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Research on the Application of Wearable Devices Combined with Computer Technology in Improving Students' Physical Fitness

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Abstract: **-**This study aims to explore the principles of wearable devices and their specific applications in the physical health management of primary and secondary school students. By analyzing the basic technology and working principles of wearable devices, the study examines their wide-ranging applications in health monitoring, understanding the integration status of wearable devices with computer technology, and enhancing the precision and effectiveness of health management through data analysis and intelligent management systems. Using a literature review and product descriptions provided by wearable device manufacturers, the study comprehensively assesses the application effects of wearable devices in improving students' physical health. The research finds that wearable devices are significantly effective in real-time monitoring of heart rate, steps, and sleep quality, helping students understand their health status and promoting healthy behaviors through personalized recommendations. However, challenges remain in terms of device accuracy and stability, data transmission reliability, battery life, and user privacy protection. In the future, with further technological advancements, wearable devices will play an even more important role in health management and physical improvement.

Keywords: Smart wearable devices; Computer technology; Physical health; Primary and secondary schools; Health management.

I. INTRODUCTION

In the era of rapid information technology development, smart wearable devices have become increasingly popular tools, not only used for health monitoring in daily life but also showing significant potential in education and sports. These devices can monitor the physiological indicators and activity data of the wearer in real-time, helping users better understand their health status [1]. As technology advances, the functions of smart wearable devices have become more diversified, evolving from simple step counters to comprehensive health management tools, including heart rate monitoring, sleep analysis, and calorie consumption calculation.

The physical health of primary and secondary school students has gradually attracted widespread attention from all sectors of society [2]. Due to heavy academic pressure and lack of exercise, many students' physical health conditions are not optimistic, with increasing issues such as obesity and myopia. Although the government has introduced various policies and measures aimed at improving students' physical health levels, many challenges remain in actual implementation [3]. Traditional methods of physical health management often rely on periodic physical examinations and manual records, lacking real-time accuracy and comprehensiveness, making it difficult to fully and accurately reflect students' health status.

With the rise of smart wearable devices combined with computer technology, new solutions for managing the physical health of primary and secondary school students have emerged [4]. These devices can monitor students' physiological indicators in real-time and provide personalized health advice through data analysis, helping to promptly identify and address health issues. Their interactivity and fun also help to stimulate students' interest in exercise, promoting the development of good exercise habits. They not only help students understand their activity levels and health status but also provide scientific health management bases for schools and parents through the accumulation and analysis of data. By analyzing students' activity data and health indicators, personalized exercise plans and dietary suggestions can be formulated to improve students' exercise enthusiasm and health levels. Smart wearable devices can also be integrated with computer technology to establish intelligent health management systems, achieving comprehensive monitoring and management of students' health data [5]. Such systems can help teachers and parents better understand students' health conditions, take timely intervention measures, and prevent health problems.

Through real-time monitoring and data analysis, teachers can understand each student's physical capabilities and health status, formulate personalized teaching plans for different students [6], improve the specificity and

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effectiveness of physical education, record students' performance in physical education classes, help teachers evaluate teaching effects, identify deficiencies in teaching, and further improve teaching methods. The application of smart wearable devices combined with computer technology in improving students' physical fitness has significant potential value and broad application prospects [7]. It can help students better manage their health and provide scientific health management tools for schools and parents, contributing to the improvement of students' physical health levels and promoting comprehensive development.

This study aims to explore the principles of smart wearable devices and their specific applications in physical health management. By analyzing the basic technologies and working principles of smart wearable devices and their extensive applications in health monitoring, the study examines the integration of smart wearable devices and computer technology, understanding how data analysis and intelligent management systems can enhance the accuracy and effectiveness of health management. The study also analyzes the specific application scenarios and effects of smart wearable devices in managing the physical health of primary and secondary school students. The research summarizes the potential value of smart wearable devices in improving the physical health of primary and secondary school students, providing scientific bases and practical guidance for future applications and promotion.

