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Article

AI-driven big data analysis on the impact of sports-induced cell molecular biomechanical stimuli on human physiological and mental health

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Abstract: With the intensification of study and work pressure, people's physical and mental health has been compromised. Sports, in general, can enhance human physiological systems like the cardiovascular and respiratory systems from a macroscopic perspective. However, from a cell molecular biomechanics viewpoint, during exercise, mechanical forces are exerted on cells. This can lead to changes in cell shape and cytoskeletal organization. Appropriate mechanical stimulation can activate intracellular signaling pathways related to cell growth and repair. Yet, without proper guidance, issues arise. Inadequate exercise might not provide sufficient mechanical stress to trigger beneficial cell molecular responses. On the other hand, excessive exercise can cause excessive mechanical damage to cells, such as disrupting cell membranes and cytoskeletons, leading to sports injuries. To address this, this paper utilized Artificial Intelligence (AI) and Big Data (BD) to study sports. A sports auxiliary system integrating AI and BD was proposed. The research on students in Class A and Class B showed that many were in a sub-optimal state of health. After sports with the aid of the proposed system, significant improvements were observed. In Class A, the proportion of students with physiological sub-health declined by 53.33%, and in Class B by 40%. The number of students with psychological issues also decreased. This indicates that the sports auxiliary system has a clear application need. By analyzing data related to cell molecular responses during exercise using AI and BD, it can optimize exercise regimens. This helps maintain appropriate mechanical stimulation on cells, promoting beneficial cell molecular biomechanical adaptations and ultimately enhancing both physiological and mental health.

Keywords: physical and mental health; impact of sports; artificial intelligence; big data analysis; cell molecular biomechanics

1. Introduction

At this stage, people are faced with various pressures from study, work and life, and their physical and mental health has been negatively affected. Sports have the functions of accelerating cardiovascular circulation, promoting muscle strengthening, and releasing pressure and bad emotions. It is of great significance to protect the physical and mental health of the human body. Based on this, this paper used AI and BD to study sports, and analyzed the impact of sports on human physiology and psychology, which hoped to provide valuable reference for related research.

Many scholars believe that sports have a positive impact on human physiological and mental health, and have studied it. Liddle et al. analyzed the impact of Australian teenagers' participation in sports on their mental health [1]. Hosker et al. studied the effects of sports, nutrition and other factors on the physical and mental health of adolescents [2]. McKeon et al. showed through research that physical activity was an effective strategy to assist in the treatment of depression,

anxiety and stress related diseases. It could prevent anxiety and depression and protect people's mental health [3]. Chekroud analyzed the correlation between American sports and mental health [4]. Belcher believed that exercise and aerobic fitness were conducive to solving the mental health problems of adolescents [5]. Lin et al. believed through experimental research that sports could enhance neural plasticity to protect people's physiological and mental health [6]. Jalolovich believed that sports were conducive to promoting people's health, and sports were an important tool to promote human health [7]. Smith explored the impact of physical education on students' mental health, and believed that sports could enhance students' self-esteem and maintain students' emotional and mental health [8]. Abdluaziz et al. reviewed exercise and other sports activities related to mental health and drew relevant conclusions that there was an obvious positive relationship between sports and protecting people's mental health [9]. Haycock discussed how schools used learning activities related to sports, sports and physical activities to solve students' mental health problems [10]. These scholars studied the relationship between sports and human physiological and mental health, and put forward valuable suggestions.

AI and BD are widely used in the field of sports. Kang discussed the role of sports for athletes based on BD analysis [11]. Chu proposed a feasible solution for different movements by using AI Internet of Things technology [12]. Dhar analyzed the role of AI in sports training [13]. Cong discussed the application of artificial intelligence in school sports information service from the perspective of scientific decision-making and automatic management [14]. AI and BD could play an important role in the field of sports. Based on this, this paper studied sports based on AI and BD analysis.

This paper analyzed and put forward a sports auxiliary system combining AI and BD analysis, and evaluated its overall architecture and functional modules. This paper made an experimental study on the current situation of students' physical health, their psychological health, their physical health after sports, their psychological health after sports and their satisfaction with sports training methods.

