow for the monitoring of mental health changes over an extended timeframe, offering a more comprehensive evaluation of how sustained engagement in yoga and other physical activities influences stress, anxiety, and depression. Therefore, this extended observation will provide a clearer understanding of the long-term benefits and effectiveness of these interventions.

4.2. Overall situation

This study collected a total of 3144 survey questionnaires through the internet. After filtering out improperly filled questionnaires, 2839 valid questionnaires were obtained (90.3%). Among the survey samples included in the analysis, there were 225 males (7.93%) and 2614 females (92.07%); 96.23% of the college students were in their first or second year, with 1351 freshmen and 1381 sophomores, while juniors and seniors accounted for only 107 people (3.77%); among the students tested, 2674 (approximately 94.19%) were aged between 18–21 years, and more than 60% had a habit of exercising.

Statistical analysis of the Sports biomechanics' mental health indicators of college students in the survey data showed that depression and anxiety were relatively common among the college student population during the pandemic, with 779 individuals (27.44%) experiencing depression, 1076 individuals (37.90%) perceiving anxiety, and 505 students (17.79%) feeling stressed. This indicates that the Sports biomechanics' mental health level of college students was at significant risk during the home isolation period following the outbreak of the pandemic.

4.3. Univariate analysis of sports biomechanics' mental health levels

The results of the univariate analysis indicate that there were no statistically significant differences in the three mental health level indicators related to major, age, yoga exercise duration per session, and approximate monthly living expenses ($p < 0.05$). There was no statistically significant difference in stress conditions related to gender, and no statistically significant difference in stress and anxiety conditions related to relationship status. Other factors showed statistical significance in the three mental health level indicators (**Table 3**), indicating that these factors can be used to predict Sports biomechanics' mental health levels.

Table 3. Significance test of sports biomechanics' mental health level differences among college students by different categories.

Category	*P*-value (Stress)	*P*-value (Anxiety)	*P*-value (Depression)
Gender	0.5787	0.0489*	0.0111*
Major	0.0892	0.6050	0.1263
Grade	<0.0001*	0.0005*	0.0037*
Age	0.5405	0.4032	0.3353
Relationship Status	0.5430	0.4870	0.0246
Duration of Each Yoga Session	0.1281	0.0690	0.1766
Weekly Yoga Practice Frequency	<0.0077*	0.0001*	<0.0001*
Form of Yoga Exercise	0.0005*	0.0029*	0.0002*
Purpose of Practicing Yoga	0.0212*	0.0205*	<0.0001*
Frequency of Sports Participation	<0.0001*	<0.0001*	<0.0001*
Exercise Habit	<0.0001*	<0.0001*	<0.0001*
Average Daily Internet Usage Time	<0.0001*	<0.0001*	<0.0001*
Approximate Monthly Living Expenses	0.7962	0.3436	0.8176
BMI Level	0.0193*	0.0338*	0.0081*

Note: Source: author's own work.

The statistical situation of Sports biomechanics' mental health indicators for different yoga exercise factors is shown in **Table 4**. It can be observed that in terms of the duration of each yoga session, there is no significant difference in Sports biomechanics' mental health indicators among different groups; regarding the frequency of yoga practice, stress, anxiety, and depression values significantly decrease as the weekly frequency of yoga practice increases; in terms of the form of yoga exercise indicators, the combination of mindfulness and asanas performs better than either asanas or mindfulness training alone; in terms of the purpose of practicing yoga, the Sports biomechanics' mental health indicators of the group practicing for physical fitness are better than those practicing for relieving psychological stress and the combination of both purposes [15–17].

Table 4. Statistical Summary of college students' sports biomechanics' mental health levels by different yoga exercise factors.

