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Quality Improvement in Long-Term Care

The purpose of this column is to discuss innovations and quality improvement efforts in a variety of long-term care settings. This column is coordinated by Marilyn J. Rantz, PhD, RN, FAAN, rantzm@missouri.edu.

Falls, Technology, and Stunt Actors

New Approaches to Fall Detection and Fall Risk Assessment

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FALLS are a critical health problem for older adults. One in every 3 people aged 65 or older falls each year, making falls the most common cause of trauma-related injuries and hospitalizations in older adults and the leading cause of death due to injury.[1] Falls are often the prelude to rapid functional decline, costly hospitalization and rehabilitation services, loss of independence, loss of physical function, and even death.[1-3]

Despite extraordinary advances in healthcare for many chronic illnesses, new solutions are desperately needed to improve fall detection methods. An interdisciplinary research team at the University of Missouri is developing innovative technological approaches that automatically detect when falls have occurred or when the risk of falls is increasing.[4-6] Unlike existing methods where older adults have to press buttons, pull cords, or wear a device, our approach uses unobtrusive technology within a person's environment.

This new "passive" approach uses sensors that when placed in a home could revolutionize fall detection and quickly summon help to older adults when they need it, not hours or days later. Because the sensors would function without deliberate action by older adults who have fallen, help would be summoned even when the older adult is unconscious. Falls that might have been unreported by older adults also would be detected. The team is also developing technology to accurately monitor

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increasing or decreasing fall risk continuously in home environments while older adults go about their daily lives.

By early detection of falls or changes in gait or activity suggestive of increasing fall risk, this new technology can act as a trigger for implementation of interventions by older adults themselves, family members, or healthcare providers to improve physical function or better manage illnesses that are precipitating falls. Falls often are early indicators of changes in health status. With early recognition, there is great potential to reduce falls and fall risk and treat incipient health problems without costly hospitalization or before life-threatening injury.

As our research team made progress with developing sensor technology to sense falls and monitor fall risk, a unique problem emerged. To adequately test the sensors, we needed to have large number of falls to detect. But, asking older people to "fall" is not a viable approach as the risk of injury is high. As well, it is difficult to predict where a fall event will happen, so placing sensors in areas of "high risk" did not seem feasible.

The team brainstormed ideas that included rejected suggestions of falls by research team members, gymnastic athletes, or volleyball athletes. We then conducted actual trials with a rescue dummy of realistic weight, made of plastic, and dropped from a mechanical lift but believed this approach did not adequately mimic a real-life fall. What we needed were actual falls done by real people and in ways that realistically replicated the falls of older adults. The solution is stunt actors.

Stunt actors were trained to fall realistically but in ways that avoid injury. With the assistance of 2 trained theater stunt actors hired for the project, we tested a series of falls that were typical of falls experienced by older adults. To ensure that the falls were realistic, an evaluation approach was designed and field-tested following review by the Health Sciences institutional review board. The rationale and results of that field test are described, and implications for practice are discussed.

METHODS

Although the problem of judging realistic falls may be unique, standard methods of validity and reliability[7] can be applied to measure the features of falls. These methods were used in developing a fall test protocol, creating a scoring rubric for 2 expert nurses to both train the actors on actions that would be part of a fall and rate the realism of each fall, and videotaping the fall testing session so that 2 other nurses could independently validate the conclusions of the expert nurse ratings.[8] The expert nurses, who had experience in long-term care settings that included witnessing falls of older adults, coached the stunt actors to help them understand and simulate the body positions and likely fall trajectories of older adults. Coaching also was recorded so it could be considered during the independent validation.

First, a fall test protocol was developed that outlined fall possibilities from standing, sitting, tripping, and slipping, and from lying positions on a bed or couch. Next, standing falls were described from 2 perspectives forming subcategories, those caused by loss of balance and those caused by loss of consciousness. These subcategories are important because when people fall while they are conscious, they attempt to break the fall with upper extremities. When a person loses consciousness and falls, those protective motions are typically not used. Within each category and subcategory, separate falls were defined by direction such as falling forward, backward, to the right, or to the left side. A total of 20 different falls were detailed in the protocol.

