Fall Assessment Methods in the Elderly: A Review

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Abstract: Falls among the elderly have become a critical global public health issue, threatening physical and psychological well-being and impeding the development of age-friendly societies. Accurate fall risk assessment is essential for effective prevention and intervention. This study systematically analyzes the technical characteristics, application status, and core limitations of existing fall assessment methods for the elderly and puts forward targeted optimization suggestions that integrate community nursing needs and technological trends. Three main method types were reviewed: traditional scales (Morse Fall Scale [MFS] and its Chinese Version [CMFS]), functional tests (Timed Up and Go Test [TUGT]), and wearable device-based fall detection algorithms. Key findings include: MFS/CMFS are widely used for convenience but have limitations in reliability and validity; TUGT facilitates rapid screening but has limited predictive efficacy and is not suitable for non-independent individuals; wearable technologies offer high real-time accuracy but face challenges in acceptance, battery life, and cost. Existing methods suffer from three core contradictions: convenience and accuracy, static assessment and dynamic risks, as well as universality and particularity. To address these, an integrated framework of combining static screening, dynamic monitoring, and special group adaptation is recommended. This framework aims to support precise fall prevention and control for the elderly.

Keywords: Falls in the elderly; Fall risk assessment; Morse Fall Scale (MFS); Timed Up and Go Test (TUGT); Fall detection algorithms based on wearable devices; Fall assessment system optimization

1. Introduction

1.1. The clinical problem of falls in the elderly

The global increase in life expectancy is an urgent and irreversible fact. Against this background, falls among older adults represent a critical public health issue demanding urgent international attention, with profound implications for both individual health and healthcare systems. World Health Organization (WHO) statistics indicate approximately 684,000 fall-related deaths annually, with individuals aged 60 and older accounting for over 50% of these cases [1]. Approximately one-third of individuals aged 65 and older worldwide experience at least one fall annually. These falls are more than just accidents: they may trigger fractures, cause permanent disability, and in extreme instances, directly lead to mortality [2]. Furthermore, falls may compromise functional independence, accelerate physical and cognitive decline, and be associated with depression, anxiety, social isolation, and

increased healthcare utilization. The fear of falling due to injury is particularly prevalent among elderly patients who have experienced falls, and this fear often leads to reduced physical activity, worsening frailty, and further functional decline [3,4]. These factors collectively underscore the severity of falls among the elderly. In China, the fall-related burden among the elderly has further demonstrated a notable upward trend over the period 1990–2019 [5]. According to data from China's Disease Surveillance System and research by Lu *et al.*, the fall incidence rate among individuals aged 50 and above in China is 19.05% [6]. Falls have become the leading cause of accidental injury deaths among Chinese adults aged 65 and older [7,8]. The fall rate among Chinese adults aged 60 and above is on the rise, with over 40 million elderly individuals experiencing at least one fall event annually [9].

The hazards of falls extend beyond visible physical injuries such as fractures and head trauma. Falls also trigger hidden and persistent psychological trauma, which often reduces the quality of life for the elderly more profoundly than physical injuries alone [10]. The most common and widespread psychological trauma is the fear of falling—a decrease in self-efficacy or confidence that arises when individuals avoid certain activities to prevent falls [11–13]. This fear is not a brief emotional fluctuation, but rather forms a vicious "psychological-behavioral" cycle: the elderly proactively reduce their outdoor activities to avoid risks, leading to muscle atrophy and diminished balance, which paradoxically increases their fall risk [14]. Simultaneously, restricted mobility exacerbates social isolation and loneliness, which in turn reinforces the fear of falling, creating a vicious cycle [15]. More critically, falls may also trigger severe psychological issues like post-traumatic stress disorder (PTSD). A hospital study of 40 participants who had fallen over one month earlier confirmed these findings. Among them, 35% developed full-blown acute PTSD, while 17.5% experienced partial acute PTSD. These psychological issues exhibited a significant tendency toward chronicity—during follow-up, patients' acute PTSD symptoms not only failed to diminish but actually worsened [16].

1.2. Research rationale and aims

As a significant risk event affecting the health of the elderly population, falls not only directly threaten their lives and physical health but also pose a severe challenge to the development of an age-friendly society. This public health problem demands urgent attention from the whole society. Considering that the risk of elderly falls is preventable and monitorable, this topic has become a priority in designing tailored protocols and services for the aging demographic, which further emphasizes the necessity and feasibility of addressing this critical public health issue [17]. Therefore, this study will systematically discuss the technical characteristics, current applications, and core limitations of existing fall assessment methods for the elderly. By integrating nursing practice needs and technological trends, this study will propose targeted recommendations for optimizing and implementing future fall assessment systems.