2. Effects of sports on human physiology and psychology

2.1. Impact on physical health

The effects of sports on human physiology and psychology include the effects on muscles, bones, nervous system, cardiovascular system, respiratory system, digestive system and urinary system, as shown in **Figure 1**.

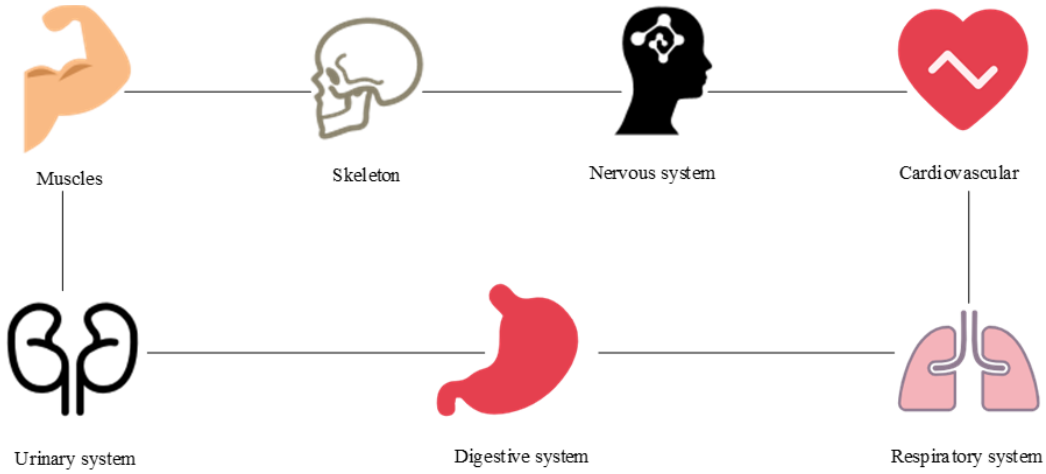

Figure 1. Effects of physical activity on physical health.

1) Effect on muscle

People who often take part in sports would have a significant increase in blood flow. With the full guarantee of blood supply and blood nutrition supply, the absorption and storage capacity of human body for nutrients would be enhanced, and muscle fiber tissue would gradually become thicker. Therefore, the muscles of the human body would be stronger, and their elasticity, endurance and other attributes would be significantly enhanced.

2) Effects on bones

Sports can promote the enhancement of bone performance. People can enhance the strength of bones and improve metabolism through frequent sports. For the normal development of young people, sports can significantly promote the growth of bone and height. In addition, sports can enhance the firmness and flexibility of joints, thereby reducing the risk of physical injury during activities.

3) Effects on nervous system

Sports can significantly promote the growth and development of cerebral cortex neurons, which is conducive to the enhancement of human reaction ability, understanding ability, attention and flexibility. This in turn makes it easier for people to reach the ideal state in terms of work and study and can extend the time of this ideal state, thereby improving people's efficiency. For students, sports can effectively improve their learning efficiency by affecting the human nervous system; for people involved in work, sports are conducive to keeping themselves in the best state.

4) Impact on cardiovascular system

The endurance sports training of the human body is conducive to promoting the slow sinus rhythm, thereby improving the heart function. Long term and frequent endurance training can enlarge the ventricular cavity of the human body, thus enhancing the diastolic capacity of the heart and providing more adequate blood supply for the human body. Sports training can increase the elasticity of blood vessel wall and reduce blood lipid content, thus ensuring the health of human cardiovascular system. This can reduce the risk of people suffering from coronary heart disease, hypertension and other cardiovascular diseases.

5) Effects on respiratory system

Chest expansion and other sports are conducive to promoting the strength growth of respiratory muscles, which can enhance the lung function of the human body, thereby increasing the vital capacity of the human body. Long term and regular sports can promote the development of lungs and increase the elasticity and permeability of alveolar. Of course, sports should also maintain a certain intensity, which should not exceed the normal range of the human body. Otherwise, the body resistance of the human body would decline during fatigue exercise, which is not conducive to the health of the respiratory system.

