Study on Risk Intervention, Identification and Warning Techniques for Preventing Fall Injuries in the Elderly

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Abstract. Fall injuries have become a major threat to the health and safety of elderly people. Domestic and international studies are increasingly carried out on fall injuries suffered by the elderly. Balance scales, assessment & warning methods and tools are applied in studying falls of the elderly. In particular, devices like dynamic balance instruments, 3D force plates and surface electromyography instruments are used to capture the activity of elderly people and analyze their ability to maintain a dynamic balance. These techniques play an important role in effectively monitoring and assessing the situations of falls in the elderly. This paper sorts up current studies by scholars on falls of the elderly and analyzes the progress in this area from the angles of kinetics and biology. It particularly focuses on analysis of fall intervention using mechanical devices, supportive training services for intervening fall injuries suffered by the elderly, construction of fall injury models, and suggestions for intervening fall injuries at home. This paper finally puts forward some prospects for the study in this area.

1. Introduction

Fall prevention and intervention for elderly people are directly related to major livelihood needs in China and are also one of the major social problems that cannot be completely solved at present. To cope with increasingly severe aging population, the 18th National Congress of the CPC witnessed the explicit proposal of “actively responding to aging population and working hard to develop the elderly Care industry”. In 2013, the State Council released the Opinions on Accelerating the Development of the Elderly Care Industry and proposed to extend the content of elderly care services. It encouraged and provided guidance for relevant industry entities to develop cultural entertainment activities, sports & fitness activities, casual traveling, healthcare services, spiritual products and legal services that are suitable for the elderly. In the same year, the State Council released the Opinions on Promoting the Development of the Healthcare Service Industry and advocated great efforts in health consultation, disease prevention and healthcare service research. It also supported research and development of healthcare products and AIDS for the elderly and the disabled.

Elderly people are highly risk of fall injuries. When they fall, their health and even safety are threatened. According to the data monitored by three hospitals in Beijing in 2011, falling ranked the first reason for the injured who went to hospital. It was also the primary reason for those aged over 60 who got injured. According to the WHO, falling is the reason, only second to traffic accidents, for deaths from unintentional injuries. It is estimated that 424,000 people die from falls every year in the world, and as many as 37.3 million people went to hospital for treatment because of severe fall injuries. The annual medical cost due to fall injuries is at least 37 billion US dollars, a heavy burden for the families and the society. Studies show that, the elderly are more afraid of accidental injuries than...
chronic diseases. The fear or even psychological disorders caused by falling will affect the quality of life of the elderly and increase the chance of falling again.

How to solve the problem of elderly falls has become an important social need in China. In 2011, the Ministry of Health (now the National Health Committee) pointed out in the Guidance on Fall Intervention Techniques for the Elderly that falling is the first reason why elderly people over 60 die accidentally in China. In 2017, the State Council released the 13th Five-Year Plan for Developing the National Elderly Care Services and Building a National Elderly Care System and pointed out that aging is a serious problem in China. It is expected that in 2020 there will be about 255 million elderly people over 60, accounting for about 17.8% of the total population, and there will be about 29 million elderly people over 80. According to the Report on the Development of the Elderly Care Service Industry in China (2013), it is expected that in 2030 there will be nearly 300 million elderly people and 90% of families with children working afar. This means that there will be over 200 million elderly people living alone without children around, which also means more and more elderly people may suffer from falls. More severe outcomes will arise from such elderly people because they cannot get help as soon as possible when they fall down or are suffering from other accidents.

2. Current Studies on Fall Injuries in the Elderly

2.1. A gradually increasing number of studies are carried out on fall injuries

Studies on fall injury prevention for the elderly and the development of related preventive devices can help to reduce the risk that the elderly get injured from falls. Based on a search for the topic of “fall injuries in the elderly” on the CNKI website (www.cnki.net), up to October 2014, a total of 179 papers are on fall injuries in the elderly. Before 1997, most of the papers were mainly about translating relevant medical knowledge from foreign scholars. After 1998, most of them shifted the focus to autonomous research, mainly involving clinical medicine, preventive medicine and hygiene, medical and health policies, laws and regulations, endocrine gland and systemic diseases, automation technology and other disciplines. Based on a search for the topic of “falls in old age” on the website of Web of Science, a total of 10,734 papers are related to this area. It is found that falls in the elderly has been paid attention to internationally since 1960. These papers are Falls in Old Age by Hobbs and On the Natural History of Falls in Old Age by Sheldon. The major directions include geriatrics, neuroscience, neurology, general internal medicine, sports medicine, rehabilitation, public environmental occupational health, endocrine metabolism and other fields.

