Keywords Bed height/Falls/Gravity

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In this article...

- Why patients are at risk from falls when they are in hospital
- Why risk assessment should cover a range of factors
- How to use gravitational potential energy to calculate risk in relation to bed height

Using gravitational potential energy to assess the risk of falls from bed

Key points

Falls are a major burden and cost to the NHS every year

All patients aged >65 years, or aged 50-64 years with certain conditions, should be screened for falls risk when in hospital

Many factors are involved in falls risk, but one consideration is bed height

Gravitational potential energy can be used to illustrate the risk of a fall at certain bed heights

It is also important to take into account the patient's ability to move out of bed with ease

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Abstract In the UK, falls in hospital are the most commonly reported patient safety incident. Risk is multifactorial and increases with age, some medications, and conditions such as delirium and dementia. Falls prevention should include a personalised assessment and discussions with patients, supported by consistent use of numerical data and a mix of word and picture formats. Any decision made to prevent a fall should be in the patient's best interests and least restrictive of their basic rights and freedoms. Gravitational potential energy is one way of showing the increased risk of harm from falls from a bed with increasing height. This can be combined with popliteal height to determine the best height that is least restrictive for patients and allows them to move safely out of bed.

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Falls prevention has been the subject of much debate and its importance is reflected in the health and social care agenda. In 2013, the National Institute for Health and Care Excellence (NICE) advised that falls risk prediction tools were not advisable, due to lack of sensitivity (NICE, 2013). Best practice is to screen all patients, regardless of the reason for their admission to acute care, if they are aged >65 years, or aged 50-64 years and considered to be at risk of a fall because of an underlying condition. Each patient should receive a personalised multifactorial risk assessment and a prompt plan to address the factors for falling in hospital that can be treated, improved or managed during their stay (NICE, 2013).

Falls have many complex and wide-ranging causes, such as:

- Muscle weakness;
- Poor balance;
- Visual impairment;
- Use of certain medicines;
- Polypharmacy;
- Environmental hazards;
- Some specific medical conditions (Public Health England, 2020).

Some of the reasons for falls – such as gait and improving lean muscle tone – can be addressed by referral to specialist teams (PHE, 2020). This article focuses on the immediate falls risk from bed and mitigating potential harm.

Who is at risk of falls?

Patients who are acutely unwell or out of their usual environment are at greater risk of falls than they would be in normal circumstances. These risks are amplified in the presence of sensory impairment, delirium or dementia (Royal College of Physicians, 2015). To reduce the risk of falls in hospital, policies and strategies need to reflect the link with conditions such as dementia or delirium, which compound issues around acute illness and chronic problems with gait or balance (RCP, 2015).

The RCP's (2015) national audit of inpatient falls found that 42% of trusts did not routinely assess for dementia and 32% of falls policies were written in isolation,

with no link to delirium or dementia policies. Research has shown that older adults with dementia are twice as likely to fall as those without the condition (National Patient Safety Agency (NPSA), 2007). Proportionally, 77% of all reported inpatient falls happen to patients aged >65 years, despite this group only representing 40% of admissions (NHS Improvement, 2017). Not only are falls more likely to occur in older patients, but they are also more likely to result in harm in this patient group. Where harm does occur, it is likely to be three times more severe for adults aged over 70 years than those aged under 70, including the risk of death in the following weeks (Boynton, 2010).

In England, 676,000 people have dementia (Department of Health, 2015a). This condition mainly affects older people and, after the age of 65 years, the likelihood of developing dementia roughly doubles every five years. An estimated 25% of hospital beds are occupied by patients with dementia (DH, 2015a); in addition, those with dementia spend nearly four times longer in hospital after a fall than those without dementia and the resulting frailty increases the risk of them being unable to return home (Boaden, 2016).

Delirium also increases the risk of falls. Older people and those with dementia, severe illness or a hip fracture are at greater risk of delirium than the general population. The prevalence of delirium is about 20-30% on medical wards and affects 10-50% of patients having surgery (NICE, 2019). Those who experience delirium stay longer in hospital, have more hospital-acquired complications such as pressure ulcers, are more likely to need long-term care and are at increased risk of mortality (NICE, 2019).

Prevalence of falls

In the NHS, falls are the most commonly reported patient safety incident, with >240,000 reported in acute hospitals and mental health trusts in England and Wales every year (RCP, 2015). Falls are estimated to cost the NHS more than £2.3bn each year (NICE, 2013) and an acute trust is estimated to incur direct costs from falls of £92,000 a year, with additional costs for litigation and increased health and social care post discharge (NPSA, 2007).