6) Effects on digestive system

The positive effects of sports on the digestive system are reflected in the following aspects: Firstly, sports are conducive to promoting gastrointestinal peristalsis and digestive juice secretion, which is conducive to strengthening the ability of gastrointestinal digestion and absorption of nutrients; secondly, frequent and moderate physical exercise is conducive to promoting defecation, so that toxins in the human body can be discharged in time, thus ensuring intestinal health; thirdly, sports can promote the diaphragm to move up and down and the abdominal muscles to move to a greater extent. To some extent, sports can play a role in massaging the digestive organs, which is conducive to improving the defense ability of mucosa and promoting the recovery of ulcers; fourthly, sports can ensure the normal operation of digestive system such as gastrointestinal system by promoting blood circulation, that is, sports can provide security for the normal operation of digestive system. However, it is worth noting that sports should abide by the objective laws, not empty stomach sports and full stomach sports. The intensity and frequency of sports should be appropriately selected according to personal conditions, so as to avoid the negative impact of sports on the human body.

7) Effects on urinary system

Positive impact: The impact of exercise on the human urinary system is mainly reflected in the kidney. Proper and appropriate physical exercise is conducive to promoting the improvement of kidney function. It is beneficial to the function of kidney to expel toxins, and maintain acid-base and body fluid balance, so as to prevent the occurrence of kidney disease or alleviate the deterioration of kidney disease. Negative effects: Uncontrolled excessive exercise can change the microstructure of human kidney tissue, and reduce renal blood flow, which can also increase the level of lipid peroxidation in the kidney, and lead to proteinuria, hematuria and other phenomena.

2.2. Positive impact on mental health

The positive impact of sports on mental health is reflected in the following aspects, as shown in **Figure 2**.

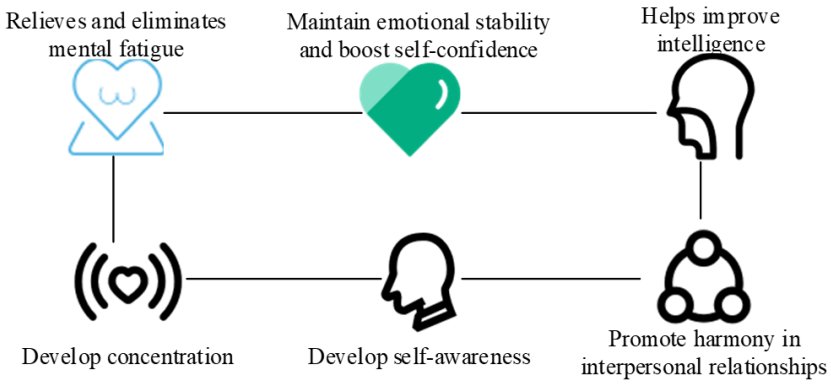

Figure 2. The positive impact of physical activity on mental health.

1) Relieving and eliminating mental fatigue

For students and workers, persistent study and work pressure not only causes physical fatigue and neurasthenia, but also causes psychological fatigue, which leads to a series of psychological problems. Moderate sports can not only improve the physical resistance of students and workers to fatigue, but also help to relax the psychology, which is conducive to alleviating and even eliminating the impact of psychological fatigue on students and workers.

2) Maintaining emotional stability and enhancing self-confidence

Sports can help people release their psychological pressure, and release the tension, anxiety and other bad emotions caused by insufficient ability, misunderstanding, personality and other reasons. This can help people develop positive emotions and emotions such as optimism and self-confidence, and can effectively promote people to correctly view the pressures and setbacks they face in life, thus helping people maintain emotional stability and develop self-confidence.

3) Helping improve intelligence

The maintenance of the normal development of intelligence is the basis and prerequisite for the protection of human mental health. The enhancement of physical fitness is closely related to the level of intelligence, and the improvement of physical fitness can provide better nutritional conditions for intellectual development. In addition, sports can significantly promote the thickening of the cerebral cortex, and increase the reaction speed of brain cells, so as to promote the development of human intelligence.

