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# Application of Exercise Injury Prevention Systems in the Elderly: Current Status and Challenges of Sensor Technology



**Abstract:** With the increasing trend of global population aging, the management of elderly exercise health has become a significant public health issue. This study evaluates the current application status of sensor technology in exercise injury prevention systems for the elderly and analyzes existing technical challenges. Through the collaborative work of multiple sensors such as accelerometers, gyroscopes, pressure sensors, and heart rate sensors, it is possible to monitor the movement status and physiological indicators of the elderly in real time, providing key data for gait analysis, balance assessment, and heart rate monitoring. The application of these technologies significantly enhances the exercise safety and health management level of the elderly. However, sensor accuracy and reliability, data fusion, multi-sensor coordination, and the response speed of real-time monitoring systems remain critical technical bottlenecks to be addressed. The accuracy and reliability of sensors directly affect the data's accuracy and the system's effectiveness, and the performance of current sensor technology in complex environments still needs improvement. The fusion of data from different sensors and the coordination and synchronization of multi-sensor systems are important technical challenges for achieving comprehensive monitoring. Therefore, this study proposes solutions aimed at improving sensor accuracy, developing self-calibration and self-diagnosis functions, multi-level data processing architecture, and efficient data compression and transmission technologies. These optimization measures can significantly improve the system's real-time performance and accuracy. In the future, the combination of sensor technology with artificial intelligence, the Internet of Things, cloud computing, and big data analysis will promote the development of intelligent and personalized health monitoring systems, providing more comprehensive health management services for the elderly and improving their quality of life and health levels.

**Keywords:** Elderly health; exercise injury prevention; sensor technology; data fusion; real-time monitoring

## I. INTRODUCTION

The trend of global population aging is becoming increasingly significant, with the proportion of elderly people continuously rising, presenting one of the major socio-economic challenges of the 21st century[1-3]. According to United Nations projections, by 2050, the global population aged 65 and above will reach approximately 1.6 billion, accounting for 16% of the total population[4]. The increase in the elderly population not only places enormous pressure on healthcare and social security systems but also raises new public health demands[5-6]. As people age, their physical functions gradually decline, and the risk of diseases, particularly chronic diseases and musculoskeletal disorders, increases. Therefore, enhancing the quality of life of the elderly and maintaining and promoting their exercise health becomes crucial. Exercise, as a simple and effective health intervention, plays a significant role in delaying aging, preventing diseases, and improving physical function. Thus, effective monitoring and management of the elderly's exercise health is an urgent problem that needs to be addressed[7].

Exercise injury is one of the main risks that elderly individuals face during physical activities, significantly impacting their quality of life[8-10]. The bones, joints, and muscles of elderly people become fragile with age, making improper actions during exercise likely to cause falls, fractures, and sprains[11-12]. These exercise injuries not only lead to further deterioration of the elderly's physical functions but also may trigger a series of health problems, such as pneumonia and thrombosis due to prolonged bed rest. Additionally, exercise injuries negatively affect the elderly's mental health, potentially leading to fear of exercise, reduced social activities, and subsequently, feelings of loneliness and depression.

To address these challenges, advancements in modern sensor technology offer new solutions for the prevention and monitoring of exercise injuries in the elderly[13-14]. By integrating multiple sensors, it is possible to monitor the elderly's movement status and physiological indicators in real time, identify potential exercise risks promptly,

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and provide personalized health advice and warnings[15]. This sensor-based exercise monitoring system not only enhances the safety of the elderly's physical activities but also aids healthcare professionals in better understanding the elderly's health conditions, thereby devising more scientific and reasonable exercise and rehabilitation plans[16-18].

Despite the significant potential of sensor technology in exercise injury prevention systems, several challenges remain in practical applications. The diversity and complexity of existing sensor technologies make it challenging to comprehensively cover all types of sensors and their application scenarios. This study comprehensively evaluates the current application status of sensor technology in exercise injury prevention systems for the elderly. By thoroughly analyzing existing literature and available market devices, we will explore the effectiveness of various sensors in monitoring the elderly's movement status, identifying exercise risks, and providing health feedback. We will also explore possible solutions to enhance the application effectiveness and user experience of sensor technology, providing theoretical foundations and technical support for the future development and optimization of exercise injury prevention systems for the elderly.