Mitigation of falls

Research has shown that multiple interventions by the multidisciplinary team, tailored to meet individual needs, can reduce falls by 20-30% (RCP, 2015). These interventions are particularly important for patients with dementia and delirium because of their high risk of falls in hospital (RCP, 2015). However, there is no single or easily identifiable intervention that, when undertaken on its own, is shown to reduce falls (RCP, 2015).

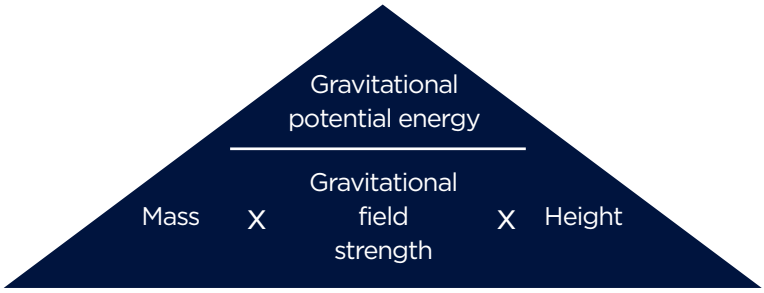
The lack of evidence around suitable strategies is echoed by NICE guidance, which highlights that, although single and multifactorial interventions to prevent falls have been the subject of research, their overall effectiveness in different care settings (such as mental health units for older people) has not been established. In addition, the effectiveness of different component parts of a multifactorial assessment is unclear and the effectiveness to different subgroups, such as people with dementia, is also unclear; as such, randomised controlled trials are needed (NICE 2013).

Given the UK's ageing population, what could immediately be done to reduce harm from a fall if it is an identified risk during a hospital admission (Deary et al, 2009; Andersen-Ranberg et al, 1999)? Many interventions require a long-term approach to optimising an individual by way of strength and balance training, as well as referrals to specialist falls teams (Bit.ly/RSPHFalls). This leaves nursing staff with the immediate issue of how to best protect their patient from harm.

Assessing risk

It is widely recognised that achieving zero falls would be unrealistic, of exorbitantly high cost and – perhaps most importantly – has potential to infringe upon, and be detrimental to, patient rehabilitation (King et al, 2018; NHSI, 2017; RCP, 2015; NPSA, 2007). Yet, with 22% of inpatient falls occurring directly from the bed (RCP, 2015), this article looks at the risk of injury to which a patient may be subject when falling from a bed at varying heights.

Fig 1. **Calculating gravitational potential energy**



"A bed with a lower height may reduce the risk of injury from a fall, but it must also be taken into account how the bed height may then affect the patient's ability to rehabilitate or mobilise"

The NHS Constitution For England advises that patients have the right to safe suitable care and staff should do all they can to protect patients from avoidable harm (DH, 2015b). NICE (2012) advocates that staff should:

- Personalise risks and benefits for a patient as far as possible;
- Be consistent in the use of data;
- Use numerical data as well as a mixture of numerical and pictorial formats (NICE, 2012).

It should be noted that, when a patient is unable to consent to their care, decisions should be taken in line with the Mental Capacity Act 2005. When any decision is made, the rationale should be documented and treatment should be:

- In the patient's best interests;
- Least restrictive of their basic rights and freedoms.

For a discussion on bed height, this means taking into account the patient's ability to mobilise, without restriction of movement, and their right to rehabilitation or movement if they are able, and wish, to stand.

Bed height and falls

A literature search using the terms "bed height" and "accidental falls" produced 39 papers. Many of these – such as Dsouza and Bertocci (2018), Thompson and Bertocci (2014) and Claudet et al (2013) – focus

Table 1. **Calculation of gravitational potential energy (GPE) at different bed heights (m)**

Height of bed	Plus surface	Total height	Gravity	Mass of patient	GPE total	Difference vs 0.39m	% increase
0.39	0.14	0.53	9.807	80	416	0	0
0.30	0.14	0.44	9.807	80	345	-71	-20
0.21	0.14	0.35	9.807	80	275	-141	-50
0.12	0.14	0.26	9.807	80	204	-212	-100

on falls in children and conclude that except for mass, injury outcome measures tended to be more sensitive to changes in environmental parameters, such as bed height and impact surface, than parameters such as body stiffness. Thompson and Bertocci (2014) and Claudet et al (2013) concurred that risk of a traumatic brain injury was statistically significant when falling from a height of >90cm.