Criteria were written for each category and subcategory of falls that included descriptions of common difficulties encountered by older adults with posture changes and gait changes (Exhibit 1). For example, many older people have shifts in their center of gravity as osteoporosis or loss of muscle mass occurs as a complication of aging or chronic illness. This shift in center of gravity causes knees to slightly bend, shoulders to round, posture to lean forward, and eyes to focus on the floor

Exhibit 1. Fall position, criteria and scoring

Standing position. From an initial standing position, the stunt actor will fall as if losing balance, then as if there is a momentary loss of consciousness

Criteria for "loses balance falls"

Leans forward, leans to left, leans to right, or leans back
Looks down
When falling tries to break fall with upper extremities
(1) fall forward Score___
(2) fall backward Score___
(3) fall to the left side Score___
(4) fall to the right side Score___

Criteria for "momentary loss of consciousness falls"

Falls much like a tree, toppling backward, forward, or sideward
Crumples to the floor
No attempt to break fall with upper extremities
(1) fall forward Score___
(2) fall backward Score___
(3) fall to the left side Score___
(4) fall to the right side Score___
(5) fall straight down Score___

Tripping and slipping. From an initial walking position, the stunt actor will trip and fall, then from an initial walking position, will slip (as if on water or ice) and fall

Criteria for walking, then tripping and slipping falls

Walks with shorten stride
Leans forward when walking
Looks down when walking
When falling tries to break fall with upper extremities
(1) trip and fall forward Score___
(2) trip and fall to the side Score___
(3) slip and fall forward Score___
(4) slip and fall to the side Score___

Sitting position. From an initial position sitting on a stationary chair (no wheels), the stunt actor will fall from the chair as if losing balance, then as if there is a momentary loss of consciousness, then slide forward and backward out of a chair with wheels

Criteria for falling from the chair

Leans and eventually center of gravity changes and falls off the chair
Attempts to break fall with upper extremities
(1) fall forward Score___
(2) fall to the left side Score___
(3) fall to the right side Score___
(4) fall by sliding forward out of the chair as the chair slides back Score___
(5) fall by sliding backward out of the chair as itslides back Score___

From bed or couch. From a lying position, the stunt actor will roll off the bed or couch.

Criteria for falls from bed or couch, somewhat awakens and attempts to get up

Sleeping, attempts to get up, legs get caught in blanket and falls
Attempts to break fall with upper extremity
(1) fall to side, upper body falls first Score___

Criteria for falls from bed or couch, does not awaken

Rolls too close to edge of bed or couch, center of gravity changes and rolls off
No attempt to break fall with upper extremity
(1) fall to side, hips and shoulders fall first Score___

as the person walks. In addition, a shortened length of stride and shuffling of feet on the surface of the floor is common.

The protocol was reviewed by 3 expert nurses knowledgeable in gerontology with clinical practice experience that included observing older adults falling and dealing with the aftermath of falls. The protocol was revised on the basis of the expert input.

Two testing sessions were planned and conducted with the stunt actors. The first was conducted to test the fall test protocol and measure the realism of each fall. The second was to have them fall following the protocol to test the sensors under development. Protective floor mats and joint protection were used to minimize the potential for injury. Video equipment was used to tape the falls for validation of the ratings.

Two expert nurses were present for the first session, which began with coaching the stunt actors about the common changes in gait and posture that occur in older adults and contribute to increasing fall risk. The stunt actors reviewed the fall test protocol and asked questions to verify each of the falls and questioned the nurses to understand coaching comments. With coaching before and during the testing of the protocol, the stunt actors approached the fall sequences "in character" of an older person using the information about common changes in older adults that contribute to fall risk. Figure 1 shows a fall from a standing position and Figure 2 a fall from a chair.