## II. CURRENT APPLICATION STATUS OF SENSOR TECHNOLOGY IN PREVENTING EXERCISE INJURIES AMONG THE ELDERLY

### A. *Types of Sensors and Their Functions*

Sensor technology plays a crucial role in preventing exercise injuries among the elderly by enabling real-time monitoring of their movement status and health conditions through the collaborative work of multiple sensors[19]. Accelerometers, one of the most commonly used sensors, primarily detect changes in body acceleration. These sensors can accurately capture changes in the gait and posture of the elderly during physical activities, providing critical data for gait analysis and fall detection[20]. By measuring acceleration, it is possible to identify behavioral patterns in different states such as walking, running, and standing, thus detecting anomalies in time to prevent potential exercise injuries.

Gyroscopes are another commonly used sensor, mainly used to measure angular velocity, i.e., the rotational speed of an object in various directions[21]. In exercise injury prevention systems, gyroscopes are primarily used to monitor the balance status of the elderly. By combining data from accelerometers, gyroscopes can provide more comprehensive motion posture information. This is especially important for the elderly, as their balance ability is usually weaker, increasing the risk of falls. Gyroscope data helps analyze balance conditions in different movement states and provides timely warnings and interventions to reduce falls and related injuries.

Pressure sensors are also widely used in monitoring the exercise of the elderly, particularly in embedded applications such as insoles or floor mats. By measuring the distribution of foot pressure, pressure sensors can analyze the force exerted by the elderly when walking or standing. This data is essential for understanding the gait and weight distribution of the elderly, helping to identify abnormal gaits and uneven forces, which are potential factors leading to exercise injuries. Additionally, pressure sensors can be used in rehabilitation training and physiotherapy to monitor pressure changes during specific exercises or rehabilitation training, ensuring that their exercise postures and forces meet safety standards.

Heart rate sensors are indispensable in exercise injury prevention systems. These sensors primarily monitor changes in the heart rate of the elderly[22]. By analyzing heart rate data, the physiological load during exercise can be understood. Heart rate sensors are usually available in wearable forms such as smartwatches or heart rate belts, recording heart rate in real-time and transmitting data to analysis systems via wireless technology. Heart rate data helps evaluate the exercise intensity of the elderly, preventing cardiovascular problems caused by over-exertion.

### B. *Application of Sensors in Monitoring Elderly Exercise*

The application of sensor technology in monitoring elderly exercise provides detailed data on movement and health through gait analysis, balance assessment, and heart rate monitoring, offering personalized health management and exercise guidance for the elderly. As technology continues to develop, the precision and reliability of sensors will further improve, leading to more extensive and in-depth applications in elderly health monitoring, thereby enhancing the quality of life and health levels of the elderly.

Gait analysis is a critical application of sensor technology in monitoring elderly exercise. Detailed gait analysis can effectively assess the movement functions and health status of the elderly[23]. Accelerometers and gyroscopes are the most commonly used sensors in gait analysis. Accelerometers capture the acceleration changes produced by the elderly while walking, recording the force and frequency of each step. Gyroscopes measure the rotational speed of the body in various directions, providing angular information about the gait. These sensors are typically integrated into insoles, leg bands, or wearable devices, transmitting data to analysis systems in real-time via wireless communication technology. Comprehensive analysis of this data can identify gait abnormalities, such as uneven step lengths, reduced step speed, and unstable gait. These abnormal gaits may indicate potential health problems, such as muscle weakness, decreased balance ability, or neurological disorders, helping medical professionals develop appropriate interventions to prevent falls and other exercise injuries.

Balance assessment is equally crucial for monitoring elderly exercise. The elderly often have poor balance ability due to physical decline, making them prone to falls. Sensor technology allows for real-time monitoring of balance status and provides warnings. Accelerometers and gyroscopes are key tools in balance assessment. These sensors can be installed on the waist, ankles, or shoe soles, measuring acceleration and angular velocity in both static and dynamic states to evaluate the balance ability of the elderly. By detecting subtle body sways and center-of-gravity shifts, it is possible to identify balance conditions during standing, walking, and turning. Combining pressure sensor data to analyze foot pressure distribution changes offers a more comprehensive understanding of the balance status of the elderly. This data enables the system to issue timely alerts, reminding the elderly or their caregivers to adjust postures and avoid falls. Balance assessment data can also be used to develop personalized balance training plans, helping the elderly improve balance ability and enhance body stability.