Two studies focused on adult patients. Merryweather et al (2015) looked at lower-extremity torque caused when patients attempted to move from a bed kept at two set heights, 38cm and 58cm. They found that low beds posed risks to the population for which they were designed – namely, the older population at increased risk of falling. This shows the importance of a multifactorial risk assessment, whereby the carer should adapt the use of the bed for the individual patient's needs.

Conversely, Menéndez et al (2013) found a reduction of 28.3% in falls with a lower-height bed in a geriatric acute hospital ward, and 1.88% fewer falls with harm, leading them to conclude that this reduced harm and cost.

Due to ethical considerations, which would inhibit studies where harm (a fall) would be inflicted on actual patients, several different researchers used a test device to simulate the effects of a falling patient/person (Dsouza and Bertocci, 2018; Thompson and Bertocci, 2014; Raymond et al, 2011).

De Paiva et al (2010) analysed 826 adverse events and found that 55% of falls were from the bed. They found these falls occurred early in the hospital stay, mostly on a neurological ward, at night, and in the older population; this led them to conclude that "high importance should be placed on studying the population to characterise those at high risk for falls to assist in the implementation of preventive measures" (De Paiva et al, 2010).

One literature review undertaken by Anderson et al (2012) found that the low height of beds was not associated with a statistically significant increase or decrease in the rate of injuries, although the standard of care in the control group was not described.

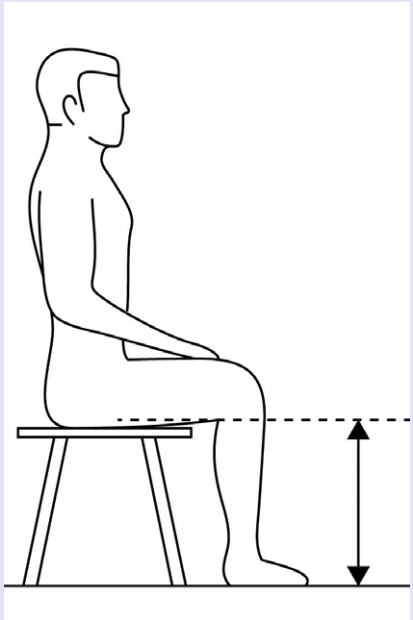
This evidence reinforces the need for high-quality randomised controlled trials to help carers make informed decisions about how to reduce the risk of harm in patients for whom a fall is an identified risk. In the meantime, it is worth considering whether anything can be done to reduce the risk of harm in those at risk of a fall that is also least restrictive of the patient's basic rights and freedoms.

Gravitational potential energy

In the absence of this clarification, and while noting that harm to patients can be affected by multiple dynamics, this article looks at what gravitational potential energy can tell us about a person's risk of falls.

Gravitational potential energy is a way to calculate the energy stored in an object because of its position or distance above the floor (Fig 1). It is a simplistic formula that uses the patient's weight and the height that the patient falls. We know that humans do not fall uniformly and a patient may seek to slow a fall by grabbing onto something or fall head or foot first, which may affect the injury sustained. But gravitational potential energy helps us illustrate the risk of a fall from an increasing height in conversations addressing risk of a fall from bed.

