



Review

Gait and balance in the aging population: Fall prevention using innovation and technology

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ABSTRACT

On a global basis, adults 65 years of age and older experience falls more frequently than younger individuals, and these often result in severe injuries as well as increased healthcare costs. Gait and balance disorders in this population are among the most common causes of falls and negatively influence quality of life and survivorship. Although falls are a major public health problem and guidelines/recommendations are available to physicians, many are fully aware of different assessments, tools, and resources available for intervention. Given the risk for potentially devastating outcomes if severe injuries occur secondary to a fall, fall prevention strategies in clinical offices is a timely consideration in today's health care landscape. This paper presents a three-tier model, comprising assessment, prevention, and intervention, to highlight methods, proactive programs, and innovative tools and technology that have been developed for fall prevention. Awareness of these resources will enhance the clinician's ability to accurately assess balance and gait, which can improve physical function, and decrease the risk of falls for both average-risk and high-risk older adults.

1. Introduction

Falls are the second leading cause of unintentional injury-related deaths globally and pose as a major public health issue, especially for older individuals [1–3]. Approximately one-third of elderly individuals over the age of 65 and one-half of persons living in community care institutions experience falls annually [4]. Each year, an estimated 37.3 million individuals experience a fall that requires hospitalizations and may lead to severe injuries, such as fractures and traumatic brain injury [1]. Approximately 646,000 falls result in death [1]. In the US, healthcare costs related to falls in 2015 totaled over \$31 billion to Medicare. Globally, this cost is expected to increase to \$240 billion dollars yearly by 2040 [4].

Although multiple factors and co-morbidities are associated with falls in older individuals, balance and gait disorders are among the most common causes [5]. Abnormalities in gait and balance are found in about 35% of adults over the age of 70 and in 61% of adults over the age of 80 [6,7].

A growing body of literature indicates a relationship between gait speed and health, overall function, and survivorship [8]. Innovative programs and developing technology can be utilized to help address this important health issue. This article presents a three-tier model for

fall prevention that includes assessments, prevention, and intervention (Fig. 1). Resources and technology to help overcome current limitations in assessment and further facilitate prevention and intervention are discussed within each tier. Additional innovative and technology-based options to assist with overcoming barriers involving access to care specific to fall prevention and treatment are reviewed.

The goal is for clinicians to provide a comprehensive and multi-disciplinary approach that addresses both the intrinsic and extrinsic factors to reduce the risk for secondary complications related to gait and balance disorders. Most falls and fall-related injuries are preventable with early assessment of risk factors, continuous monitoring, and timely interventions [9]. Although guidelines by the U.S. Preventive Services Task Force and the American and British Geriatrics Societies exist, the information provided to facilitate interventions extend little beyond recommendations for “exercise and physical therapy” [10]. Many clinicians are not fully aware of available resources and not extensively educated on appropriate interventions to prescribe [9,11,12].

2. Methods

This comprehensive review presents assessments, resources, and

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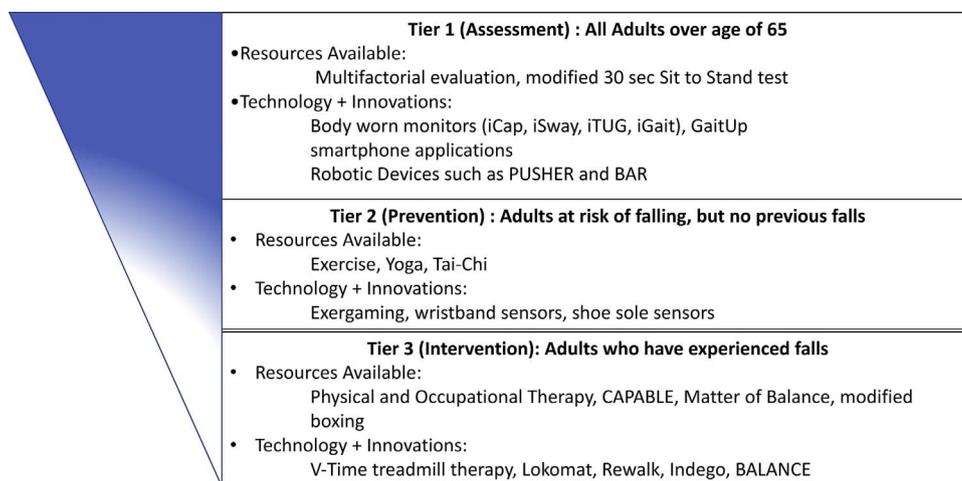


Fig. 1. Three-Tier Model for Fall Assessment.

tools utilized in improving balance and gait, and technological advancements in the field. A search of PubMed, Clinical Key, and Google Scholar was conducted. Keywords such as “balance and gait training”; “fall interventions”; “Balance and gait evaluations”; “wearables and robotics”; and “exergaming” were used to identify articles published in peer-reviewed; English language journals up through October 2017. These articles were assessed and systematic reviews; Randomized Control Trials; and meta-analyses were primarily selected.