II. Research Methods

A. Research Path

This study aims to explore the application of smart wearable devices combined with computer technology in improving students' physical fitness, analyze their impact on various physical indicators of students, evaluate their actual effectiveness, and provide theoretical basis for future education and health management. By systematically analyzing existing research and relevant cases from smart wearable device brands, the actual application effects, potential advantages, and main challenges of smart wearable devices are clarified, providing a scientific basis for further promotion and optimization of such technologies.

1). Select high-quality literature related to the research topic, focusing on research results published in recent years to ensure the timeliness and relevance of the selected literature. The next stage is literature analysis and sorting. Detailed reading and analysis of the selected literature are performed to extract key information, summarize research conclusions, and form a systematic literature review report.

2). Collect product descriptions and application cases provided by smart wearable device manufacturers to understand their technical specifications and actual application effects. By comparing the characteristics and user feedback of devices from different manufacturers, evaluate their performance in actual use and propose targeted recommendations based on the results of literature analysis. Case analysis helps the research team better understand the performance of smart wearable devices in different application scenarios, identifying their strengths and weaknesses.

3). Combine the results of the literature review and case analysis to comprehensively evaluate the application effects of smart wearable devices in improving students' physical fitness. The systematic research design and methods comprehensively evaluate the application of smart wearable devices combined with computer technology in improving students' physical fitness, providing a solid theoretical foundation and practical guidance for further promotion and optimization of such technologies.

B. Data Collection Methods

The data collection methods of this study mainly include two parts: literature review and information collection. The literature review involves systematically searching and analyzing existing research on the application of smart wearable devices in health management to understand their potential roles and application status in improving students' physical fitness. The main databases include PubMed, Web of Science, and Google Scholar. Keywords such as "smart wearable devices," "physical fitness improvement," "student health management," and "computer technology" are used in the literature search to select high-quality literature related to the research topic. Key information on application cases and research results of smart wearable devices in sports monitoring, health management, and education fields is extracted through reading and analyzing these literatures.

The information collection part mainly involves obtaining product descriptions, technical specifications, user feedback, and application cases provided by relevant smart wearable device manufacturers. Information sources include official websites of manufacturers, user reviews, product evaluation reports, etc. By collecting and organizing this information, understand the actual application effects and user experience data of smart wearable

devices. Analyze the actual application situations in improving students' physical fitness based on the functional characteristics of mainstream smart wearable devices in the market. The analysis primarily evaluates the application cases provided by smart wearable device manufacturers. By comparing the functions, user feedback, and technical specifications of different devices, analyze their performance in actual use, especially their performance in monitoring health indicators such as heart rate, steps, activity volume, and sleep quality, as well as the effectiveness of their data processing and feedback mechanisms.

Combine the results of the literature review and case analysis for a comprehensive evaluation of the application effects of smart wearable devices combined with computer technology in improving students' physical fitness. Identify the main challenges in current research and applications through comprehensive evaluation, propose solutions to these challenges, and future development directions. Focus on the technical difficulties in implementation, practical issues in device usage, and potential development trends in the future to provide a scientific basis for further promotion and optimization of smart wearable devices in education and health management.

III. Results and Discussion

A. Principles and Mechanisms of Smart Wearable Devices

Smart wearable devices integrate various sensors and computer technologies to monitor, transmit, and process various physiological parameters of the human body. The basic components of smart wearable devices include sensor modules, processors, memory, communication modules, power modules, and display modules [8]. These parts work collaboratively: sensors collect physiological data, processors handle data processing, communication modules enable data transmission, and finally, the display modules provide feedback to the user [9]. Sensors are the core components of the devices, such as accelerometers for measuring movement states, heart rate sensors using photoplethysmography to measure heart rate, blood oxygen sensors measuring blood oxygen saturation through the Beer-Lambert law, and temperature sensors using thermistors to measure temperature (Table 1).