2.2. Studies on fall injuries are from diversified angles

The analysis tools of fall injuries in the elderly are based on the assessment tools of fall injuries in foreign countries and modified in consideration of the actual situations in China. The main researches are as follows:

Gao Jing et al. (2014) applied Tinetti POMA to evaluate 200 elderly people from two elderly hospitals in Chengdu, and found that Tinetti POMA has good reliability and validity, which can be used as a tool to evaluate the risk of falls of the elderly in China.

Zhu Geyi et al (2014) made a survey of the reliability and validity of the risk assessment scale for falls in the elderly designed by the Ministry of Health based on 643 elderly people aged over 60 from four communities (Tong Village, Yanglin, Zijing and Fushan) in Quzhou Zhejiang Province. They found that FRASE in guidance on intervention techniques for falls in the elderly released by the Ministry of Health has good reliability and validity, is easy to operate with high sensitivity. It is helpful to distinguish different fall risk levels and effective to give warning against fall risk.

Zhao Liqun carried out a research on domestic and international risk assessment tools for falls of the elderly in 2012. He divided these tools into three types: scales used for comprehensive assessment of fall risk; tools used for psychological assessment of the elderly when they fall down; and tools used for assessment of balance function of the elderly.
Many scholars studied falls from the angle of sports medicine, covering reason analysis and prevention of falls in sports activities as well as the role of exercise in preventing the occurrence of falls. It is found that certain exercise can help to enhance the strength of arms and legs and improve the balance, coordination and mobility of the body, thus improving the adaptability to dangers in the environment, reducing the danger of falls. The most effective way of fall prevention is exercise instead of medicine therapy. So it is better to encourage the elderly to take exercise.

Qin Chaohui et al. (2005) applied the biological mechanisms in the study of dangers of falls and fundamental scientific prevention of falls. They paid attention to the factors that affect body balance and intervention to balance control. The focus was on the nervous system and the skeletal and muscular systems. The researchers studied the correlation between central nervous system, ontological perception, vestibular function and falls respectively.

Kannus et al. (2000) conducted a study on falls from the perspective of applied science and found that hip fractures were mostly caused by falls during body rotation and related to the body contact with the ground after falling. Based on this, the researchers designed a hip protection device that could act as a buffer during falls. The case was selected from a randomly controlled study in Finland to evaluate the effect of Danish hip protection device on reducing fracture risk in elderly people in geriatric institutions, and the results showed that fracture risk was significantly reduced in the intervention group.

Kempston et al. (2000) studied falls in the elderly from the perspective of community intervention, and conducted community intervention experiments on multiple risk factors for falls, including detection of gait and balance function, rational drug therapy, physical training, and evaluation of family safety. An Australian health education program was designed for community members to prevent falls, covering 40,000 to 60,000 people at a cost of 6 million Australian dollars. It reduced the incidence of falls by 22% and the number of hospitalizations caused by falls by 20%.

2.3. Comprehensive intervention is the key to fall injury prevention
Developing an entire system of warning and intervention techniques for fall preventions of the elderly is an effective way of reducing the risk of falls in the elderly. As the occurrence of falls in the elderly is a potential risk factor, it can be prevented and controlled. As an effective way to prevent falls, fall monitoring is committed to ensuring the physical and mental health of the elderly to the maximum extent. Therefore, the research and development of fall monitoring & warning and practical key techniques will help reduce the occurrence of falls in the elderly and reduce the severity of falls suffered by the elderly.

Zhang Yunpu et al. (2014) designed a wearable fall monitoring system for the elderly based on MEMS sensor. The fall algorithm applied to smart phones is proposed. The acceleration value is used to detect the impact amount of human body hitting the ground and the angular velocity value to detect the rotation Angle of human trunk. The data is sent to smart phones via Bluetooth device to determine the fall event, and the SMS alarm and voice alarm are finally conducted through the phone.

Other related scholars studied the biomechanical characteristics of human falling and the intervention mechanism of limb movement on fall prevention, and systematically studied the causes of falling, dynamic occurrence process, early warning control time and limb regulation mechanism. Taking human falls and daily activities as the research object and inertial sensor network as the test method, they studied the dynamic occurrence process of human falls and analyzed the warning time and critical attitude Angle of warning from the aspects of sensor node location optimization and parameter optimization. Through optimization and comparative analysis, the optimal installation position of fall warning sensor is determined, and the optimal warning threshold value of different directions of fall warning sensor is optimized, which provides data support for the design and development of human fall warning system.
3. Studies on Fall Injury Intervention of the Elderly based on Mechanical Devices

Although assessment scales like the Tools for Assessing Fall Risk in the Elderly, the Scale of Measuring Balance Function of the Elderly and the Scale of Assessing Household Dangers in Fall Prevention of the Elderly play an important role in assessing the situations of fall injuries suffered by the elderly, they cannot accurately measure the risk of falls in the elderly. Based on this, applying mechanical devices in assessing and analyzing the situations of fall injuries suffered by the elderly has become an important trend in current studies in this area.