Category		Stress	Anxiety	Depression
		Mean ± SD	Mean ± SD	Mean ± SD
Duration of Each Yoga Session	1	8.65 ± 0.17	6.95 ± 0.15	6.41 ± 0.16
	2	7.93 ± 0.31	6.23 ± 0.27	5.78 ± 0.30
	3	8.63 ± 0.66	6.82 ± 0.57	6.15 ± 0.62
Weekly Yoga Practice Frequency	1	8.88 ± 0.26	7.17 ± 0.23	6.84 ± 0.25
	2	8.28 ± 0.22	6.58 ± 0.19	5.97 ± 0.21
	3	7.65 ± 0.38	5.81 ± 0.33	5.11 ± 0.36
Form of Yoga Exercise	1	8.51 ± 0.56	7.48 ± 0.49	7.11 ± 0.53
	2	9.14 ± 0.22	7.18 ± 0.19	6.80 ± 0.21
	3	7.97 ± 0.20	6.38 ± 0.17	5.71 ± 6.19
Purpose of Practicing Yoga	1	9.92 ± 0.57	7.96 ± 0.49	8.54 ± 0.53
	2	8.05 ± 0.37	6.32 ± 0.32	6.05 ± 0.35
	3	8.47 ± 0.17	6.79 ± 0.14	6.12 ± 0.15

Note: Source: author's own work.

4.4. Prediction of sports biomechanics' mental health levels based

A. Introduction to Artificial Neural Networks: Artificial Neural Networks (ANNs) consist of a complex network formed by a large number of simple processing units (also known as artificial neurons) connected in a certain structure. They represent a simplification, abstraction, and simulation of human brain neural networks. To date, hundreds of artificial neuron models have been proposed [16,17].

Furthermore, this study shows that a parallel and distributed processor that outputs a single value. It connects to many other neurons, with multiple input channels each corresponding to a connection weight coefficient [18]. The operation of an artificial neural network mainly consists of two phases: the working phase, where the connection weight coefficients are fixed and the state of the computing unit changes to reach a stable state, and the learning phase, where the state of the computing units remains unchanged while the connection weight coefficients are modified through sample learning methods [19–24].

B. Construction of Neural Network: Based on the definition of sport biomechanics mental health, evaluation indicators are divided into three categories: stress, anxiety, and depression indicators. The construction of the neural network considers the following principles: (1) evaluation and formulation modules are divided and established based on the type of components, with the same indicators evaluated and formulated by the same network module; (2) different psychological indicators are represented by different neural networks. This system can be constituted by 9 sub-networks (frequency of sports participation, Sport biofluids participation, average daily internet usage time, exercise habit, form of yoga exercise, weekly frequency of yoga practice, purpose of practicing yoga, BMI, gender, relationship status), i.e., the system consists of 9 parallel neural sub-networks, each corresponding to three (stress, anxiety, depression) neural network evaluation and formulation modules.

C. Determination of structural type and modeling: A feedforward structure, i.e., the BP model, is selected. Information such as individuals' subjective choices regarding health indicators serves as the input, and the health level prediction model as the output. An appropriate sample set is chosen to train the neural network, determining the connection weight coefficients between neurons in the network. Once training is complete and health level model information is input into the neural network, it can be used for evaluation. The evaluation process is essentially a reasoning process, where the known input pattern (subjective choice of indicators) is calculated to obtain the output pattern (health level). The model learns using the BP algorithm, which operates on the principle that for a training sample, the input is propagated forward through the current connection weights, transformed by the function of each neuron node to produce an output. This output is then compared to the desired sample output. If there is a deviation (training error), this deviation is propagated backward from the output layer, adjusting connection weight coefficients and thresholds to align the network's expected output with the sample output as closely as possible, thus minimizing the error cost function (optimization target function).

From Equation 1 below. The input-output transformation relationship of the network is given as:

$$S_i(q) = \sum_{j=0}^{n_{q-1}} W_{ij} q_{X_j}(q-1)(X_0^{(q-1)} = 0_i^{(q)}, W_{j0}^{(q)} = -1)$$
$$X_i{}^{(q)} = f s_i{}^{(q)} = \frac{1}{1+e^{-\mu si\,6}} \tag{1}$$

Equation (1). The input-output transformation relationship of the network equations.

where *u*—learning rate; During the learning process of the BP algorithm, to reduce errors quickly, the delta rule is commonly applied.