2. Analysis of existing fall assessment methods for the elderly
2.1. Morse Fall Scale (MFS) and the Chinese Version of the Morse Fall Scale (CMFS)

As one of the most widely used fall risk assessment methods in the global community of geriatric care, the Morse Fall Scale (MFS) has become a routine choice for primary care nurses to screen fall risks in the elderly, due to its comprehensive dimensions and ease of operation [18]. However, its deficiencies in reliability and validity for the elderly, especially for the advanced-aged living alone, and insufficient scenario adaptability have gradually become key constraints on assessment accuracy. Therefore, the applicability of MFS requires a systematic analysis

that integrates the physiological characteristics and care needs of the elderly population.

The MFS constructs an assessment framework through six core dimensions, as follows: history of falls (0 points = none, 25 points = yes), presence of secondary diagnosis (0 points = none, 15 points = yes), use of ambulatory aids (e.g., canes, wheelchairs, or walkers) (0 points = not used, 15 points = using a wheelchair/bedridden, 30 points = requiring nurse assistance), receipt of intravenous infusion therapy (0 points = no, 20 points = yes), gait type (0 points = normal, 10 points = bedridden, 20 points = immobile), and cognitive status (0 points = aware of own abilities, 15 points = unaware of own abilities). The MFS score ranges from 0 to 125 points, with higher scores indicating a greater likelihood of falling [19]. According to Morse, the scale has a sensitivity of 78%, a positive predictive value (PPV) of 10.3%, a specificity of 83%, and a negative predictive value (NPV) as high as 99.2% [19]. Morse recommends that 45 points be used as the optimal cutoff value for identifying high fall risk in long-term care wards, chronic disease wards, and emergency wards [19].

Regarding the prevalence of its application, the MFS is one of the most widely used clinical methods. Its core advantages include short assessment time [20,21], simplicity of operation, ease of understanding, and good reliability and validity [22,23]. Currently, the scale has been translated into multiple languages and is widely used in medical institutions globally [24]. It has also undergone long-term testing in clinical settings in countries like the US, Sweden, and Australia [25–27].

In 2010, Zhou *et al.* also conducted a study on the Chinese Version of the Morse Fall Scale (CMFS), applying it to fall risk assessment of hospitalized elderly population in Guangzhou, China, and systematically verifying its reliability and validity [28]. This study showed that the internal consistency of the CMFS was poor: the Cronbach's α coefficient of the total scale was only 0.102, and the corrected Cronbach's α coefficient was only 0.206. Even after removing the item "intravenous infusion or use of heparin lock," the internal consistency of the scale improved, with the Cronbach's α coefficient increased to 0.444, but still did not reach the ideal level. Based on this, Zhou *et al.* noted that while the CMFS has strengths—including simple items, short assessment time, and good inter-rater reliability—it has key limitations: low internal consistency, uneven item contribution, and the need for further optimization of content validity. Subsequently, in 2014, Wang *et al.* revised the CMFS and formed a new version consisting of 5 dimensions and 12 items [29]. This revised version significantly improved the aforementioned deficiencies with excellent reliability and validity—the Cronbach's α coefficient for internal consistency of the total scale was 0.891 (0.530–0.796 for each dimension), the test-retest reliability was 0.982 (0.650–0.994 for each dimension), and the sensitivity and specificity were 89.4% and 97.3%, respectively. The revised CMFS is suitable for fall risk assessment of all hospitalized patients and can provide a reliable basis for clinically targeted preventive interventions.

In summary, the MFS, with its core advantages of convenient operation and clear dimensions, has become a widely used fall risk assessment method in the global community of geriatric care, providing reliable support for fall risk screening of the elderly. The revised CMFS has also achieved significant breakthroughs in reliability and validity. Boasting excellent internal consistency, test-retest reliability, and high sensitivity and specificity, the revised CMFS not only addresses the adaptability issues of the original scale in the Chinese clinical context but also offers a tailored and reliable assessment option for fall risk screening among hospitalized elderly in Chinese medical institutions. Together, the MFS and CMFS complement each other in global and local application scenarios, laying a solid foundation for standardized fall risk assessment and targeted preventive interventions in geriatric care.