4) Promoting the harmony of interpersonal relationship

Sports have the characteristics of public participation and social interaction. In schools, students often establish a harmonious friendship after participating in sports together. Cooperative sports can not only cultivate students' cooperation ability, but also promote friendly cooperation and communication between students, so as to promote students to establish harmonious interpersonal relationships. Competitive sports would not lead to opposition between students. It would stimulate students' competitive spirit and enterprising spirit, which would help students win the recognition of competitors. On the contrary, the two sides of competitive sports would establish a solid and harmonious friendship. In society, people and like-minded friends meet in fitness squares and other places for sports, which is conducive to the stability of interpersonal relations.

5) Cultivating self-awareness

When people play sports, they can clearly understand which sports they like or dislike, the specific projects they are good at in sports and the projects in which they do not perform well, so as to set sports goals for themselves. The self-consciousness that people awaken in sports is also conducive to other fields. This is conducive to promoting people's all-round development.

6) Cultivating attention

People must concentrate when they achieve a goal, and so do sports. In sports, if people want to make sports play the best effect, they must devote their attention to sports to achieve their own goals. Therefore, sports can cultivate people's habit of concentration, which is conducive to avoiding the temptation of foreign things for students and people involved in work, and improving their efficiency of study and work.

3. Establishment of sports auxiliary system based on AI and BD evaluation

3.1. Overall system architecture

Sports auxiliary system includes data layer, business layer and application layer. The data layer includes data acquisition, data storage and data processing. Through the monitoring equipment of sports auxiliary system, the system can realize the data collection of sports objects. Data storage is to store the collected sports data, personal characteristics data and other information. Data processing is to extract and refine the information in the data storage to make the data more valuable. The operation layer includes AI technology, motion vision technology, etc. The application layer includes face recognition, motion pose detection, performance detection, personalized suggestions, etc.

3.2. System function module

The sports auxiliary system analyzed by combining AI and BD includes IoT cameras, IoT voice broadcasting equipment, AI servers, client screens and other hardware devices. This system has the following functional modules, as shown in **Figure 3**, specifically including face information authentication module, sports file creation and tracking module, posture monitoring detection module, violation warning voice broadcast module, score report module, and personalized suggestion module.