From Equation (2) below, to minimize the objective function EP, a common solving method is the first-order gradient method, from which the correction amount for the connection weight coefficient can be derived:

$$\varDelta W_{ij}{}^{(q)} = \eta \delta_{P_j}^{(q)} X_j{}^{(q)} = -\eta \sum_{p=1}^{p} \frac{\partial E^p}{\partial \omega_q}$$
$$\delta_{\mathrm{p}}^{(\mathrm{q})} = \eta \frac{\partial \mathbb{E}_{\mathrm{p}}}{\partial \mathbb{S}_{\mathrm{i}}^{(\mathrm{q})}} \tag{2}$$

Equation (2). Equations of minimize the objective function EP.

where η is factor; $\delta p_j(q)$ is training, and error of the *j*-th neuron in the *Q*-th layer for the *p*-th sample.

By applying the method of differentiation of composite functions, the formula for the connection weight coefficients of each neuron in each layer can be derived.

D. Program flowchart: The learning process for sport biomechanics mental health prediction based on artificial neural networks can be considered following the program flowchart shown in **Figure 1**. Whether the input and output arrangement of each evaluation module is reasonable or not significantly affects the network training time, and incorrect arrangements may even lead to non-convergence [25]. Moreover, there are no fixed experiences and principles for how to arrange the input and output of evaluation modules. It should be determined based on actual conditions such as the user's health status and requirements, with the goal of reducing network training time [26].

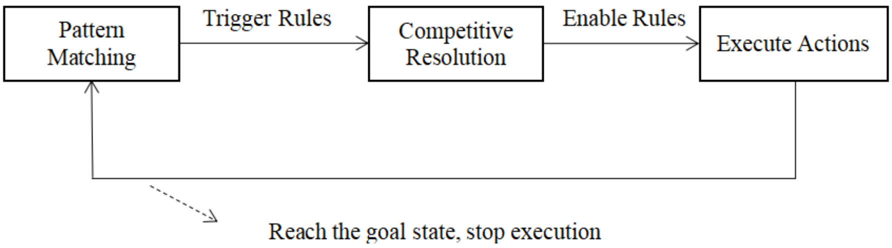

Figure 1. Schematic of system inference engineering.

Source: author's own work.

E. Structural design: The structure of the health assessment neural network system is shown in **Figure 2**. The system consists of two parts: the development environment and the operational environment. The development environment is composed of three parts, learning to create a knowledge base through example samples, specifically: 1) Learning samples; 2) Determining the system framework; 3) Neuron learning. The operational environment essentially functions as an expert system, designed to solve real problems, composed of the following: 1) Self-test health evaluation parameters; 2) Conversion of input patterns; 3) Reasoning mechanism; 4) Knowledge base system (knowledge base); 5) Conversion of output patterns. Learning for the expert system is implemented in the development environment, where the system provides a health level for each user's information through a series of reactions, storing this process and learning from it as a sample. Users can re-enter the system for health prediction after undergoing different yoga exercise interventions.

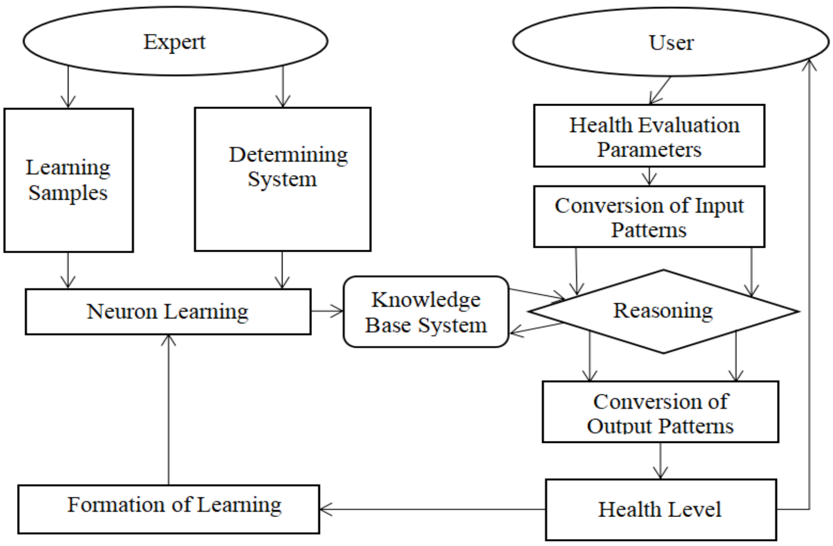

Figure 2. Structure of artificial neural network health prediction and evaluation system.

