A Review of Research on Intervention and Identification Technology for Preventing Fall Injuries in the Elderly

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Abstract. Fall injuries in the elderly have become a major threat to the health and safety of the older adults in China. Many scholars have carried out relevant research on the interventions and early warning of falls in the elderly. Assessing the risk of falls in the elderly by constructing fall risk assessment scales, and identifying and alerting fall risk based on video surveillance and patterns. Vibration analysis, human posture and motion and other methods play important roles in preventing falls and fall injuries. Based on the analysis of the existing literature, this paper aims to provide reference for further research on the fall intervention and identification technology for preventing falls in the elderly.

1. Introduction
With the gradual aging of China, the number of the elderly population has continued to grow. According to the statistics of the National Bureau of Statistics, as of the end of 2018, the total number of people aged 60 or over is 249 million, accounting for 17.9% of the total population of China. Among them, people aged 65 or over account for 11.9% of the total population of China.

The health and safety of the elderly have become an important issue of social concern. Therefore, the analysis of risk factors for and injury prevention of falls in the elderly has gradually become one of the research focuses of social security and public health. The analysis of the risk factors for injuries in the elderly by scholars at home and abroad generally boils down to physiological factors, diseases and drugs, and psychosocial and environmental factors. At the same time, it has been found that fall injuries in the elderly at home have become the most direct and serious risk factor for injuries in the elderly.

Most studies have shown that due to the physiological and psychological characteristics of the elderly and the particularity of their living environment, fall injury is the most common type of injuries in the elderly. The result of a survey done in 2010 by Lin Peixian, Zhong Qianhong et al showed that in the elderly in the communities in Guangzhou City, the leading causes of injuries were falls (50.3%), transport accidents (13.6%), burns (13.6%), followed by psychological trauma, and contact with sharp instrument. The survey done by Xue Chengbing, Liu Xiaohong et al indicated that the top five causes of injuries in the elderly in Jiangsu Province were falls, traffic accidents, animal bites, burns and bruises from colliding with a solid object. Among them, falls are the leading cause.

The monitoring and warning of and interventions for falls in the elderly are effective means to prevent falls, so as to maximize the physical and mental health of the elderly; actively carrying out the interventions for falls in the elderly will help reduce the incidence of falls in the elderly and the severity of injuries caused by falls in the elderly.
2. THE DEVELOPMENT STATUS OF FALL INJURY INTERVENTIONS FOR THE ELDERLY

The elderly population is at high risk of fall injuries, and the occurrence of falls often threatens the health of the elderly and even their lives. The monitoring data of three hospitals in Beijing in 2011 showed that falls were the leading cause of injury-related hospital visits and the primary cause of injuries in the elderly over 60 years old. According to the WHO, falls are the second leading cause of accidental or unintentional injury deaths worldwide, after road traffic injuries. Each year an estimated 424,000 individuals die from falls globally, and 37.3 million falls that are severe enough to require medical attention occur each year. The annual cost of medical care due to falls is at least $37 billion, putting a heavy burden on families and society. Studies have shown that the elderly are more afraid of accidental injuries than chronic diseases; fears and even psychological barriers caused by falls can further affect the quality of life of older adults and increase the chance of falling again.

Falling is one of the major problems that cannot be solved in the current hospital environment. The International Statistical Classification of Diseases and Related Health Problems (ICD-10) has clearly coded falls as a type of disease. The incidence of falls in the elderly is very high due to the ageing of their body, and the degradation of their balance, reflex actions, and sensory and cognitive ability. However, at present, there is no effective means in the hospital environment to reduce or avoid falls in the daily life of the elderly, since falls are influenced by the physiological environment of the human body, external living environment and other factors, and related to many influencing factors such as physiology, pathology, drugs, psychology, etc., especially the degenerative deterioration of the elderly, and except for physiological factors, a hospital cannot solve those influencing factors. Therefore, it is necessary to implement joint interventions by the community, family, and hospital, and it is urgent to develop a series of practical key technologies for fall prevention and intervention for the elderly and to build a complete technical system for fall prevention and intervention for the elderly.

How to solve the problem of falls in the elderly has become a major social demand in China. The “Technical Guide for Fall Interventions for the Elderly” released by China’s Ministry of Health (now National Health Commission) in 2011 stated that falling was the leading cause of accidental death in the elderly aged over 65 in China. It is predicted that China’s aging population will be nearly 300 million by 2030, and the proportion of empty-nest families will reach 90%, which means that there will be more than 200 million empty nesters. When an empty nester has an accident such as a fall, it may have more serious consequences because he or she will not receive timely assistance.

The development of a complete technical system for falls early-warning and interventions for the elderly is expected to be an effective way to reduce the risk of falls in the elderly. Because the falls of the elderly are related to potential risk factors, they can be prevented and controlled. The monitoring of falls in the elderly are effective means to prevent falls, so as to maximize the physical and mental health of the elderly.