The nurses observed each fall and independently rated them on a scale of 1 to 4, with 1 (*not realistic*), 2 (*a little bit realistic*), 3 (*somewhat realistic*), and 4 (*very realistic*). A priori, a decision was made that to be judged realistic, both nurses needed to independently score a fall either 3 or 4. After scoring each fall, the nurses compared their rating and provided feedback to the stunt actors in cases that scored less than 3 or 4. In those cases, the stunt actor repeated the fall to improve the realism until the raters achieved agreement of 3 or 4. This approach using a 4-point rating scale was modeled after content validity index procedures described by Waltz et al.[7]

Two trained theater stunt actors performed the 20 falls of the fall test protocol. One stunt actor was a female about 5′3″ and the other a

Figure 1.

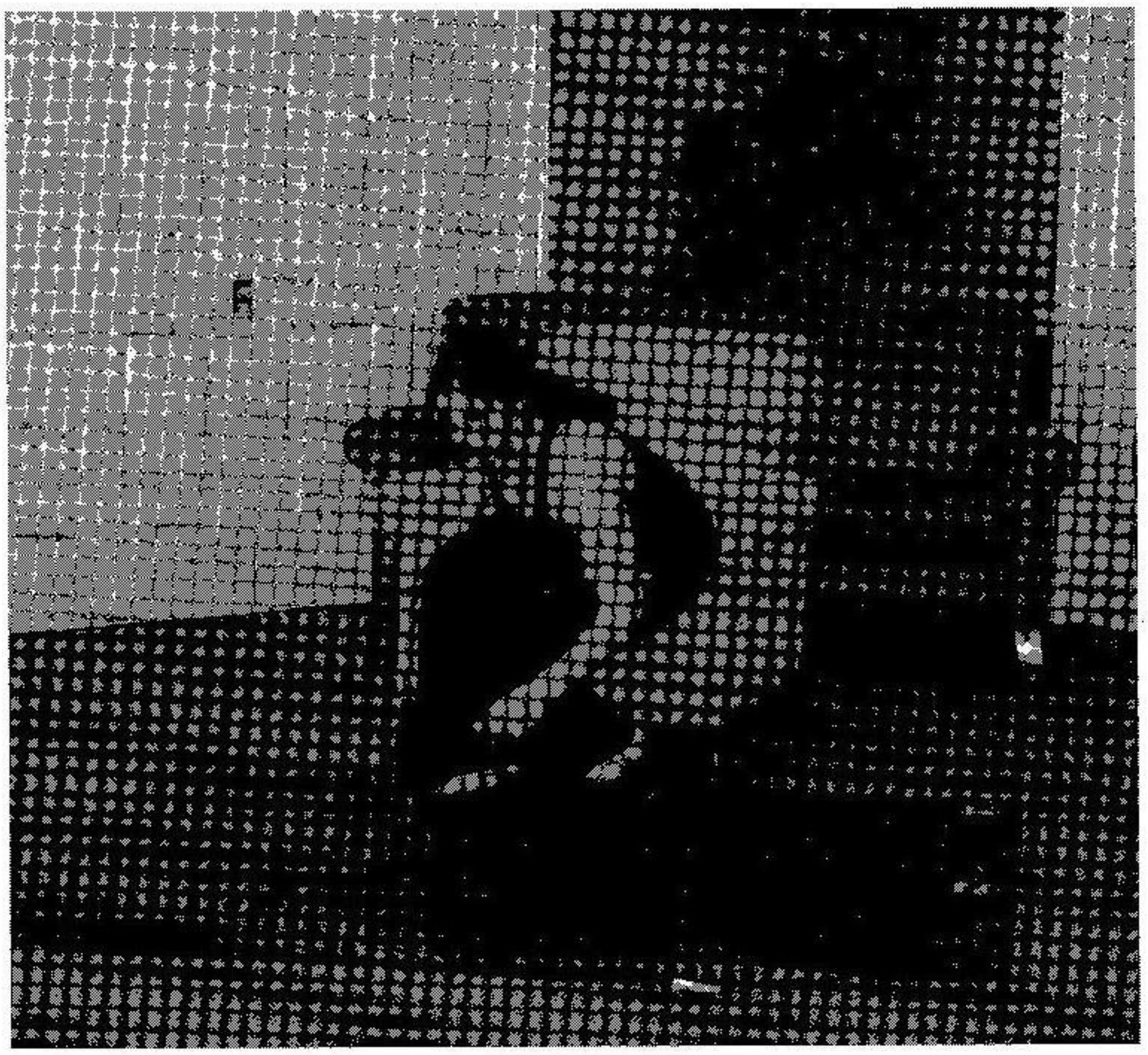

Figure 2.