Source: author's own work.

Certainly, using machine learning models to carry out simulations of sport biomechanics' mental health accuracy is shown in **Table 5**. Overall, the simulation accuracy for stress is higher than for anxiety, with the lowest accuracy for depression predictions. In advancing the application of neural networks within my research, this study employs Artificial Neural Networks (ANNs) due to their ability to model complex relationships in large datasets. My work focuses on utilizing these networks to analyze patterns and predict outcomes related to technological innovation and organizational behavior. Specifically, this study implements Backpropagation (BP) algorithms to fine-tune the network's performance, which enhances both prediction accuracy and the generation of actionable insights. This method facilitates a deeper understanding of how factors such as digital transformation and leadership styles influence organizational outcomes. The inherent adaptability and learning capabilities of neural networks significantly contribute to refining the precision and relevance of the research findings, making them an indispensable tool for exploring intricate dynamics within the enterprise context.

Table 5. Prediction accuracy of sport biomechanics' mental health levels by different models.

	Stress	**Anxiety**	**Depression**
MLP	0.83	0.67	0.57

Note: Source: author's own work.

The results of the variable importance assessment for models of different sport biomechanics mental health levels are shown in **Table 6**. Likewise, the importance of model variables varies for different mental health indicators. For the depression indicator, the frequency of sports participation, Sport biofluids participation, average daily internet usage time, and exercise habit rank in the top three in importance, respectively at 1.89%, 19.09%, and 16.47%, with a cumulative contribution reaching 57.44%. Yoga exercise-related variables contribute up to 21.93%; for the anxiety indicator, the frequency of sports participation, weekly frequency of yoga practice, and average daily internet usage time rank in the top three in importance, respectively at 19.13%, 14.39%, and 12.74%, with a cumulative contribution reaching 46.27%. Yoga exercise-related variables contribute up to 29.31%. For the stress indicator, the frequency of sports participation, average daily internet usage time, and purpose of practicing yoga rank in the top three in importance, respectively at 29.95%, 16.15%, and 9.43%, with a cumulative contribution reaching 55.52%. Yoga exercise-related variables contribute up to 25.95%. Overall, besides the frequency of sports participation and average daily internet usage time, yoga exercise plays a significant role in predicting sport biomechanics' mental health levels. Yoga exercise-related indicators appear among the top three important variables for predicting anxiety and stress, with an overall contribution rate ranging from 21.93% to 29.31%.

Table 6. Estimation of prediction variable importance.

Depression		Anxiety		Stress	
Prediction Variable	**Importance (%)**	**Prediction Variable**	**Importance (%)**	**Prediction Variable**	**Importance (%)**
Frequency of Sports Participation	21.89	Frequency of Sports Participation	19.13	Frequency of Sports Participation	29.95
Average Daily Internet Usage Time	19.09	Weekly Frequency of Yoga Practice	14.39	Average Daily Internet Usage Time	16.15
Exercise Habit	16.47	Average Daily Internet Usage Time	12.74	Purpose of Practicing Yoga	9.43
Form of Yoga Exercise	8.22	Grade	11.54	Weekly Frequency of Yoga Practice	9.26
Weekly Frequency of Yoga Practice	7.22	Exercise Habit	9.21	Grade	9.01
Purpose of Practicing Yoga	6.48	BMI	8.89	Form of Yoga Exercise	7.27
BMI	6.39	Purpose of Practicing Yoga	7.75	BMI	6.72
Grade	5.58	Form of Yoga Exercise	7.16	Exercise Habit	5.17
Gender	4.62	Gender	4.79	Relationship Status	4.28
Relationship Status	4.04	Relationship Status	4.38	Gender	2.78

Note: Source: author's own work.