Heart rate monitoring through real-time heart rate data can effectively assess exercise intensity and cardiovascular health status in the elderly[24]. Heart rate sensors, often in the form of wearable devices such as smartwatches, heart rate belts, or patches, continuously monitor heart rate changes, providing real-time data. Heart rate monitoring is particularly important during exercise as excessive exercise may overburden the heart, increasing the risk of cardiovascular events. Heart rate data allows the system to evaluate the elderly's heart rate response under different exercise intensities, determining whether they are exercising within a safe range. The system can set a target heart rate zone to help the elderly maintain an appropriate heart rate during exercise, avoiding over-exertion. Heart rate monitoring can also combine other physiological indicators such as blood oxygen saturation and blood pressure to comprehensively assess the cardiovascular health status of the elderly. When abnormal heart rate conditions such as excessively high or low heart rates occur, the system can promptly issue alerts, advising the elderly to stop exercising and seek medical attention. Long-term heart rate monitoring data can also be used in health management, aiding medical professionals in formulating personalized exercise prescriptions and health plans, thereby improving overall health levels.

### *C. Case Analysis of Existing Systems and Devices*

Currently, the market offers a variety of devices specifically designed for monitoring elderly exercise, integrating multiple sensors to monitor their movement status and health conditions in real time (Table 1). Brands like Fitbit and Garmin have smartwatches and fitness trackers that are popular among the elderly[25]. These devices are typically equipped with accelerometers, gyroscopes, and heart rate sensors, capable of monitoring steps, gait, heart rate, and calorie consumption. Some advanced devices also integrate GPS functionality to track the movement path and speed of the elderly. These devices transmit data to mobile applications or cloud storage via Bluetooth or Wi-Fi, allowing users and caregivers to view exercise and health data anytime and receive personalized health advice and reminders.

Another common type of device is smart insoles and foot sensors, such as those from Moticon and Lechal. These devices embed accelerometers and pressure sensors to monitor plantar pressure distribution and gait changes, providing detailed gait analysis and fall risk assessment. These devices are not only suitable for daily exercise monitoring but are also widely used in rehabilitation training and physical therapy to help the elderly regain motor functions and improve balance. Additionally, the market offers specialized home health monitoring systems, such as CarePredict and Lively. These systems use multiple sensors (including motion sensors, environmental sensors, and biosensors) to monitor the activities of the elderly at home in real time. Upon detecting abnormal behavior or

emergencies, the system automatically sends alerts to family members or caregivers, ensuring the safety of the elderly.

In academic research and clinical trials, the application of sensor technology is more in-depth and extensive[26]. Many research projects are dedicated to developing innovative sensor systems to enhance the accuracy and practicality of elderly exercise monitoring. For instance, a research project at Stanford University developed a fall warning system based on wearable sensors. This system integrates accelerometers, gyroscopes, and pressure sensors to monitor the movement status of the elderly in real time and uses machine learning algorithms to analyze data, predict fall risks, and provide warnings. The research results show that the system has high accuracy and sensitivity in fall prediction, with potential for widespread application in home and community care for the elderly.

Another project at the Massachusetts Institute of Technology explored methods for gait analysis and rehabilitation training using smart insoles. The research team embedded high-precision pressure sensors in the insoles to monitor plantar pressure distribution and gait parameters, analyzing gait patterns and balance abilities in the elderly. The system not only identifies gait abnormalities but also adjusts rehabilitation training plans based on real-time data, improving training effectiveness. The research results indicate significant improvements in balance ability and gait stability in the elderly using smart insoles in rehabilitation training.

The University of California, Los Angeles developed a smart home system integrating multiple sensors, including environmental sensors, motion sensors, and biosensors. This system can monitor the activities, heart rate, blood pressure, and sleep conditions of the elderly at home in real time. Data analysis provides personalized health management advice and warnings. The research results demonstrate that the system significantly improves the health management level and quality of life of the elderly.

The existing elderly exercise monitoring devices on the market and the application cases of sensor technology in academic research demonstrate the wide application and great potential of sensor technology in elderly health monitoring. As technology advances, these devices and systems will become more intelligent, accurate, and personalized, providing more comprehensive health management services for the elderly and enhancing their quality of life and health levels.