male about 5′11″. Both were of medium build; the female actor was in her early 40s and the male in his mid-20s. Both actors were experienced in falling in stage productions and had advanced training and experience in the complexities of realistic falls. The plan was to have each actor perform the sequences of standing falls for losing balance, then for losing consciousness, tripping and slipping, sitting, and lying falls, alternating the actors so that fatigue would be minimized. Actors of different height provided variation for the raters to judge the realism of the falls in the context of different performers.

RESULTS

The expert nurse observers independently rated each fall. In 4 cases for each actor, the nurses coached after a fall and had the actor repeat the fall, correcting an approach to improve the realism of the fall. In all corrected falls, both raters scored the repeat fall as a 4, very realistic. The other falls were independently scored as 4, very realistic, by each nurse.

A second set of 2 other nurses observed the videotaped session of the stunt actor falls and coaching by the expert nurses. These nurses independently scored the falls and validated the findings by scoring all falls a 3 or 4 with the exception of a backward fall that one of the nurses rated a 2 and the other a 3. The average score across all falls by these 2 raters was 3.5, indicating that the falls by stunt actors were realistic and closely resemble falls by older adults.

Following the successful field test of the fall test protocol, it was time to test a variety of prototype fall detection sensors using the protocol in a laboratory setting of a staged home environment. One of the stunt actors who participated in the field test helped computer engineers on the research team test the sensors by falling realistically (as an older adult would likely fall) using the fall test protocol. One of the nurse experts assisted in

the laboratory setting to coach and watch the stunt actor fall to ensure that they realistically resembled falls by older adults. While complex data processing and analysis are still under way, an essential component of the test was in place—realistic falls for the sensors to detect.

Implications

Despite healthcare providers' efforts at prevention, falls among older adults continue to be a critical and costly problem. Clearly, new methods are needed to address this issue. Our interdisciplinary research team is committed to the development of new technology that can detect unreported falls (such as when the person falls and then rises from the floor independently) and falls with injuries (such as when the person cannot rise from the floor, needs assistance but may be unable to call for it). Detecting both unreported falls and falls with injuries has potential to reduce time to treat the underlying cause(s) of falls. In particular, data previously unavailable on unreported falls without injury provide valuable information to healthcare professionals about the increasing fall risk of individuals. Armed with this knowledge, preventive interventions can be implemented to avoid or reduce costly hospitalizations as well as pain and suffering from injuries.

In addition to fall detection, the new technology that we are developing to embed in elders' homes will passively and continuously assess for fall risk as the person goes about normal activities of daily living. With such technology, sensor data could be used not only to calculate fall risk but also to alert providers of increasing fall risk. Providers could respond with early interventions to help older adults improve physical function or take other steps to avoid impending falls. Such actions have potential to minimize the impending losses in physical function that accompany falls and ultimately reduce healthcare costs.

From a practical perspective, these new and innovative approaches to measure fall risk using sensors embedded in living environments can provide clinicians with much-needed tools for frequently and accurately measuring fall risk and fall occurrences. This new technology could become a proxy for the clinically labor-intensive, multifactorial fall risk assessment (that is rare if ever performed for many elders) and be made widely available. One could imagine a sensor network available for use in a Senior Center or retail store, much like a blood pressure machine is available to the public. After a brief walk through the networked space, pausing to complete some prompted motions, one could receive a calculated fall risk assessment with suggestions for improving fall risk.