5. Discussion

In this study, conducted during the COVID-19 pandemic when students were attending classes from home, an online survey was used to explore the impact of yoga interventions on the sport biomechanics' mental health levels of college students. The main conclusions are as follows:

During the epidemic, mental health risks among college students who participated in yoga classes remained notably high, with 779 individuals (27.44%) exhibiting symptoms of depression. showing tendencies towards depression, 1076 individuals (37.90%) experiencing anxiety, and 505 students (17.79%) feeling stressed.

Among all yoga-related exercise factors, there was no statistical difference in the stress-anxiety-depression states based on the duration of each yoga session ($p < 0.05$). However, significant differences were observed in stress-anxiety-depression states related to the purpose of practicing yoga, the form of yoga exercise, and the weekly frequency of yoga practice. Increased frequency of yoga practice, a combination of mindfulness training and asanas, and practicing yoga for physical fitness were associated with better sport biomechanics' mental health levels among college students.

6. Conclusion

Artificial neural network models can predict normal and abnormal states of stress, anxiety, and depression among college students. Overall, the simulation accuracy for stress was higher than for anxiety, with the lowest accuracy for depression predictions. The analysis of variable importance showed that besides the frequency of sports participation, Sport biofluids participation and average daily internet usage time, yoga exercise plays a significant role in predicting mental health levels, especially for anxiety and stress, with an overall contribution rate ranging from 21.93% to 29.31%.

All in all, In the post-pandemic transport era, work and lifestyle maintaining social distance will become mainstream. Sports biomechanics and Yoga exercise has great potential in alleviating the psychological health issues of college students. It is recommended that colleges scientifically and reasonably offer yoga courses to promote and safeguard the sport biomechanics' mental health of students on campus [27].

This study has several limitations that should be acknowledged. Firstly, the reliance on self-reported data introduces potential bias, which may impact the accuracy of mental health predictions. Additionally, although the study emphasizes the significant role of yoga in predicting mental health levels, the sample was restricted to college students, which may limit the generalizability of the findings to other demographic groups. Furthermore, while the models employed in this study are effective, there is room for improvement by incorporating additional variables or advanced methodologies to enhance prediction accuracy. Future research could address these limitations by expanding the sample population and integrating more diverse data sources or advanced analytical techniques [27–32].

Future research should focus on several key areas to build upon the current study's findings. First, validating the results with a more diverse sample encompassing various age groups and settings will be crucial for ensuring broader applicability and generalizability. Expanding the study to include longitudinal data could offer valuable insights into the long-term effects of yoga and other physical activities on mental health. Additionally, incorporating advanced machine learning models and integrating physiological data could enhance the precision of predictions [33–39]. Furthermore, examining the impact of different types of physical activities, both individually and in combination, will provide a more comprehensive understanding of effective interventions for mental health improvement. These approaches will help refine the study's conclusions and contribute to more robust and actionable findings.

Author contributions: Conceptualization, JC; methodology, JC; software, JC; validation, HY and JC; formal analysis, JC; investigation, JC; resources, HY and JC; data curation, JC; writing—original draft preparation, JC; writing—review and editing, JC; visualization, JC; supervision, JC; project administration, XZ, YL, HZ, MW and JC; funding acquisition, XZ, YL, HZ, MW, HY and JC. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The author received support from Xi'an University of Science and Technology in Chinese Universities for the research, and Solbridge International School of Business in Republic of Korea.

Ethical approval: Not applicable.

Conflict of interest: The authors declare no conflict of interests.