**Table 1** Elderly Exercise Monitoring Devices And Research Projects

| Brand/System          | Application Case                                                                    |
|-----------------------|-------------------------------------------------------------------------------------|
| Fitbit                | Smartwatches and fitness trackers,                                                  |
| Garmin                | monitor steps, gait, heart rate, and calorie consumption                            |
| Moticon               | Smart insoles, monitor plantar pressure distribution and gait changes,              |
| Lechal                | provide gait analysis and fall risk assessment                                      |
| CarePredict           | Home health monitoring system, uses multiple sensors to monitor elderly             |
| Lively                | activities in real-time, sends automatic alerts                                     |
| Stanford University   | Wearable sensor-based fall warning system, uses machine learning algorithms         |
| Research Project      | to analyze data, predict fall risk and provide warnings                             |
| MIT Research Project  | Use of smart insoles for gait analysis and rehabilitation training, monitor plantar |
|                       | pressure distribution and gait parameters, adjust rehabilitation training plans     |
| UCLA Research Project | Integrated multi-sensor smart home system, real-time monitoring of elderly          |
|                       | activities,                                                                         |
|                       | heart rate, blood pressure, and sleep conditions, provides health management        |
|                       | advice and warnings                                                                 |

### III. DATA COLLECTION AND PROCESSING TECHNOLOGY

#### A. *Data Collection Methods*

Data collection forms the foundation of an elderly exercise monitoring system. Through real-time data acquisition from sensors, a large amount of physiological and movement data can be obtained during the exercise of elderly individuals. These sensors typically include accelerometers, gyroscopes, pressure sensors, and heart rate sensors. Real-time data collection means that sensors continuously record motion parameters and update data at high frequencies. This method ensures the timeliness and continuity of the data, helping capture subtle changes and sudden occurrences during the exercise. Accelerometers can collect data hundreds of times per second, recording the force and rhythm of each step taken by the elderly; heart rate sensors can monitor heart rate changes in real-time, reflecting the physiological responses under different exercise intensities.

Data transmission and storage are critical links in the data collection process. The data collected by the sensors are usually transmitted to a central processing unit or cloud storage through wireless communication technologies such as Bluetooth or Wi-Fi[27]. The application of wireless transmission technology not only improves the efficiency of data transmission but also reduces the cable connections of the devices, enhancing the comfort and convenience for the elderly wearing the equipment. The data transmitted to the cloud can be stored for a long time, facilitating subsequent analysis and comparative studies. Storage systems generally need to have high reliability and security to ensure the integrity and privacy protection of the data. Additionally, to meet the storage needs of large data volumes, distributed storage systems are a common solution, which can not only improve the scalability of data storage but also enhance the flexibility of data access.

#### B. *Data Processing and Analysis*

Data processing and analysis are core aspects of the elderly exercise monitoring system. By deeply processing the collected data, valuable information can be extracted, and accurate risk assessments can be conducted. Data preprocessing is the first step in data processing, mainly including filtering and noise reduction. The raw data collected by sensors may contain a large amount of noise and irrelevant information, which must be removed through filtering techniques to improve data quality and accuracy. Common filtering techniques include low-pass filtering, high-pass filtering, and band-pass filtering, with specific choices depending on the characteristics of the data and the application scenario. Noise reduction can be achieved through multiple sampling and data smoothing techniques, further enhancing data stability.

Feature extraction and selection are critical steps in data processing. By extracting features from the preprocessed data, key information reflecting the elderly's exercise status and health condition can be obtained. Features such as stride length, step frequency, and swing time can be extracted from gait data, while features such as average heart rate and heart rate variability can be extracted from heart rate data. These features not only intuitively reflect the exercise capacity and health level of the elderly but also provide a basis for subsequent risk assessments. Feature selection involves choosing the most representative features from a large set to improve the model's efficiency and accuracy. Common feature selection methods include Principal Component Analysis (PCA), correlation analysis, and feature selection algorithms in machine learning.

Model training and risk assessment are the final steps in data processing and analysis. By modeling the extracted features, accurate assessments of the elderly's exercise risks can be achieved. Model training usually combines supervised learning and unsupervised learning methods[29], using historical data and labeled data for training to improve the model's prediction and generalization abilities. Common models include decision trees, support vector machines, neural networks, and deep learning models. These models can analyze the elderly's exercise data in real-time, predicting risks such as falls and cardiovascular events, and providing corresponding warnings and intervention measures[30]. Risk assessment results can be displayed through visualization tools, allowing the elderly and caregivers to timely understand health status and take necessary measures for intervention and prevention.

Data collection and processing technology is at the core of the elderly exercise monitoring system(Table 2). Through real-time data collection, effective data transmission and storage, and in-depth data processing and analysis, comprehensive exercise and health monitoring services can be provided to the elderly, improving their quality of life and health levels.