Some critical pieces make the development of a fall and fall risk sensor network possible. First, the skill of the researchers developing the technology is essential as are the clinical and research skills of the expert nurses in gerontology and the skills of other members of the interdisciplinary research team. However, in fall detection, the essential component is a fall—so trained theater stunt actors who know how to fall in ways that realistically resemble falls of older people (and not hurt themselves!) are essential to success.

REFERENCES

1. Centers for Disease Control and Prevention. Falls among older adults: summary of research findings. 2006. www.cdc.gov/ncipc/pub-res/toolkit/SummaryOfFalls.htm. Accessed November 18, 2006.
2. National Council on Aging. *Falls Free: Promoting a National Falls Prevention Action Plan*. Washington, DC: National Council on Aging; 2005.
3. Tinetti ME. Preventing falls in elderly persons. *N Engl J Med*. 2003;348(1):42–49.
4. Demiris G, Hensel BK, Skubic M, Rantz MJ. Senior residents' perceived need of and preferences for "smart home" sensor technologies. *Int J Technol Assess Health Care*. 2008;24(1):102–124.
5. Demiris G, Parker-Oliver D, Dickey G, Rantz M, Skubic M. Findings from a participatory evaluation of a smart home application for older adults. *Technol Health Care*. In press.
6. Rantz MJ, Marek KD, Aud MA, Tyrer HW, Skubic M,

Demiris G, et al. Technology and nursing collaboration to help older adults age in place. *Nurs Outlook.* 2005;53(1):40–45.
7. Waltz CF, Strickland OL, Lenz ER. *Measurement in Nursing Research.* Philadelphia: FA Davis; 1984.
8. Kerlinger FN. *Foundations of Behavioral Research.* 3rd ed. Fort Worth, TX: Holt, Rinehart and Winston; 1986.

Letter to the Editor

Time to Move On: Definitions of Evidence-Based Practice

I have noticed that many nurse-writers, presenters, and those involved in developing evidence-based practice (EBP) programs use the definitions of evidence-based medicine offered by Sackett and colleagues:

1. "Evidence-based medicine . . . is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."[1(p2)]
2. "Evidence-based medicine is the integration of the best research evidence with clinical expertise and patient values."[2(p1)]

Although these are definitions of evidence-based *medicine*, they have been of value across the healthcare professions. In an elegant way, they have reminded healthcare professionals who provide direct services to the public to make an effort to bring scientific evidence into their care planning and decision making.

However, these definitions provide a limited and potentially misleading portrayal of EBP in *nursing* because they do not fully capture, or accommodate, EBP as it is being enacted in many clinical settings. The limitations of Sackett and colleagues' definitions as I see them are listed below:

1. The definitions' portrayals of how clinicians incorporate research into practice do not capture the full range of ways in which nurses and multidisciplinary teams engage research evidence—(*a*) Their portrayal of EBP is limited to individual clinicians seeking research evidence to incorporate into their decisions about the care of individual patients; (*b*) Generic evidence-based guidelines for populations or groups of patients and agency evidence-based protocols are not recognized as approaches central to EBP; and (*c*) The important role of organizational context in promoting EBP is not acknowledged. In particular, the definitions do not recognize that the aims and methods of evidence-based nursing and quality improvement programs are overlapping and complementary.
2. The definitions describe a form of EBP that is not widely achievable in nursing given the educational profile of the direct care nursing workforce and the pressures of nursing work environments.

Broader definitions and models of evidence-based nursing exist. Importantly, these more inclusive definitions accommodate both the organizational approach of setting evidence-based standards of care for specific patient populations and the individual clinician's use of research evidence in deciding what care to give to individual patients. For these reasons, they should be considered as working frameworks rather than the definitions of Sackett and colleagues.

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REFERENCES

1. Sackett DL, Richardson WS, Rosenberg W, Haynes RB. *Evidence-Based Medicine: How to Practice and Teach EBM.* New York: Churchill Livingstone; 1997.
2. Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. *Evidence-Based Medicine: How to Practice and Teach EBM.* 2nd ed. Edinburgh: Churchill Livingstone; 2000.