Table 1. Sensor functions and formulas

Sensors	Function	law	Formula
Acceleration sensor	Measure linear acceleration	Newton's second law	$a = \frac{F}{m}$ a:acceleration, F:force, m:mass;
Heart rate sensor	Measure heart rate	-	-
Blood oxygen sensor	Measure blood oxygen saturation	Beer-Lambert law	$A = \epsilon \cdot c \cdot l$ A: absorbance, ϵ :molar absorptivity, c :concentration, l optical path length;
Temperature sensor	Measure temperature	-	$R_t = R_0 \cdot e^{\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)}$ R_t: Resistance at temperature, R_0:Resistance at temperature, β:Material constants。

Data transmission for devices is typically achieved through Bluetooth Low Energy (BLE) technology, which is characterized by low power consumption and stable transmission. Wi-Fi technology is suitable for scenarios requiring higher transmission rates [10]. In terms of data processing, the computing power of both the device's internal processor and external devices work together to process sensor data through filtering, feature extraction, and pattern recognition algorithms. Filters are used to remove data noise, feature extraction identifies key information from raw data, and machine learning algorithms such as Support Vector Machines (SVM) and Convolutional Neural Networks (CNN) are used to recognize user activity patterns and health statuses. The combination of these technologies enables smart wearable devices to provide real-time, accurate health monitoring and management.

The effectiveness of smart wearable devices relies on theoretical support from sensor technology and data processing mechanisms [11]. Physiological signal processing theory helps understand the biophysical characteristics and noise properties of physiological signals, kinematic theory provides the basis for understanding human motion, and computer algorithms and data processing theory play key roles in signal processing and machine learning. Supported by these theories, smart wearable devices can achieve precise monitoring and analysis of users' health statuses, providing a foundation for student physical health management.

B. Basic Components and Working Principles of Smart Wearable Devices

The basic components of smart wearable devices are deeply integrated with modern technology, giving them significant advantages in the field of physical health monitoring. These devices typically consist of six parts: sensor modules, processors, memory, communication modules, power modules, and display modules [12]. The sensor module is responsible for collecting the user's physiological data, such as acceleration, heart rate, blood oxygen saturation, and body temperature. The processor module handles real-time processing and analysis of this data. The memory stores the data and processing results, while the communication module transmits the data to the user's smartphone or cloud via Bluetooth or Wi-Fi. The power module supplies the necessary power for the device's operation, and the display module provides real-time feedback to the user through LED or electronic ink screens. The coordinated work between these modules allows smart wearable devices to efficiently and accurately monitor users' health statuses.

Their working principle relies on precise sensors and complex computer algorithms. Sensors are the core components of the devices, converting physical signals into electrical signals [13]. For example, accelerometers detect acceleration using the piezoelectric effect or changes in capacitance and calculate the user's motion state through the processor. Heart rate sensors measure heart rate using photoplethysmography (PPG), where LED light sources illuminate the skin, and light reflection changes caused by blood flow are detected. Blood oxygen sensors use two different wavelength light sources (red and infrared) to calculate blood oxygen saturation by measuring the absorption rates of different wavelengths in the blood, based on the Beer-Lambert law. Temperature sensors, such as thermistors, measure body temperature by detecting resistance changes caused by temperature variations. Data collected by these sensors is transmitted to the processor for real-time analysis, providing users with health data.

In terms of physical health monitoring, smart wearable devices show broad application prospects and potential. Their portability and real-time monitoring capabilities enable them to provide continuous health monitoring for students and offer personalized health advice based on the monitored data. However, smart wearable devices also face challenges, such as sensor accuracy and stability, reliability of data transmission, device battery life, and user privacy protection. With the further development of sensor technology, data processing algorithms, and artificial intelligence, smart wearable devices will achieve more intelligent and personalized health management. The development of new sensor materials and miniaturization technology will also enhance the performance and expand the applications of smart wearable devices, better serving users' health management needs.

C. Sensor Monitoring of Students' Physiological Parameters

Smart wearable devices integrate multiple sensors to comprehensively monitor students' physiological parameters [14]. These devices use advanced sensor technology and data processing algorithms to provide real-time feedback on important health indicators such as heart rate, step count, and sleep quality. Through continuous monitoring and data analysis, smart wearable devices can help students understand their health status, provide personalized health management advice, and promote good habits and healthy behaviors. They have been widely applied in the field of health monitoring, with core technologies including various types of sensors that can monitor users' physiological parameters in real-time, such as heart rate, step count, and sleep quality. This article will detail the working principles of various sensors in smart wearable devices and their applications in student health monitoring (Figure 1).