References

1. Antony MM, Bieling PJ, Cox BJ, et al. Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. Psychological Assessment. 1998; 10(2): 176-181. doi: 10.1037/1040-3590.10.2.176
2. Arbogast KB, McDonald CC. Sport Safety for Adolescents: Linking Biomechanics of Repetitive Head Impacts with Health and Wellbeing. Journal of Adolescent Health. 2023; 72(4): 485-486. doi: 10.1016/j.jadohealth.2022.12.024
3. Avedesian JM, Covassin T, Baez S, et al. Relationship Between Cognitive Performance and Lower Extremity Biomechanics: Implications for Sports-Related Concussion. Orthopaedic Journal of Sports Medicine. 2021; 9(8): 232596712110322. doi: 10.1177/23259671211032246
4. Breiman L. Random forests. Machine learning. 2001, 45(1): 5-32.
5. Cai Y, Tang L. Correlation Analysis between Higher Education Level and College Students' Public Mental Health Driven by AI. Computational Intelligence and Neuroscience. 2022; 2022: 1-11. doi: 10.1155/2022/4204500
6. Cai Z. Minsky's Career in Artificial Intelligence. Science and Technology Review. 2016, 34(07): 54-55.
7. Carberry J. Toward a Unified Theory of High-Energy Metaphysics: Silly String Theory. Journal of Psychoceramics. 2008; 5(11): 1-3. doi: 10.5555/12345678
8. Challa S, Pulford GW. Joint target tracking and classification using radar and ESM sensors. IEEE Transactions on Aerospace and Electronic Systems. 2001; 37(3): 1039-1055. doi: 10.1109/7.953266
9. Chen J, Yuan D, Dong R, et al. Artificial intelligence significantly facilitates development in the mental health of college students: a bibliometric analysis. Frontiers in Psychology. 2024; 15. doi: 10.3389/fpsyg.2024.1375294
10. Cortes C, Vapnik V. Support-vector networks. Machine Learning. 1995; 20(3): 273-297. doi: 10.1007/bf00994018
11. Gong X, Xie X, Xu R, Luo Y. Report on the Simplified Chinese Version of the Depression-Anxiety-Stress Scale (DASS-21) Among Chinese College Students. Chinese Journal of Clinical Psychology. 2010; 18(004): 443-446.
12. Cui J, Gan Z, Ning Z. Impact of Management Philosophy and Organization on China Technical Xiaomi Company. Academic Journal of Management and Social Sciences. 2023; 5(2): 45-49. doi: 10.54097/ajmss.v5i2.11
13. Cui J, Liu H, Wan Q. Measuring the Digital Assets, Brand Services and Service Quality Quantitative Analysis: Evidence from China. International Journal of Social Sciences and Public Administration. 2024; 2(3): 503-510. doi: 10.62051/ijsspa.v2n3.68
14. Cui J, Wan Q, Wang W, et al. Research on Alibaba company's Digital Human Resource management and Recruitment Information Platform: A systematic case study. International Journal of Global Economics and Management. 2024; 2(3): 162-172. doi: 10.62051/ijgem.v2n3.17
15. Edalatfar M, Piri SM, Mehrabinejad MM, et al. Biofluid Biomarkers in Traumatic Brain Injury: A Systematic Scoping Review. Neurocritical Care. 2021; 35(2): 559-572. doi: 10.1007/s12028-020-01173-1
16. Forte P, Teixeira JE. Exercise Biomechanics for Health: Evaluating Lifelong Activities for Well-Being. Healthcare. 2023; 11(6): 900. doi: 10.3390/healthcare11060900
17. Goldstein MS, Siegel JM, Boyer R. Predicting changes in perceived health status. American Journal of Public Health. 1984; 74(6): 611-614. doi: 10.2105/ajph.74.6.611
18. Cui J, Chen W, Wan Q, et al. Design and Analysis of a Mobile Automation Testing Framework: Evidence and AI Enhancement from Chinese Internet Technological Companies. Frontiers in Business, Economics and Management. 2024; 14(2): 163-170. doi: 10.54097/xevpea32
19. Goodfellow I, Bengio Y, Courville A. Deep learning. MIT Press; 2016.
20. Han T, Ma W, Gong H, et al. Analysis of Negative Emotions and Influencing Factors Among College Students During Home Quarantine Due to COVID-19 Pandemic. Journal of Xi'an Jiaotong University (Medical Sciences). 2021.
21. Henriksen K, Schinke R, Moesch K, et al. Consensus statement on improving the mental health of high performance athletes. International Journal of Sport and Exercise Psychology. 2019; 18(5): 553-560. doi: 10.1080/1612197x.2019.1570473
22. Huang S, Lai X, Ke L, et al. AI Technology panic—is AI Dependence Bad for Mental Health? A Cross-Lagged Panel Model and the Mediating Roles of Motivations for AI Use Among Adolescents. Psychology Research and Behavior Management. 2024; 17: 1087-1102. doi: 10.2147/prbm.s440889
23. Jiao S, Shi K, Zhou H, et al. Public Psychological State and Emotion Guidance Strategies in Response to COVID-19 Risk Information. Medicine and Society, 2020; 4: 1-10.