2.2. Timed Up and Go Test (TUGT)

In 1986, Mathias *et al.* proposed the "Up and Go" test, which was developed to assess the balance ability of older adults [30]. Then, in 1991, this test was further modified by Podsiadlo and Richardson into the Timed Up and Go Test (TUGT)—a standardized method for the rapid quantitative evaluation of subjects' functional mobility, dynamic balance control, and fall risk [31]. This test requires a chair with a backrest (seat height ~46 cm, armrest height ~21 cm) and a stopwatch. A thick yellow line is affixed to the floor in front of the chair and 3 meters away as the starting and ending points, respectively. During the test, the subject will be asked to sit in the back chair. Upon the researcher's "start" instruction, the subject needs to stand up from the chair, walk forward quickly after stabilizing, turn 180° after passing the thick yellow line 3 meters away, walk back to the starting point as fast as possible, and turn around to sit down. The total time taken for the entire process is recorded with a stopwatch.

Due to its simplicity and ease of implementation, this method has accumulated extensive reliability and validity evidence internationally, with high reliability and validity. In China, it is mostly used for fall prediction in stroke patients. Research by Lin *et al.* showed that the intraclass correlation coefficient (ICC) of the TUGT among stroke patients was high (ICC = 0.963, 95% CI [0.938, 0.978]), and the Cronbach's α coefficient was 0.983—indicating that the TUGT has good reliability and consistency during testing [32]. However, in 2017, Kang extended the application of this method to fall prediction and risk assessment in the elderly population [33]. The study results indicated that the predictive efficacy of the TUGT alone for any fall did not meet clinical standards (AUC <0.7), but it could effectively predict frequent falls (AUC = 0.733 after adjusting for age and gender). Additionally, the risk screening model constructed by combining the TUGT with gender, diabetes, fall history, and depression (cutoff = 7, AUC = 0.748, screening accuracy = 82.5%) has good predictive value for falls in this population and can be used for relevant screening in primary care and hospitals. Nevertheless, the validity of this model needs further verification in other populations. Subsequently, Kurosawa *et al.* proposed that adding the analysis of kinematic indices (time ratio, trajectory, trajectory length per unit time, and body inclination angle) based on the traditional TUGT would be more helpful in determining TUGT indicators for healthy older adults [34]. However, the TUGT itself has notable limitations—it is only suitable for conscious subjects who can walk independently and does not apply to the elderly requiring caregivers. Therefore, incorporating measurements of other kinematic indices would further increase the difficulty of applying this method.

In summary, the TUGT has established itself as a standardized, simple, and easy-to-implement functional assessment method, with robust international evidence supporting its reliability and validity. While it demonstrates excellent performance in fall prediction for stroke patients in China, its standalone predictive efficacy for occasional falls in the elderly population falls short of clinical standards. Despite these merits, the TUGT is constrained by its applicability limitations, as it only suits conscious, independently ambulatory elderly. Overall, the TUGT remains a valuable asset in fall risk assessment, and its utility can be further maximized through a combination with other assessment tools or targeted validation of its derived models in diverse elderly subgroups.

2.3. Fall detection algorithms based on wearable devices

Traditional assessment methods, such as the MFS and TUGT, while becoming routine clinical screening methods due to their ease of use and accessibility, still have significant limitations. For instance, they rely on subjective manual judgment or single static tests, failing to capture fall risks in the elderly's daily activities in real time. Against this background, fall detection technology based on wearable devices has gradually emerged as an important supplement to traditional assessment methods, and relevant studies have already established the core

framework of this technology [35].

This technology is not specifically designed for the elderly, but it holds important reference value for fall detection in the elderly population. Firstly, the technology defines a fall as an involuntary, sudden loss of balance resulting in impact with the ground or low-lying objects. It also divides the fall process into four phases: imbalance, fall, impact, and immobility, and classifies falls into different types based on causes, injury severity, and occurrence scenarios [36]. This method mainly lies in a complete detection system: data are mainly collected through sensors such as accelerometers and gyroscopes, which are typically most appropriately worn on the waist. Motion information related to daily activities (e.g., walking, sitting) and falls is then transmitted via technologies like Bluetooth Low Energy (BLE) [37,38]. The collected data undergo processes such as noise filtering, standardization, and segmentation to improve quality [36,39], followed by the extraction of key motion features. Finally, models are established using algorithms such as support vector machines (SVMs) and decision trees. Among these, models integrating data from multiple sensors achieve higher fall recognition accuracy [36,38,39].