3. The Development Status of Intervention and Early Warning Technology for Preventing Fall Injuries in the Elderly

Assessment methods of fall risks in the elderly based on biological mechanism, include gait and balance function assessment methods, physical fitness assessment methods, and fall self-confidence assessment methods. There are more than 12 types of fall risk assessment scales, but they have low predictive value due to their lack of reliability and effectiveness studies. There is no single method that can foresee every fall. Thus, in fact, these assessment tools have not been popularized. Morse’s study found that 20% of falls are unpredictable; Edwards believed that a good tool should have better predictive value, better sensitivity and higher specificity, and is easy to use; many scholars have tried to develop a more effective fall risk assessment tool to detect falls and offer protection against falls in a timely manner without affecting normal human activities.

A variety of human fall detection methods based on different technologies have been proposed, which can be roughly classified into the following three categories: methods based on video monitoring and pattern recognition, methods based on vibration analysis, and methods based on
human body posture and motion. Both methods based on video surveillance and pattern recognition and methods based on vibration analysis are subject to space constraints. They can only detect falls in specific areas and configure devices according to different environments. Moreover, video surveillance also gives rise to some privacy issues, which may cause the user to reject the system. A fall detection method based on human body posture and motion generally makes use of a wearable device, so that it is not limited by space, generally does not require special configuration, and is at a low cost, which has become a more practical new method.

At present, fall detection based on wearable sensors is the most widely used method at home and abroad. The method mainly uses an information collecting device consisting of an acceleration sensor, a gyroscope and a tilt sensor to study the impact on and the posture change of the body during the process of falling by measuring the linear acceleration or angular velocity changes. U. Lindeann et al. proposed a fall detection method based on acceleration sensor. A threshold-based algorithm was used to analyze the combined acceleration of the X-Y plane, and the combined acceleration and angular velocity of the sagittal plane. When a certain threshold was exceeded, it was judged that a fall has occurred. AK Bourke et al. proposed a fall detection method based on a dual-axis gyroscope and a threshold-based algorithm. Studies have shown that the detection method using a single acceleration sensor or gyro sensor is liable to a high probability of misstatement due to the limit of the data modality and measurement accuracy or the insufficient quality of the threshold algorithm.

Subsequently, scholars have proposed a threshold-based fall detection method with multi-inertial sensors. However, these fall detection methods can only distinguish the falls from daily actions, but can neither predict the falls nor reduce the damage caused by the falls.

Research on early warning before falling in the elderly is also advancing. In addition to finding the best position for placing the sensors and the best fall warning and detection feature values, Zhao Guoru et al. also analyzed the turning points in the fall process and divided the process into three stages: pre-impact, impact and post-impact. On this basis, and based on the understanding of the fall warning time and attitude stability angle, in the published research paper, nine MTx sensor modules were used to measure the motion characteristics of different parts of the body, and the threshold algorithm was used to compare and analyze the data of each part, so as to determine the optimal position for placing the sensor during early warning identification and early warning; by analyzing the stability angles of the body posture during the forward falling, backward falling and lateral falling, it was found that there was the largest body posture stability angle in a lateral falling event, and the longest time to adjust the body angle to avoid falling in a forward falling event, and the shortest warning time and the minimum body posture stability angle in a backward falling event.

4. Conclusion

By analyzing the current status of intervention and early warning technology for fall injuries in the elderly, it is necessary to strengthen the research on falls in the elderly from three aspects.

First, modify and improve the risk assessment scale for falls in the elderly. The scale can specifically include two parts: The history of injuries, including the location of fall injuries in the elderly, the cause of fall injuries, the severity of fall injuries, the early warning of fall injuries and the safe treatment, etc., for individual analysis, in order to eliminate the individual differences caused by habitual falls, and at the same time, the data can also be used to analyze the causes of habitual falls; the assessment of the anti-fall body functions of the elderly, including assessment of the risk factors related to falls in the elderly, assessment of the balance of the elderly, and fall risk assessment for the elderly, all of which can add localized weights by adjusting and improving the three scales, i.e. “Evaluation of Risk Factors in Home Environment for Falls in the Elderly”, “Evaluation of the Balance of the Elderly” and “Evaluation Tools for Fall Risks in the Elderly” released by the Ministry of Health.

Second, develop an integrated prevention and control system that integrates fall prevention, intervention, nursing, and care. In view of the high cost associated with the current research and development of elderly fall injuries intervention and identification technology and equipment, and the
unsatisfactory actual performance thereof, research and development of low-cost, practical early warning and intervention technology system for preventing falls should be conducted and community application and demonstration should be promoted, so as to solve the major livelihood needs of the elderly in terms of fall prevention and effectively protect the health and safety of the elderly; at the same time, it can also promote the development of elderly rehabilitation equipment, elderly health service industry and other emerging elderly industries.

Third, carry out research on the core algorithm of high-precision fall warning, using multiple sensors such as Xsens motion capture system with inertia sensors, plantar pressure processor and EMG signal acquisition system to simultaneously measure various heterogeneous biokinetic and biomechanical data of multimodality of people in daily activities and fall events. Give reasonable advice to the elderly for different injury tests, so as to raise the awareness of the prevention of fall risks among the elderly, reduce the hazards of falls, and thus reduce the risk of falls in the elderly.

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