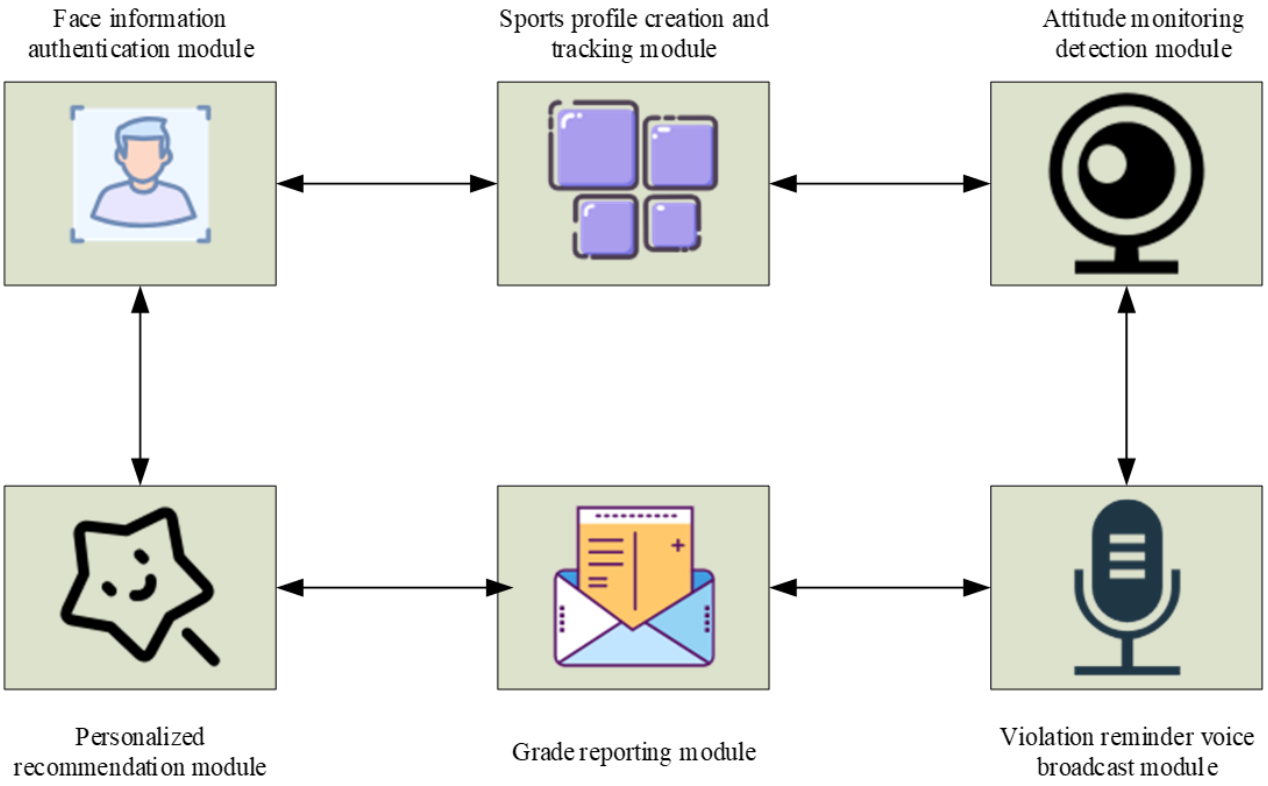

Figure 3. System function modules.

Face information authentication module: Through face authentication, the identity of the system user is recognized for the convenience of subsequent system functions. Sports file establishment and tracking module: Users can log in to the system to establish personal files and sports training tasks. Through the system, the tracking of personal movement, personal physiological information and personal health can be realized. Attitude monitoring and detection module: The intelligent Internet of Things camera is used to monitor the movement of sports objects, and detect whether the attitude of the moving objects is standard and whether violations occur. Voice broadcast module: When the sports objects have illegal actions, the system would notify the sports objects through voice broadcast equipment, and then correct the illegal actions of the sports objects in a timely manner. Performance report module: The client screen and other devices are used to display the performance of moving objects, making the movement data more visual. Personalized suggestion module: The system uses BD analysis technology to analyze a large number of multi type data generated by moving objects, and then recommends more suitable personalized information for moving objects.

3.3. Advantages of the system

1) Using AI and BD to realize sports guidance

The sports assistant system can use AI and BD to realize sports guidance, thus playing a role in replacing private education. For sports enthusiasts, it is conducive to the intelligent guidance of their own sports, and also reduces the cost of inviting private education. For women, it also avoids the security and privacy problems brought by inviting private education.

2) Using AI and BD to improve the scientificity of sports

The sports auxiliary system can use AI and BD to ensure the scientificity of sports. Through intelligent BD analysis, the system can provide more scientific and reasonable programs for sports objects according to their physical quality and sports effects, so that sports objects can achieve sports effects more easily [15]. BD technology can analyze all kinds of sports data and the shortcomings in their sports every time the sports objects play sports, so as to judge whether the sports effect reaches the expectation. After the sports objects have played sports for many times, the system can use BD technology to compare the sports conditions of the sports objects each time, so as to systematically and comprehensively analyze the sports objects to understand their own changes, which is conducive to continuously adjusting scientific sports strategies for sports objects.

3) Using AI and BD to realize the safety and personalization of sports

On the one hand, the system can effectively avoid the sports injuries caused by the blind pursuit of sports intensity, and effectively help the sports objects to adopt the correct sports mode, which makes sports safer. On the other hand, the system provides targeted training programs for the moving objects by recording and calculating the physical sign changes of the moving objects. In addition, sports objects can use the system to carry out personalized sports according to their own needs and preferences.