Currently, a set of common standards has been developed to evaluate the performance of this technology, including detection accuracy, timeliness of fall alert, and false alarm rate. Additionally, nine public datasets are available for validating technical effectiveness. Based on these data, the detection accuracy of such technology mostly ranges from 92.6% to 98.5% [35]. However, the technology currently faces two major challenges: first, wearable devices have limited battery life, computational capacity, and storage space, posing the problem of how to improve power efficiency and reduce memory usage without compromising detection performance; second, most existing recognition models are trained in controlled experimental scenarios. When applied to different populations, new activity patterns, or complex real-life environments, detection accuracy may decline, which requires models to autonomously adapt [40]. Existing studies have analyzed system design, algorithm selection, and sensor types; compared the pros and cons of different detection methods; refined classification standards; and evaluated practical application characteristics. They listed device parameters and related products, analyzed development trends and existing problems, and compared model construction and evaluation criteria—highlighting the advantages of multi-sensor fusion [35]. All these provide important references for the subsequent optimization of fall assessment methods for the elderly.

3. Conclusion

Falls in the elderly have become a major public health issue requiring urgent attention worldwide. They not only increase the risk of accidental death among the elderly aged 65 years and above (with falls being the leading cause of accidental death in this population in China) but also easily trigger long-term psychological trauma, such as fear of falling and social isolation, forming a "physiological-psychological" vicious cycle. Therefore, accurate fall risk assessment has become the core premise for prevention and intervention. Currently, assessment methods applied in clinical and community settings are mainly categorized into three types: traditional scales, functional tests, and emerging sensor technologies. Each type demonstrates value in specific scenarios but faces limitations in adapting to the characteristics of the elderly population and the needs of community nursing.

The Morse Fall Scale (MFS) and its Chinese Version (CMFS) have become a mainstream method in global community geriatric care due to their comprehensive dimensional coverage and low equipment requirements. Their six core dimensions can initially capture multi-factor risks, and the short assessment time per case aligns with the fast-paced needs of community care. However, the original MFS has deficiencies in reliability and

validity, with a low Cronbach's α coefficient for the elderly. The revised CMFS has significantly addressed this issue: its Cronbach's α coefficient for internal consistency meets clinically accepted standards, and it possesses high sensitivity and specificity, making it effectively adaptable to both inpatient and community settings. Nevertheless, specific indicators need to be supplemented for the advanced-aged and cognitively impaired groups to improve accuracy.

The Timed Up and Go Test (TUGT) is a functional test focusing on "sitting-standing-walking-turning." With the advantages of extremely simple operation and short time consumption, it exhibits good reliability and validity in the elderly, making it suitable for rapid dynamic balance screening in communities. However, its predictive efficacy is limited. When used alone, its AUC for "any fall" does not meet clinical standards, and it only has predictive value for "frequent falls." Additionally, it relies on the ability to independently complete the "sit-to-stand" movement. Some advanced-aged populations cannot participate due to joint pain and muscle weakness, resulting in insufficient coverage of high-risk groups. Although studies have proposed an optimized scheme of "TUGT + kinematic indices," it requires additional equipment and professional analytical capabilities, which instead increases operational complexity. Thus, it is more suitable to jointly construct models with methods like the MFS to fully exert its value.

Fall detection technology based on wearable devices can collect real-time daily activity data through accelerometers and gyroscopes, and achieve detection by combining algorithms such as support vector machines (SVMs). With relatively high accuracy, it can make up for the shortcomings of traditional methods—reliance on subjective judgment and inability to conduct real-time monitoring—and provide "passive protection" for the elderly living alone. However, the practical application of this technology still faces bottlenecks: at the device level, the elderly have low acceptance of wearable devices, and the devices have limited battery life and computational capacity; at the model level, algorithms trained in laboratory settings exhibit reduced generalization and increased false alarm rates in complex community environments; at the cost level, the investment in equipment and analysis systems exceeds the budget of most communities. Currently, it is still in the supplementary exploration stage and requires a lightweight transformation to gradually integrate into real-world practice.

Overall, existing fall assessment methods have three major common contradictions: the contradiction between convenience and accuracy (traditional tools are convenient but have significant subjective biases, while new technologies are accurate but operationally complex); the contradiction between static assessment and dynamic risks (both MFS and TUGT are single static assessments, making it difficult to cover daily dynamic risks); and the contradiction between universality and particularity (most target general older adults, with insufficient adaptability to groups such as the advanced-aged living alone). In future studies, it is necessary to focus on the needs of community nursing practice to promote the dimensional iteration of traditional methods, the combined application of functional tests, and the lightweight transformation of emerging technologies. An integrated assessment framework that combines static screening, dynamic monitoring, and adaptation to special groups should be developed to facilitate the precise prevention and control of falls in the elderly population.

Disclosure statement

The author declares no conflict of interest.

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