**Table 1** Functions, Features, Applications, And Technologies

| Category                           | Functions/Features                                                                                                                                                                                                                                                     | Applications/Technologies                                                                                                                                                      |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Real-time Data Collection          | Sensors continuously record motion parameters, high-frequency data updates; accelerometers collect data hundreds of times per second, heart rate sensors monitor heart rate changes in real-time                                                                       | Capture subtle changes and sudden events in motion in real-time, improving data timeliness and continuity                                                                      |
| Data Transmission and Storage      | Wireless communication technologies (e.g., Bluetooth, Wi-Fi) transmit data to central processing units or cloud storage; high reliability and security storage systems, distributed storage systems enhance scalability and access flexibility                         | Improve data transmission efficiency, reduce device cable connections, enhance wearing comfort; long-term data storage facilitates subsequent analysis and comparative studies |
| Data Preprocessing                 | Filtering techniques (low-pass, high-pass, band-pass filters, etc.) remove noise; noise reduction achieved through multiple sampling and data smoothing techniques                                                                                                     | Enhance data quality and accuracy, stability; remove irrelevant information, improve data utilization                                                                          |
| Feature Extraction and Selection   | Extract features such as step length, step frequency, and swing time from gait data; extract features such as average heart rate and heart rate variability from heart rate data; feature selection through PCA, correlation analysis, and machine learning algorithms | Obtain key information reflecting motion status and health condition, improve model efficiency and accuracy                                                                    |
| Model Training and Risk Assessment | Combination of supervised and unsupervised learning for model training; common models include decision trees, support vector machines, neural networks, and deep learning models; risk assessment results visualized through tools                                     | Accurate assessment of motion risks, provide warnings and interventions; improve prediction ability and generalization                                                         |

#### IV. EXISTING TECHNICAL CHALLENGES

##### A. Sensor Accuracy and Reliability

In the system for preventing exercise injuries in the elderly, the accuracy of sensors is crucial for data accuracy and reliability. High-precision sensors can capture subtle movement changes and physiological signals[31], providing accurate monitoring data to effectively predict and prevent exercise injuries. For instance, high-precision data from accelerometers and gyroscopes can precisely analyze the gait and balance of elderly individuals, identifying potential fall risks. However, in practical applications, sensor accuracy is influenced by various factors, including the sensor's technical parameters, external environmental conditions, and installation position and method. These factors may cause data deviations and errors, affecting the overall effectiveness of the injury prevention system.

Reliability issues of sensors in practical applications are also significant challenges. Sensors need to work stably in various complex environments, such as homes, outdoors, and medical institutions. Environmental factors like temperature, humidity, and electromagnetic interference may affect sensor performance. Long-term use of sensors can lead to decreased sensitivity and increased failure rates, affecting data continuity and accuracy. To improve sensor reliability, strict quality control and testing must be conducted to ensure stable operation under various conditions. Additionally, developing intelligent sensors with self-calibration and self-diagnosis functions is an effective way to enhance sensor reliability.

### B. *Data Fusion and Multi-Sensor Coordination*

In the elderly exercise monitoring system, data from a single sensor is often insufficient to comprehensively reflect the exercise status and health condition of elderly individuals. Therefore, data fusion and multi-sensor coordination become key to addressing this issue. Data fusion methods for different sensors mainly include sensor-level fusion, feature-level fusion, and decision-level fusion[32]. Sensor-level fusion involves preliminary processing and fusion of data from different sensors during data acquisition, such as data fusion through weighted averaging or filtering. Feature-level fusion involves comprehensive analysis and processing of features extracted from different sensors during data processing, using methods like Principal Component Analysis or clustering algorithms. Decision-level fusion involves integrating the analysis results of data from different sensors during data analysis, using methods like voting or Bayesian networks.

Coordination and synchronization of multi-sensor systems are also crucial for achieving data fusion. In multi-sensor systems, each sensor needs to coordinate in time and space to ensure data synchronization and consistency. In gait analysis, data from accelerometers and gyroscopes need to be precisely synchronized to provide accurate gait information. Sensor coordination and synchronization can be achieved through hardware synchronization and software synchronization. Hardware synchronization is usually realized through clock synchronization and trigger signals, providing high-precision time synchronization. Software synchronization is achieved through timestamping and data alignment algorithms, offering good flexibility and adaptability. Additionally, to enhance system stability and reliability, effective fault detection and tolerance mechanisms need to be established to ensure normal operation in case of sensor failure or data loss.