From the perspective of dynamic balance, the equipment such as human center of gravity balance instrument is used to analyze the balance ability of the elderly based on the static station and standing of fall injury, check the balance disorder of the elderly through qualitative and positioning, and judge the occurrence of fall injury risk of the elderly based on the vestibule-spinal reflex and spinal-cerebellar reflex to detect the balance adjustment ability of the human body and the vestibular system and cerebellar function state. The group data of the peak value of the center of gravity distribution of the elderly, the center of gravity distribution data most likely to induce falls injury of the elderly and the safest center of gravity distribution data were analyzed, so as to obtain the trend chart of the center of gravity distribution under different activity states of the elderly, so as to realize the risk assessment of falls injury of the elderly.

It has also become a research direction to use surface wireless electromechanical and pressure sensor to analyze the gait status of the elderly. The walking mechanics experiment of the elderly, the 180° turning mechanics experiment of the elderly, and the plantar pressure experiment of the elderly walking and turning activity are constructed for the three-dimensional force analysis of the elderly walking, the three-dimensional force analysis of the elderly turning and the foot pressure distribution analysis of the elderly to achieve the risk assessment of falls injury of the elderly walking and turning.

In addition, wearable devices and facilities have also been applied in the field of fall injury prevention for the elderly. Through three-dimensional motion capture analysis system, data collection is conducted on the movement of the elderly in the sit-to-stand state, and based on the data, analysis and identification are carried out on the dangerous posture most prone to fall and the safest posture from sitting to standing for the elderly. This model can collect and analyze data in real time and display it in the form of 3D animation. Based on the analysis results of the dangerous posture of the elderly from sitting to standing, the general suggestions that are in line with the safety and prevention of falls injury of the elderly can be proposed.

4. Conclusion and Prospects

Based on the current research status of fall injuries in the elderly and combined with the current main modes of home-based care in China, it is necessary to study and analyze the risk assessment, early warning and intervention of fall injuries in the elderly from the perspective of home safety, so as to construct a comprehensive systematic intervention technology for fall injuries in the elderly and effectively improve the health and safety level of the elderly.

4.1. Assistance training service platform for fall injury intervention of the elderly

The establishment of the fall injury intervention assistance training service platform for the elderly is, on the one hand, to effectively use the existing software and hardware facilities to train the elderly in aspects of balance, vision strength, safety and health, etc. Through the combination of software and hardware equipment, this can provide training for the elderly in the balance of gravity center by exercise, publicize the elderly fall injury safety and health activities and vision correction, and avoid the elderly fall injury problems. Secondly, by refitting the dynamic balance instrument of professional mechanical equipment, it can exercise the activities of the elderly moving forward, backward, to the left and to the right so as to adjust the key tendency points of the elderly and actively intervene the possibility of falling injury of the elderly. Third, it strengthens the elderly health education and training and knowledge publicity. It improves the elderly to pay more attention to falls and take more exercises to achieve the elderly safety and health.
4.2. Risk model construction for fall injury intervention of the elderly

Combined with the accident tree model, the risk intervention demand model for fall injuries among the elderly was constructed, and the demand collation and analysis were conducted on the survey results of small AIDS for falls injury, personal life assistance facilities, psychological intervention adjustment and safe home products. Through the analysis of the intervention demand model for fall injuries among the elderly, home safety products for the elderly were developed to reduce the possibility of fall injuries among the elderly and the severity of consequences.

4.3. Suggested solutions for fall injury intervention of the elderly living home

Based on the results obtained from the balance scale and mechanical equipment testing of the elderly, and combined with the identification, assessment and prediction of fall injuries in the home environment of the elderly, the personalized falls injury risk intervention program is provided for the elderly, so as to achieve the comprehensive assessment of the elderly balance ability test, the trend of the center of gravity of movement, the prone sites of fall injuries, the prone posture of fall injuries and the physiological changes of fall injuries. All these efforts aim to provide comprehensive fall injury intervention programs for the elderly.

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