3. A three-tier model

3.1. Tier 1 – assessment

Tier 1 encompasses all adults over the age of 65. With the growing elderly population worldwide, there is a greater need for frequent and accurate assessments of gait and balance as a part of the overall clinical assessment [13]. According to the 2003 Rand Report and 2012 Cochrane Systematic Review, individualized assessments that utilize clinical gait and balance measures were effective in reducing the risk of falling in older adults [14,15]. Guidelines for Prevention of Falls in Older Persons created by both the American and British Geriatrics Societies recommend that clinicians assess and identify known risk factors for falls in all patients over the age of 65 [16]. At annual office visits, all patients should have an assessment of fall risk that includes a multifactorial evaluation with the following [5,17,18].

1. History of falls, balance, and gait problems: Providers should inquire about number of falls that have occurred to date, the circumstances of the falls and if falls have caused any injuries or unwanted consequence. Previous falls are one of the strongest risk factors for future falls [17].
2. Medical History: Does the patient have musculoskeletal, metabolic, neurologic, or sensory problems?
3. Medications: Is the patient taking new medications or increased dosages? Do the current medications affect alertness and balance, or cause visual disturbances?
4. Social History: Does the patient’s household contain any environmental hazards, such as throw rugs and steep stairs? Does the patient utilize assistive devices?
5. Physical Exam: Neurologic, musculoskeletal, and cardiovascular examination should be performed to identify balance and gait issues.
6. Visual Exam either in the office or referral for one.

In patients who have not experienced falls, in-office gait and balance evaluations can be performed to evaluate the patient’s fall risk status.

The Timed Up and Go (TUG) test has been recommended for use as a screening test that is performed in the office setting. The TUG test is often recommended to identify potential fallers [16,17]. It measures the time it takes for an individual to rise from a chair, walk 3 m, and return back to the chair. A shorter time indicates greater functional mobility and balance. However, standardized cutoff scores used to predict fall risk have not been established and were found to vary from 10 to 33 s in different studies [19,20]. Additionally, a 2014 systematic review suggested that the TUG test has poor to moderate specificity and sensitivity in predicting falls in community-dwelling older adults and may be more useful for the screening of individuals living in community care institutions [20].

An alternative to the TUG test that has been found to discriminate between fallers and non-fallers and can be used in adults with and without mobility limitations is the modified 30-s Sit to Stand test [21]. This exam assesses the number of times an adult can sit and stand with the assistance of upper extremities and armrest in a 30 s period. Individuals able to complete 7 repetitions during the time period are considered unlikely to fall. Unlike the TUG test, results of the Sit to Stand test have shown a relationship to risk of falling.

New technology is in development to more accurately assess the gait and balance status of adults. In individuals with neurological disorders or with mobility problems, precise and effective measurements of gait and balance are difficult to attain using only office screening tools [22]. Assessments often vary in protocol and application, resulting in inconsistent results and data. To overcome these limitations, usage of accelerometer-based body worn monitors (BWM) paired with a standardized algorithm have been recommended [23]. Examples of these instrumented assessments for postural control, balance and mobility include iCap, iSway, iTUG, and iGait. Studies using these programs have shown reliable and sensitive measurements of accelerations and balance and gait characteristics [23–26].

Companies, such as Gait Up, have begun to utilize similar protocols to create small devices that measure acceleration, monitors activity, and analyses walking and running technique. These devices have been used to provide gait parameters in geriatric patients in several research studies performed since 2013 [27]. Smartphone devices are another medium through which these measurement algorithms can be applied to for monitoring of gait and posture in older adults. Use of accelerometers and gyroscopes already existing in smartphone have been found to provide accurate and reliable parameters of gait and postural control in adults performing various postural tasks [28,29].

In addition to smartphone applications, rehabilitation robots may soon be able to more accurately examine balance and better differentiate aspects of balance under different conditions: standing, walking, and applied external force. Two quantitative approaches have been developed to assess balance via robotic technology [22].

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