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Original Article

Fractures and Repeated Falls

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Introduction

Whereas most fractures are preceded by falls, most falls do not result in fractures *(1,2)*. Clinicians therefore have an ideal opportunity to prevent fractures by identifying those patients who sustain or are likely to sustain repeated falls, a relatively easy task that can be accomplished by merely asking whether the patient fell or had a "near fall" during the past few months. An affirmative answer would trigger either a thorough assessment to identify the etiology of these falls or, given the time limitation, a note to referring physicians alerting them that the patient's fracture risk is increased, independent of other risk factors, because of the increased risk of falls.

A number of questionnaires and algorithms are also available to identify those patients at risk of falling, including the Downton Fall Risk Index *(2)*, the Timed Get up and Go Test, the Tinetti Performance Oriented Mobility Assessment, the Berg Balance Test, and the Unipedal Stance Test *(3)*.

It is debatable whether a comprehensive "falls assessment" should be performed in a primary care office or in a "bone/osteoporosis clinic." Notwithstanding, clinicians managing osteoporosis should take into consideration the risk of falls while developing their management strategy because it has direct therapeutic management implications. For instance, because of repeated falls, pharmacological treatment may be offered to a patient with densitometric evidence of osteopenia whose 10-yr probability of sustaining a fracture as per the FRAX algorithm does not reach the threshold recommended by the National Osteoporosis Foundation. The pharmacological treatment will not reduce the risk of falls but will impact the outcome of the fall and reduce the risk of fractures by increasing bone density and possibly improving bone quality, thus allowing the bones to sustain trauma without fracturing.

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"Hip protectors" may be recommended for patients who sustain repeated falls as they reduce the fracture risk if patients wear them *(4–6)*. Similarly, walking frames and tripod and quadripod canes offer more stability than regular walking canes.

Given that a number of factors modulate the relationship between repeated falls and fractures, solid data on this relationship are not available. For instance, it is known that fractures of the radius are more common during the perimenopausal and early postmenopausal periods and that hip fractures are more common in older patients. It is also known that this is probably due to younger people tending to fall forward and protect themselves by extending their arms as they fall, whereas older people tend to fall backward or sideways. Therefore, whereas the major impact of falls in younger people is on the wrist, in older patients it is on the hip. However, quantifying this relationship is not yet possible given the number of possible permutations and other factors that affect the impact of the fall. It is therefore not possible at present, for instance, to calculate the percent of falls by age group, independent of disease, that result in a fracture of the hip, the vertebrae, or the forearm. Besides, many vertebral fractures are silent (morphometric factures) and are accidentally discovered while the patient is undergoing imaging studies for some unrelated condition. At present, therefore, it is not possible to accurately calculate the independent impact of increased falls risk on fracture risk. Indeed, the FRAX algorithm includes a number of risk factors affecting fracture risk but does not include the risk of falling.

Falls are common: in the United States in 2014, 28.7% of older adults reported falling at least once in the previous 12 mo *(1)*. The prevalence of falls increases with age from 26.7% in the 65- to 74-yr age group to 36.5% in those aged 85 yr and older. The prevalence is higher among whites (29.6%) than blacks (23.1%) and Asian/Pacific Islanders (19.8%) *(1)*. Fall-related injuries interfere with patients' ability to continue with their daily activities, increase the burden of caring by relatives and caregivers, and are expensive to manage. It is estimated that, in the United States

in 2015, the direct medical costs for the management of fatal and nonfatal fall-related injuries were 637.5 million and 31.3 billion, respectively *(7)*. Several fall prevention programs are available and effective at reducing falls *(8)*. In many instances, repeated falls especially in older individuals have a multifactorial etiology *(9)*.