Heart rate monitoring is one of the most common functions of smart wearable devices. Heart rate sensors mainly use photoplethysmography (PPG) to measure heart rate. PPG technology calculates heart rate by illuminating the skin with a light source (usually a green LED light) and detecting changes in light reflection caused by blood flow. When the heart beats, blood flows through the wrist or fingertip, altering the absorption of light. The photoelectric sensor captures these changes and converts them into electrical signals. The processor calculates the heart rate by analyzing the frequency of these electrical signal changes. The core components of PPG sensors include the LED light source and the photodetector [15]. The light emitted by the source penetrates

the skin, and some of it is absorbed by the blood while the remaining light is reflected back to the photodetector. By analyzing the intensity variations of the reflected light, a waveform synchronized with the heartbeat can be obtained. The processor can calculate the beats per minute (BPM) by analyzing the frequency of the waveform. This method is simple and efficient, suitable for most daily activities. However, factors such as exercise, ambient light, and skin color may affect measurement accuracy. Therefore, modern smart wearable devices often combine multiple algorithms, such as filters and signal processing techniques, to improve measurement accuracy. By continuously monitoring heart rate, smart wearable devices can help students understand their heart health and provide real-time health feedback. During physical activities, the device can monitor heart rate changes to ensure students exercise within a safe range. Through long-term data analysis, the device can also identify abnormal heart rate changes and remind users to seek medical attention in time.

Step count monitoring is an important indicator for evaluating students' daily activity levels. Smart wearable devices usually use accelerometers and gyroscopes to detect steps. The accelerometer detects steps by measuring changes in the device's acceleration along different axes, while the gyroscope measures changes in the device's angular velocity to improve step detection accuracy. The working principle of accelerometers is based on Newton's second law ($F = ma$). The sensor contains a mass that, when the user moves, is acted upon by inertial forces, causing displacement. This displacement changes the capacitance or resistance within the sensor, generating an electrical signal proportional to the acceleration. By analyzing the frequency and amplitude of these electrical signals, the processor can recognize and count steps. The gyroscope measures the device's rotational motion, providing information about the device's posture changes by detecting angular velocity along different axes. Combining accelerometer data, the processor can more accurately identify the user's steps, reducing false positives and missed counts. Step count monitoring plays an important role in student health management. By monitoring daily steps, smart wearable devices can help students understand their activity levels and encourage them to maintain a reasonable amount of physical exercise. The device can also set step count goals, providing motivation and feedback to help students develop good exercise habits. Additionally, step count data can be used to evaluate overall health status, identify high-risk groups with insufficient activity, and promote health interventions.

Sleep quality is an important indicator for assessing students' physical and mental health. Smart wearable devices usually monitor sleep quality by comprehensively using multiple sensors, including accelerometers, heart rate sensors, and electrodermal activity sensors. These sensors provide data on the user's movements, heart rate, and physiological state, helping the device identify sleep stages and evaluate sleep quality. Accelerometers detect the user's movement status during sleep, allowing the device to identify sleep onset time, wake-up time, and the number of nighttime turns. Heart rate sensors provide data on heart rate changes, helping identify different sleep stages, such as light sleep, deep sleep, and rapid eye movement (REM) sleep. Studies have shown that heart rate changes significantly across different sleep stages, with higher heart rates during light sleep and lower heart rates during deep sleep. Electrodermal activity (EDA) sensors measure changes in skin conductance, providing information about the user's psychological and physiological state. Skin conductance is influenced by sweat gland activity, and changes in conductance occur when the user is tense or relaxed. By analyzing these data, the device can identify the user's emotional fluctuations and stress levels during sleep. Sleep quality monitoring is of great significance in student health management. By continuously monitoring sleep data, smart wearable devices can help students understand their sleep patterns and quality, providing personalized improvement suggestions [16]. For example, the device can identify factors leading to poor sleep, such as staying up late or environmental noise, and remind users to adjust their schedules and environment. Long-term sleep data analysis can also help identify sleep disorders, such as insomnia and sleep apnea, providing early intervention and treatment recommendations.