Fig 2. **Measurement of popliteal height**



Calculation

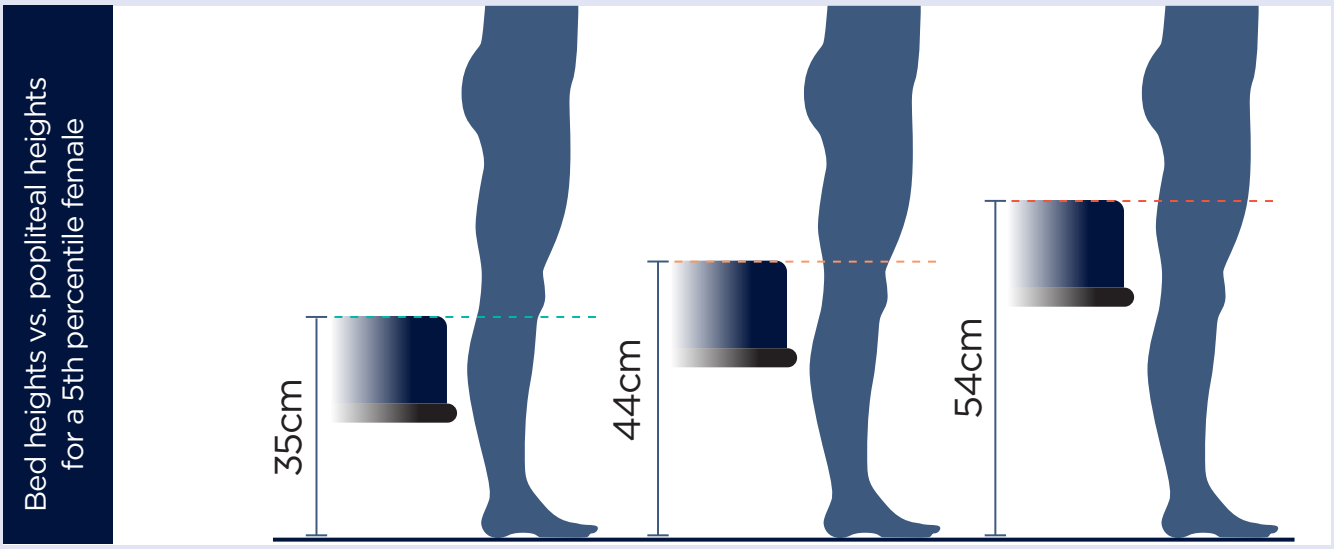
Simple physics indicates that the lower the bed, the lower the risk, and gravitational potential energy can be used to show this. A patient with a weight of 80kg has been used to illustrate the reduction in gravitational potential energy with a lower bed. To provide uniformity in this calculation, a 14cm foam surface has been added to the low height of a range of medical/surgical beds in common use (Table 1). Taking 39cm bed height as a starting point plus a 14cm foam mattress, the gravitational potential energy was calculated in reducing height increments of 1cm.

The calculations show that a bed at 21cm has half the gravitational potential energy of a bed at 39cm. A bed with a low height of 12cm would have 100% less gravitational potential energy than a bed with a low height of 39cm (Table 1).

As a caregiver is required to consider the "least restrictive of the patient's basic rights and freedoms", in accordance with the Mental Capacity Act 2005, a patient's ability to mobilise from a bed at floor height needs to be considered. This is especially as Merryweather et al (2015) showed that lower extremity torque at low heights actually increased the risk of falls in older people, who may be less able to compensate for a low bed height because of physical and cognitive deficits.

Nursing staff need to look at both the risks and benefits for patients, especially the vulnerable within their care. Therefore, although a bed with a lower height may reduce the risk of injury to a patient

Fig 3. **Bed heights versus popliteal heights (the point that ligaments attach at back of knee)**



from a fall, due to a reduction in gravitational potential energy, it must also be taken into account how the bed height may then affect the patient's ability to rehabilitate or mobilise. Martindale (2021) on the popliteal measurement (distance from the floor to behind the knee) (Fig 2) of the British population shows that, for someone to be able to sit at the edge of their bed with their feet firmly on the floor and move to stand, a height of 35cm-35.5cm is ideal. With a mattress height of 14cm, it suggests a bed frame 21cm from the floor would be suitable for a patient to safely start to mobilise (Fig 3). This height also reduces the gravitational potential energy and risk of harm should a patient fall or roll from bed, without impeding safe movement out of bed.

Conclusion

Falls reduction is a complex area with many interconnected factors. All patients have unique risks, and it is important to identify these in any multifactorial assessment so that the appropriate steps can be taken to treat, improve or manage them during the patient's stay in hospital.

Risks will alter as the patient's condition changes and should be reassessed as necessary. NICE (2013) guidance on falls calls for more robust evidence on which interventions are most effective in different settings and with different subgroups of patients. When discussing risks with patients, relatives or those with legal responsibilities for patients, numerical data, words and pictorial images should, where possible, be used to illustrate the points made.

Gravitational potential energy has been used as a simple illustration of how falling from different bed platform heights can increase the risk of injury. The limitations of this approach are acknowledged, including that patients do not fall uniformly and the direction of a fall can have a bearing on the type of injury caused.

Care should be taken that, where a bed is set at a low height, the lower extremity torque does not hinder a patient's ability to mobilise, as this in itself could increase the risk of a fall. This would be particularly important where a patient cannot consent to treatment. Use of popliteal measurements, as discussed in an earlier article (Martindale, 2021), further helps the discussion on the appropriate bed height to reduce falls risk, while allowing a patient to move out of bed.

Where a patient is at immediate risk of harm from a fall, it is vital that a balanced and considered approach to the risk of harm is discussed. **NT**

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