Background

Human evolution developed in such a way that stability has been sacrificed for mobility. The bipedal erect standing posture has the advantage over the quadrupedal posture of widening the field of vision, increasing the individual's space and reach, as well as increasing one's mobility, but comes at a cost: a precarious equilibrium. The whole body is supported by 2 relatively small unstable platforms: the feet, which can flex, extend, and rotate internally and externally, thus offering a great range of movement and ability to walk or run on various terrains, but relatively little stability especially given the number of small bones in the feet. Each ankle joint is just over an inch wide, and yet each one in turn supports the whole body weight while walking and running and maintains the body's center of gravity in such a position to prevent subjects from losing their balance and falling. During these activities, the entire body weight is supported by only a part of the sole; the rest of this surface is used to propel the body forward. Similarly, each hip supports the body weight (minus one leg) and maintains the center of gravity in an optimum position to allow the individual to remain in an upright position while engaging in a range of activities, including walking, running, and jumping. The vertebrae are also precariously stacked on top of each other to allow for maximal mobility but, again, at the expense of stability.

While standing up from the seated position the individual's center of gravity precariously shifts forward as the knees and hips extend and the vertebrae bend forward while the feet remain perpendicular to the leg, parallel and anchored to the floor. While walking or running, the musculoskeletal system constantly adjusts to the changing position of the body's center of gravity and maintains it in a position to avoid a fall.

As individuals grow older, several factors jeopardize stability: the knees buckle, the thoracic vertebrae become kyphotic, and, to compensate for the shift forward of the center of gravity, the lordotic curvature of the lumbar vertebrae becomes accentuated *(10)*. In older individuals, the center of gravity is easily displaced and this may result in a fall. Furthermore, proprioception, postural control, and reflexes in older people tend to become blunt and less responsive to the changing position of the body's center of gravity, thus increasing the risk of falls. It may be argued therefore that rather than asking "Why do elderly patients fall?" the more pertinent question should be "Why don't more elderly people fall?" The answers to these questions lie in the pathophysiology of balance, equilibrium, postural control, and reflexes.

Basic Physiological Mechanisms Ensuring an Upright Posture

Intrinsic Factors

A Functional Musculoskeletal System

The skeleton is the framework that supports the body. A good, healthy, fully functional musculoskeletal system is a sine qua non for adopting an upright posture, ensuring stability and mobility while at the same time preventing falls. The closely integrated activities of the musculoskeletal system ensure the center of gravity is maintained in the optimum position no matter where various parts of the body are and no matter how much additional weight is carried by the arms or the back.

Musculoskeletal dysfunction can be due to skeletal abnormalities such as any of the arthropathies *(11)* that, in addition to causing pain, increase the risk of falling by interfering with the alignment, effectiveness, and stability of the articulation. Fractures also may cause falls. Although most of the time a fall precedes the fracture, sometimes a fracture occurs spontaneously and is followed by a fall. This is particularly likely to occur when the patient is in the process of assuming the standing from the sitting position or is turning: the torque force involved in turning one's body may exceed the bone strength and may induce a fracture, which is then followed by a fall. In these instances, it is the fracture that leads to the fall as opposed to the fall leading to the fracture.

Feet problems including painful feet, even ingrowing toe nails, may jeopardize the patient's equilibrium. An examination of the feet is an important part of the clinical examination of a patient who presents with repeated falls. Similarly, inadequate footwear may reduce the support to the feet and ankles and may result in instability and repeated falls *(12)*. In some instances, the patient may trip over untied shoelaces, torn slippers, or unsuitable footwear. Asking about and, if possible, inspecting the patient's favorite footwear should be part of history taking and clinical examination.

Muscle weakness may interfere with postural balance, and patients may not be able to rapidly change and readjust the position of the body's center of gravity to prevent a fall *(13)*. Common causes of myopathies especially in older people include vitamin D deficiency, thyroid dysfunction, neoplasia, malnutrition, reduced physical activity, and immobilization. Sarcopenia is a recently redefined clinical entity associated with reduced muscle mass and resulting in muscle weakness, increased risk of falls, and fractures *(14)*. Although there is a paucity of large-scale studies examining the impact of sarcopenia on the risk of falls, it is likely to increase such a risk.

Intact Neurological System

For the musculoskeletal system to effectively adjust the position of the body, maintain an upright position, and prevent falls while maintaining a full range of physical ac-