### C. *Response Speed of Real-Time Monitoring Systems*

The response speed of real-time monitoring systems is an important indicator of their performance. For the elderly exercise monitoring system, a fast response speed not only provides timely health feedback but also offers quick warnings and interventions in emergencies. When the system detects a fall risk in elderly individuals, it can immediately issue an alert, prompting preventive measures, thereby effectively reducing fall incidents. Improving response speed relies on efficient data processing algorithms and fast data transmission technologies.

To enhance system response speed, a multi-layered data processing architecture can be adopted, dividing data processing tasks into different layers. For example, the basic layer can perform simple data preprocessing and preliminary analysis to quickly filter out abnormal data, while the advanced layer can conduct complex data analysis and pattern recognition to provide detailed health assessments and predictions. This layered processing architecture can improve data processing efficiency and offer different levels of health feedback to meet the needs of various scenarios. Using efficient data compression and transmission technologies to reduce delays during data transmission is also an effective means to improve system response speed.

### D. *User Acceptance and Wearability*

The acceptance of monitoring devices by elderly individuals and the comfort and wearability of these devices are crucial factors influencing their promotion and usage. Although high-tech devices can provide detailed health monitoring data, the system's effectiveness will be significantly compromised if the elderly are unwilling to wear or use them. Therefore, designing devices suitable for the elderly to enhance their acceptance and comfort is a key consideration in the research and development process. Elderly individuals usually are not accustomed to complex operations and heavy equipment, so the device should simplify the user interface to enhance ease of use.

The comfort and wearability of the devices are also important factors influencing elderly acceptance. Sensor devices should be designed to be lightweight and soft, suitable for long-term wear without causing discomfort. For wearable devices like smartwatches and fitness trackers, the choice of materials and design should consider skin compatibility and breathability to avoid skin allergies and discomfort. Battery life and charging convenience are also considerations; long battery life and convenient charging methods can increase elderly reliance on and frequency of use of the devices.

### E. *Continuous Improvement and Future Directions*

Improving sensor accuracy and reliability, optimizing data fusion methods, and enhancing the coordination and synchronization of multi-sensor systems are key directions for future research. With the development of artificial intelligence and machine learning technologies, the application of intelligent sensors and adaptive algorithms will provide new ideas and methods to address these challenges. Developing intelligent sensors with self-learning capabilities that can automatically adjust parameters based on the environment and usage conditions will provide more accurate and reliable data. Multi-sensor data fusion algorithms based on deep learning can better explore potential patterns and relationships within the data, enhancing the system's predictive capability and accuracy.

In the future, sensor technology will play an increasingly important role in elderly health management. By integrating with other technologies[34], such as the Internet of Things (IoT), cloud computing, and big data analytics, it is possible to build intelligent and personalized health monitoring and management systems. These systems will not only provide real-time exercise and health data but also offer personalized health advice and intervention measures through intelligent analysis and prediction, thereby improving the quality of life and health levels of elderly individuals.

## V. CONCLUSION

This study comprehensively evaluated the application status of sensor technology in the prevention system of exercise injuries in the elderly, revealing the potential of this technology in improving the quality of life and health levels of elderly individuals. Sensor technologies such as accelerometers, gyroscopes, pressure sensors, and heart rate sensors have been widely used in gait analysis, balance assessment, and heart rate monitoring. These technologies can provide detailed exercise and health data, offering a reliable basis for the personalized health management and exercise guidance of elderly individuals. Sensor accuracy and reliability are critical factors affecting the effectiveness of exercise injury prevention systems. High-precision sensors can capture subtle movement changes and physiological signals, providing a foundation for the accurate prediction and prevention of exercise injuries. In practical applications, sensors are susceptible to external environmental conditions and installation methods, leading to data deviations and errors. Long-term use of sensors can also result in performance degradation. Therefore, improving sensor accuracy and reliability and developing intelligent sensors with self-calibration and self-diagnosis functions are important directions for future research.

Data fusion and multi-sensor coordination are also significant technical challenges for implementing elderly exercise injury prevention systems. Data from a single sensor is often insufficient to comprehensively reflect the exercise status and health conditions of elderly individuals. Thus, multi-sensor data fusion and coordinated work are needed to provide more comprehensive and accurate information. Common data fusion methods include sensor-level fusion, feature-level fusion, and decision-level fusion, and multi-sensor coordination is achieved through hardware and software synchronization. Enhancing the response speed of real-time monitoring systems to ensure the system can provide rapid warnings and interventions in emergencies is also crucial for improving system effectiveness. Through these optimizations and improvements, sensor technology will play an increasingly important role in elderly health management, providing a solid foundation for improving the quality of life and health levels of elderly individuals.

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