In addition to heart rate, step count, and sleep quality, smart wearable devices can also monitor other physiological parameters such as blood oxygen saturation, respiratory rate, and body temperature. Blood oxygen sensors measure blood oxygen saturation using photoplethysmography [17]. The sensor emits two different wavelengths of light (red and infrared) and calculates blood oxygen saturation by measuring the absorption rates of light in the blood. This indicator is important for assessing students' respiratory health. Respiratory rate sensors measure the respiratory rate by detecting chest and abdominal movements, typically using piezoelectric or capacitance change technology. Respiratory rate is an important indicator for assessing students' lung function and overall health, particularly in exercise and stress management. Body temperature sensors monitor the user's temperature by measuring skin temperature or core body temperature. Infrared temperature sensors measure the skin's surface temperature using infrared radiation, while thermistors or thermocouples are used for more precise

core body temperature measurements. Body temperature monitoring can help identify infections and other health issues early in student health management.

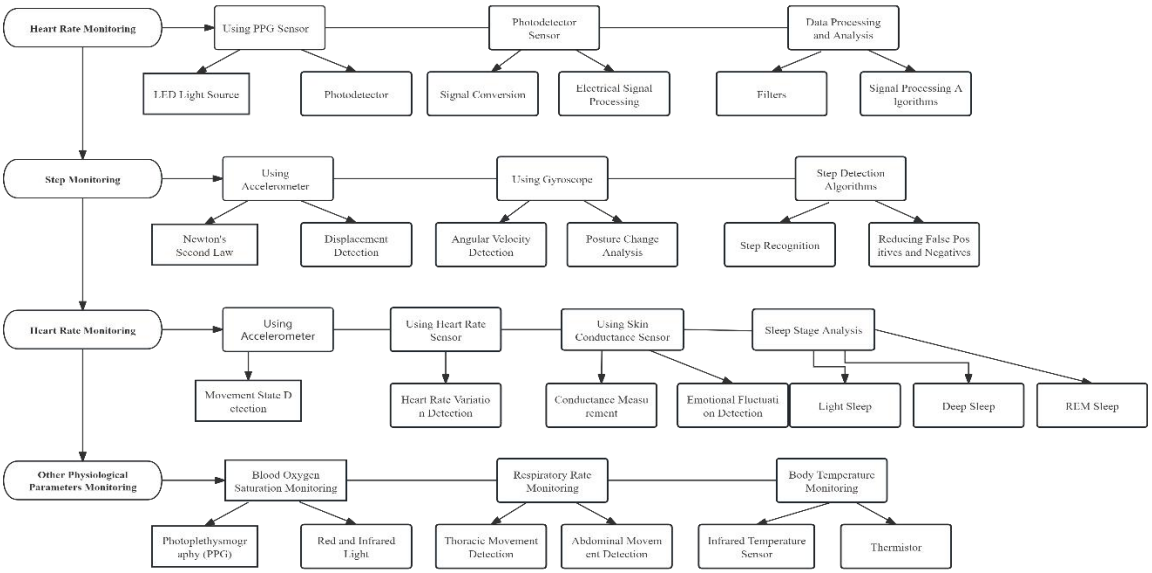

Figure 1. Working principles of various sensors in smart wearable devices and their applications in student health monitoring

D. The analysis of commonly seen smart wearable devices on the market:

The smart wearable device market is vibrant, with major brands like Apple, Fitbit, Huawei, Xiaomi, and Garmin holding significant positions globally (Table 2). The Apple Watch, as a leader in smartwatches, with its latest models Series 8 and SE, not only includes traditional health monitoring functions but also adds temperature sensors and car crash detection, offering advanced heart rate monitoring, ECG, and blood oxygen saturation measurement. Fitbit devices focus on health and fitness tracking, providing precise heart rate monitoring, sleep scores, blood oxygen measurement, stress management, and multiple exercise modes. Huawei's Watch GT series attracts numerous users with its long battery life and comprehensive health management functions, Xiaomi's Mi Band series holds an important position in the mass market due to its high cost-performance ratio and practical features, while Garmin enjoys a reputation among sports enthusiasts and professional athletes for its professional sports data analysis and outdoor navigation functions.