4. Evaluation of the impact of sports on human physiological health based on random forest algorithm

Construction of decision tree: The database attribute set of indicators of physical impact of sports is set as follows:

$$X = \{x_1, x_2, ..., x_i\} \tag{1}$$

For index x, there are W values of $\{x^1, x^2, ..., x^W\}$. If x is used to divide dataset E, W branches would be generated, and the formula is as follows:

$$Ent(E) = -\sum_{j=1}^{|\gamma|} i_j \log_2 i_j \tag{2}$$

Among them, i_j is the proportion of the j-type sample in the current sample set E.

The branch node is given a weight of $\frac{|E^W|}{|E|}$, so the information gain obtained by dividing the sample set E with x is as follows:

$$Gain(E, x) = Ent(E) - \sum_{W=1}^{W} \frac{|E^W|}{|E|} Ent(E^W) \tag{3}$$

The out-of-pocket data is selected to calculate the prediction error rate of the decision tree, and the average error of the number of decision trees is used to express the importance of sports to a certain indicator feature of the human body.

The information gain is used for attribute selection to obtain a new attribute set x_*, which is expressed as follows:

$$x_* = \arg\max_{x \in X} Gain(E, x) \tag{4}$$

5. Investigation on application demand and effect of sports auxiliary system based on AI and BD evaluation

This paper first selected two classes of students in S school, and investigated their physical health and mental health. The two classes were called Class A and Class B respectively, with 45 students in Class A and Class B respectively. In this paper, the students in Class A were trained in sports by using the sports auxiliary system combined with AI and BD analysis, and the students in Class B were trained in sports in a common way. The students in the two classes were followed up for four months to investigate their physical and mental changes after sports and their satisfaction with the way of sports. The basic characteristics of students are shown in **Table 1**.

Table 1. Basic characteristics of students.

	Class A	**Class B**
Average age	20.35	21.04
Male students	32	28
Female students	13	17

5.1. Physical health status of students

The physical health status of students was investigated, and the physical measurement was used to determine the physical health status of students. The physical health status was divided into three categories: healthy, sub-health, and unhealthy, as shown in **Figure 4**.

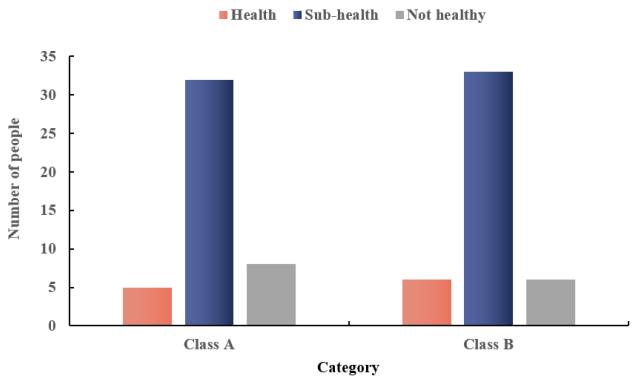

Figure 4. The current status of students' physical health.

As shown in **Figure 4**, among the students in Class A, there were 5 students who were physically healthy, 32 students who were physically sub healthy, and 8 students who were not healthy. Among the students in Class B, there were 6 students with healthy physiology, 33 students with sub healthy physiology and 6 students with unhealthy physiology. It could be seen that no matter Class A or Class B, the students' physiological health level was not high enough. There were 40 students in Class A who were physically sub healthy and physically unhealthy, accounting for 88.89% of the students in Class A. There were 39 students in Class B who were physically sub healthy and physically unhealthy, accounting for 86.67% of the students in Class A. This showed that students' physical health needed to be improved urgently.

5.2. Status quo of students' mental health

Through the mental health test, students' mental health status could be understood. The mental health status could be divided into two types: healthy and unhealthy. The current situation of students' mental health is shown in **Figure 5**.