24. Jun C, Cheng Y, Ng A, Hong H. Tencent’s Corporate Strategic Organizational Digital Management and Digital Transformation: A Case Study. Journal of Business and Social Sciences. 2022; 2022(02): 1-15.
25. Kilbourne AM, Valenstein M, Bauer MS. The Research-to-Practice Gap in Mood Disorders: A Role for the U.S. Department of Veterans Affairs. The Journal of Clinical Psychiatry. 2007; 68(04): 502-504. doi: 10.4088/jcp.v68n0402
26. Kira I. Artificial neural networks and mental health prediction. Journal of Psychological Research. 2020; 45(2): 150-165.
27. Liu H. Applications of Artificial Intelligence to Popularize Legal Knowledge and Publicize the Impact on Adolescents’ Mental Health Status. Frontiers in Psychiatry. 2022; 13. doi: 10.3389/fpsyt.2022.902456
28. Liu H, Cui J. Framework for evaluating technological innovation, CSR, and ESG performance in the Chinese art industry: A quantitative analysis. Journal of Infrastructure, Policy and Development. 2024; 8(8): 6366. https://doi.org/10.24294/jipd.v8i8.6366
29. Long D. Research on the Application of Artificial Neural Network Expert Systems. Journal of Guangdong University of Technology. 2000; 17(3): 44-47.
30. Luo RC, Tse Min Chen. Autonomous mobile target tracking system based on grey-fuzzy control algorithm. IEEE Transactions on Industrial Electronics. 2000; 47(4): 920-931. doi: 10.1109/41.857973
31. Park CL, Slattery JM. Yoga as an integrative therapy for mental health concerns: An overview of current research evidence. Psychiatry International. 2021; *2*(4): 386-401.
32. Rezapour M, Elmshaeuser SK. Artificial intelligence-based analytics for impacts of COVID-19 and online learning on college students’ mental health. PLOS ONE. 2022; 17(11): e0276767. doi: 10.1371/journal.pone.0276767
33. Shohani M, Badfar G, Nasirkandy M P, et al. The effect of yoga on stress, anxiety, and depression in women. International Journal of Preventive Medicine. 2018; 9.
34. Supej M, Spörri J. Special Issue on “Sports Performance and Health.” Applied Sciences. 2021; 11(6): 2755. doi: 10.3390/app11062755
35. Wang X, Musicki D. Low elevation sea-surface target tracking using IPDA type filters. IEEE Transactions on Aerospace and Electronic Systems. 2007; 43(2): 759-774. doi: 10.1109/taes.2007.4285369
36. Wang Y. Principles and Methods of Artificial Intelligence. Xi’an: Xi’an Jiaotong University Press; 1998.
37. Wei H. Theories and Methods of Neural Network Structural Design. Beijing: National Defense Industry Press; 2014. p. 5.
38. Wu F, Yang L, Qin S. Data Structure Design and Implementation in the Comprehensive Quality Assessment Analysis System for Senior Management Talent. Journal of Changzhou Institute of Technology. 2014.
39. Zhang L. Computerization of Talent Assessment Techniques and Their Application in Talent Selection and Recruitment [Master’s thesis]. Tongji University; 2014.