In terms of main functions, each brand’s device has its unique features. The Apple Watch not only supports heart rate monitoring, ECG, and blood oxygen measurement but also comes with temperature sensing and car crash detection, enabling comprehensive monitoring of the user's health status. Fitbit devices are renowned for their high-precision sleep analysis and stress management functions, helping users improve sleep quality and reduce stress. Huawei devices, with their long battery life and comprehensive health monitoring functions, have a distinct advantage in continuous health monitoring. Xiaomi devices, with their price advantage and multifunctionality, provide users with practical health management tools. Garmin devices, designed for extreme sports and professional training, significantly enhance users' athletic performance and health levels through precise data analysis and professional reports.

Smart wearable devices have shown significant effects in health monitoring and physical fitness improvement. The Apple Watch, with its rich exercise modes and activity recording functions, helps users set and achieve fitness goals, improving their physical condition. Fitbit, through its diverse exercise tracking functions and community motivation mechanisms, inspires users' interest in exercise, helping them gradually improve their physical condition. Huawei devices, through their scientific exercise guidance and comprehensive health data, play an important role in improving users' physical condition. Xiaomi devices, with their high cost-performance ratio and multifunctionality, provide practical tools for physical improvement to entry-level users. Garmin devices, through precise data and professional training modes, significantly enhance professional users' physical fitness and athletic performance. In the future, with further technological advancements, smart wearable devices will play an even more important role in health management and physical fitness improvement.

Table 2. Common smart wearable devices

Brand	Model	Main Features	Technical Specifications	User Reviews	Application Effectiveness
Apple	Apple Watch Series 8	Heart rate monitoring, ECG, blood oxygen measurement, temperature sensing, workout detection, GPS, crash detection	S8 chip, Retina display, Always-On display, 18-hour battery life	Stylish design, comprehensive features, well-integrated ecosystem, relatively short battery life	Early disease detection, health management, personalized training guidance
Fitbit	Fitbit Charge 5	Heart rate monitoring, sleep score, blood oxygen measurement, stress management, GPS, multiple workout modes	High-precision sensors, AMOLED display, 7-day battery life	Accurate health and fitness tracking, lacks some smart features and app ecosystem	Improves sleep quality, reduces stress, enhances overall health
Huawei	Huawei Watch GT	Heart rate monitoring, blood oxygen measurement, sleep analysis, stress monitoring, GPS, long battery life	Kirin A1 chip, AMOLED display, up to 2-week battery life	Long battery life, rich health features, app ecosystem not as extensive as Apple	Continuous health monitoring, scientific workout guidance
Xiaomi	Xiaomi Mi Band 8	Heart rate monitoring, blood oxygen measurement, sleep tracking, stress management, GPS, high cost-performance ratio	High-resolution AMOLED display, 14-day battery life	High cost-performance ratio, practical functions, lacks advanced features and professional capabilities	Health management tools suitable for beginners
Garmin	Garmin Fenix 7	High-precision heart rate monitoring, blood oxygen measurement, outdoor navigation, workout data analysis, professional training modes	High-precision GPS chip, MIP display, up to 20-day battery life	Highly rated by professional athletes, accurate data, strong workout features, higher price	Enhances athletic performance and health, suitable for professional users

IV. Conclusion

This study explores the application and potential of wearable devices in the physical health management of primary and secondary school students. Wearable devices provide comprehensive health data by monitoring physiological parameters such as heart rate, steps, and sleep quality in real time, helping students understand their health status and promote the formation of good lifestyle habits through personalized recommendations. By recording and providing feedback in real time, the devices can help students develop good exercise habits and improve their physical health levels. The interactivity and fun of wearable devices also help stimulate students' interest in exercise and increase their enthusiasm for participating in physical activities.

Wearable devices still face some challenges in practical applications, including accuracy and stability of the devices, reliability of data transmission, battery life, and user privacy protection. The way the devices are worn and their quality may affect data accuracy, and students' awareness of correct usage and maintenance needs to be further improved. Future research should continue to focus on the actual application effects of wearable devices in education and health management, exploring how to enhance the accuracy and stability of the devices through technological improvements. Meanwhile, schools and parents should strengthen education and training for students on the use of wearable devices to ensure correct usage and maintenance.

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Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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