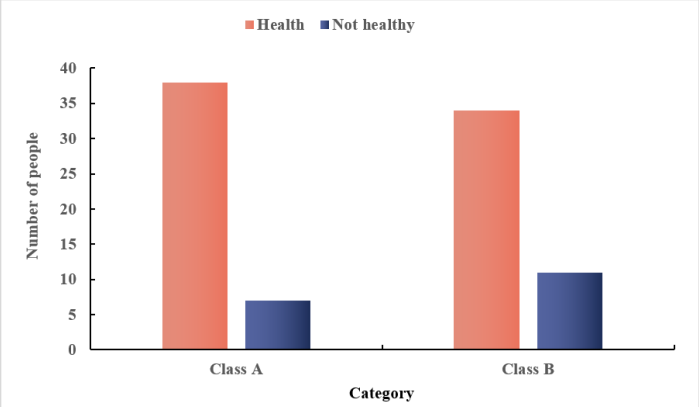

Figure 5. The current state of students' mental health.

As shown in **Figure 5**, in Class A, there were 38 students with normal mental health. 7 students suffered from anxiety, tension, depression and other unhealthy emotions, and their psychology was in an unhealthy state. In Class B, there were 34 students with normal mental health. There were 11 students suffering from anxiety and other unhealthy emotions, and their psychology was in an unhealthy state. It could be seen from the above data that due to the pressure of study and life, some students' mental health was abnormal, and their mental health needed to be changed urgently.

5.3. Physical health of students after exercise

The physical health of students after exercise was measured. The physical health included healthy, sub-health and unhealthy, as shown in **Figure 6**.

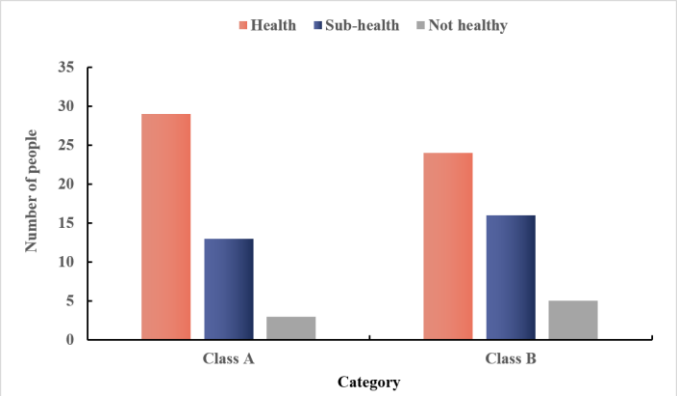

Figure 6. Physical health of students after exercise.

As shown in **Figure 6**, the physical health of students in Class A and Class B was significantly improved after sports. From the specific data, there were 29 students in Class A who were physically healthy after sports. There were 13 students with sub healthy physiology and 3 students with unhealthy physiology. After sports, there were 24 students in Class B who are physically healthy. There were 16 students with sub healthy physiology and 5 students with unhealthy physiology. After sports, there were 16 students in Class A who were physically sub healthy and physically unhealthy, accounting for 35.56% of the students in Class A. The proportion of students in Class B who were physically sub healthy and physically unhealthy was 46.67%. According to **Figure 4**, the proportion of students with sub healthy and unhealthy physiology in Class A decreased by 53.33%, and the proportion of students with sub healthy and unhealthy physiology in Class B decreased by 40%. It showed that sports could obviously protect and promote students' physiological health, and sports auxiliary system based on AI and BD analysis was more conducive to promoting students' physiological health.

5.4. Mental health of students after sports

The physical health of students after exercise was measured. The physical health included healthy, sub-health and unhealthy, as shown in **Figure 7**.

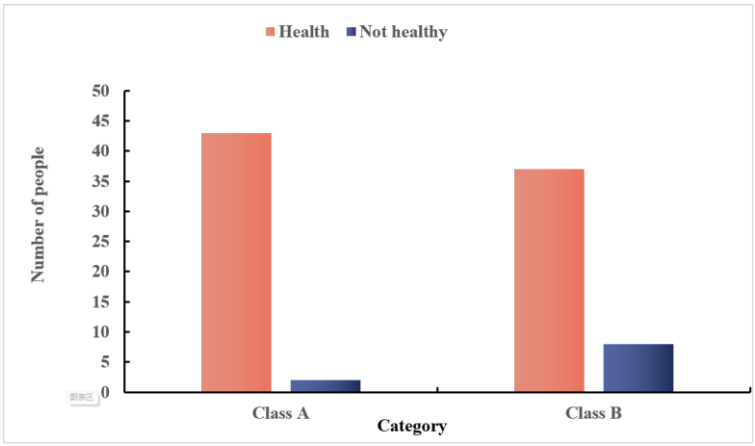

Figure 7. Mental health after student exercise.

As shown in **Figure 7**, after sports, there were 43 students in Class A with normal mental health and 2 students with unhealthy mental health. After sports, there were 37 students in Class B with normal mental health and 8 students with unhealthy mental health. According to **Figure 5**, the number of unhealthy students in Class A decreased by 5, and the number of unhealthy students in Class B decreased by 3. This showed that sports could help improve students' mental health.

5.5. Student satisfaction

The satisfaction of Class A students with the sports training methods using the sports auxiliary system was investigated every month, and the satisfaction of Class B students with the general sports training methods was investigated. The range of satisfaction was 1–100, as shown in **Figure 8**.

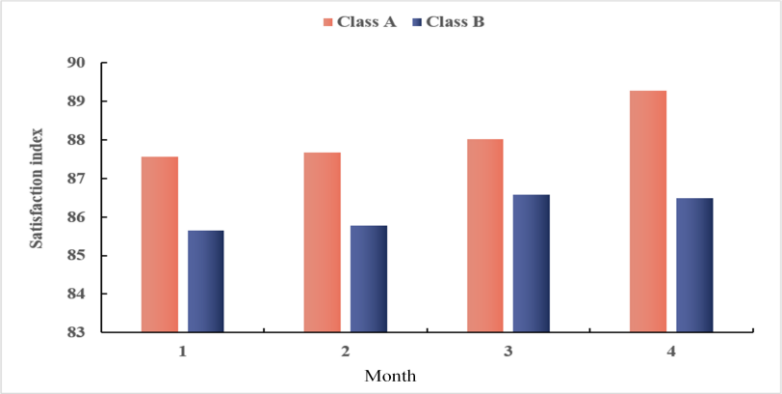

Figure 8. Student satisfaction.

As shown in **Figure 8**, in the first month, students in Class A were 87.56 satisfied with sports training methods, and students in Class B were 85.64 satisfied with sports training methods. The students in Class A were satisfied. In the second month, students in Class A were 87.67 satisfied with the way of sports training, while students in Class B were 85.78 satisfied with the way of sports training. In the third month, students in Class A were 88.02 satisfied with sports training methods, and students in Class B were 86.57 satisfied with sports training methods. At the fourth month, the students of Class A were 89.27 satisfied with sports training methods, and the students of Class B were 86.49 satisfied with sports training methods. From the average data of each month, the average satisfaction of students in Class A with sports training methods was 88.13, and the average satisfaction of students in Class B with sports training methods was 86.12. The average satisfaction of students in Class A with sports training methods was 2.33% higher than that of students in Class B. This showed that students were more satisfied with the sports training method using the sports auxiliary system compared with the general sports training method.

6. Conclusions

This paper first discussed the effects of sports on human physiology and psychology. In human physiology, sports could promote muscle strengthening, bone hardness and cardiovascular circulation; in terms of human psychology, sports could help alleviate and eliminate psychological fatigue, and maintain emotional stability,

so as to enhance self-confidence and cultivate self-awareness. This paper discussed the application of AI and BD in sports, and put forward some suggestions on sports training by using sports auxiliary system combining AI and BD analysis. Finally, this paper studied the application requirements and effects of sports assistant system. Through the research, the following conclusions were drawn: Most students' physiological health was not maintained at a healthy level, and some students' psychological state was also abnormal; sports could effectively enhance the physical quality of students and improve their unhealthy and sub healthy physiological state. Sports could effectively help students release emotional pressure and improve their psychological quality, so that students' psychological state remained healthy; combined with AI and BD analysis, sports assistant system could have a positive impact on students' physical and mental health.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

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