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Invited Commentary

Catherine M Said

I congratulate Pai and Bhatt on this elegant review,[1] which provides a comprehensive overview of the very exciting work on slips done by their research team. I agree with the authors that this work is highly relevant given the high costs of falls in our society, particularly as the majority of falls occur during dynamic tasks, such as walking. The novel method that they have developed and utilized for quantifying stability during dynamic tasks has allowed the team to develop new insights into the mechanisms behind slips and falls. In addition, the model and method they have developed will allow stability during other dynamic tasks to be explored. In this commentary, however, I will focus on the implications of this research for clinical practice.

An Early Predictor of Fallers?

Although the authors emphasize the implications of their research for training, future development of this research also may lead to better identification of people at risk for falling. Current testing methods are able to identify people who are at high risk for falls or who are already falling.[2] However, early identification of peo-

ple who are at risk for becoming a "faller" is still difficult. A test such as the "slip" test may be more sensitive than other tests. The slip test is challenging, as it provides an unexpected external perturbation during a dynamic task. Currently, there are no clinical tests widely available that test this aspect of postural control. In addition, performance on the test can be quantified. These features may assist in early identification of people who are at risk for falls. This would allow targeted treatment programs to be implemented earlier, which may help prevent falls. However, to date, the relationship between falls and performance on the slip task in the laboratory and falls in the "real world" has not been examined. So, although there is real potential for this research to lead to changes in the way in which people at risk for falls are identified, prospective exploration of the laboratory/real-world relationship would be necessary.

A Novel Method of Fall Prevention

As pointed out by the authors, current interventions for fall prevention or balance training do not focus on promoting reactive strategies. Currently, clinical balance retraining is strongly focused on training proactive control of stability. This review presents evidence that reactive strategies also can be trained. Upon repeated exposure to the slip condition, participants modified their movement patterns both proactively and reactively to reduce the chance of a fall. There is evidence that these modifications can be retained over time, with a relatively low intensity of training. But before therapists start training reactive balance control in their clients, some issues need to be considered.

First, it is not known how applicable these findings are to the types of clients physical therapists currently treat. Generally, we treat clients who have a balance problem and are at high risk of a fall. All of the subjects included in these trials to date have been unimpaired and have no history of falls or balance problems. Although the results of these studies are promising and indicate that reactive strategies can be trained, the same level of improvement may not be observed in subjects with balance problems. People with a history of falls also may experience greater levels of fear and anxiety during training,[3] which also may affect the success of training. Examination of training protocols in clinical populations is an important area of future investigation.

Second, whether training reactive strategies in the laboratory or clinical environment can transfer to the real world has yet to be established. Several factors may limit transfer of the skill trained using this paradigm. In these experiments, even though there were a number of "nonslip" trials, participants were all aware that there was a chance that a slip may occur. In addition, subsequent slips were all under exactly the same environmental conditions, and no competing demands or distractions were placed on subjects. This differs from the real-world environment, where slips are not always predicted and occur under varying environmental conditions and often with competing attentional demands. The motor learning literature suggests that for optimal transfer of a skill, practice needs to occur under variable conditions,[4] so it is likely that practice under more varied conditions is required to maximize the transferability of this skill. Although the results of these studies are promising, training and testing need to be undertaken in more ecologically valid conditions, and additional evidence about the effectiveness of this training on fall prevention is required.

Finally, how training of reactive strategies can practically be performed in the clinical environment needs to be considered. To train reactive strategies, a person must lose stability, which carries with it the risk of a fall. The risk of a fall is probably greater in clinical environments, as clients usually have a balance problem. In addition, safety equipment such as the harness system used in the laboratory setting is not always available in the clinical setting. Common methods of reducing falls risk during balance training are to have a wall or rail alongside the patient or to have a therapist beside the patient to assist in balance recovery. Both of these methods are suboptimal. Relying on upper-limb support to assist balance recovery changes the nature of the reactive strategies utilized[5]; therefore, training may not be optimal. Relying on a therapist to provide assistance if stability cannot be regained may place the therapist at unacceptable risk of injury; a risk that would be even greater while training reactive strategies. Before reactive balance training can be widely incorporated into clinical practice, consideration needs to be given to the ready availability of appropriate safety devices, such as harnesses.

Conclusion

The review by Pai and Bhatt highlights training of reactive strategies as an underutilized tool in the prevention of falls. Their research to date provides a solid foundation for further work to address many questions of clinical importance. This area of investigation may lead to significant changes in the way fall prevention and balance retraining programs are provided.

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Author Response

Yi-Chung Pai, Tanvi S Bhatt

We are grateful for Said's insightful appraisal of our work,[1] and we would like to respond to her thought-provoking comments, as follows.

An Early Predictor of "Fallers"?

In concurrence with Said, we believe that prospective exploration of the relationship between the laboratory and the "real world" could provide essential verification of current hypotheses. We have recently examined the relationship between scores on one of the commonly used volitional-based performance measures (the Timed "Up & Go" Test [TUG]) and slip recovery outcomes, along with self-reported falls experienced in the "real world" during the past 12 months, among the same group of older adults (>65 years of age). We found in this prospective study that 4 (31%) of the 13 respondents reported at least one fall. The recovery response and, most notably, variables indicative of a person's adaptability to slips were better predictors of future falls than the TUG scores after controlling for the confounding variables of sex and age. We noted that the number of subjects in the follow-up portion of this study was relatively small because of the long interval between the initial laboratory testing and the follow-up interview (~30 months). This observation, at the very least, however, provided a sound rationale and justification for a full-scale investigation.

A Novel Method of Fall Prevention

It is indeed still unknown to what extent this training paradigm is applicable to typical clients receiving physical therapy intervention for a balance-related problem or other sensory, motor, or cognitive impairment predisposing them to an elevated risk for falls. It remains likely, nevertheless, that these individuals will benefit from a repeated perturbation training paradigm such as this one because of the promising adaptation capabilities of the central nervous system, clearly demonstrated even in the presence of existing neurological insults.[2–4] Examination of the extent and the length of training required to enable these individuals to adapt to such a training paradigm and retain the benefits over a meaningful period may shed light on the specific role of sensorimotor systems in the adaptation and retention processes.

We agree with Said that it remains to be established whether training using both proactive and reactive strategies in the laboratory or clinical environment can be transferred to the "real world." As a first step, an answer to this question can be found through a prospective study of falls experienced in "real world" by the same people who participated in the initial training session. Those subjects who have received training are expected to experience fewer falls (ie, lower reported incidence) than the controls. With this kind of first-hand knowledge, investigation then can focus on how to improve transfer, which is indeed possible, at least in theory. Recent findings among young adults suggest an interlimb transfer of the repeated-slip training effects.[5] These results showed measurable generalization of the training effects to the contralateral, untrained side, leading to a significant reduction in falls incidence from ~30% on the first unexpected slip to ~10% on the first untrained side slip in gait. Our preliminary results indicated a similar, if not an even better, efficiency of transfer among older adults than young adults. Investigation also is under way focusing on intertask transfer. Although transfer theoretically can be improved when practice is carried out under variable conditions, future studies need to determine how variable these conditions must be in order to augment the transfer of the intended effects, obtained from the laboratory and

clinical settings, to the real-life conditions.

Logistically, demonstrating that the benefits acquired in a single training session can be retained for months and beyond is a necessary prerequisite for further consideration of the related transfer issues. One of the unique properties of this paradigm is this suspected outstandingly long sustainability of the training effects, and this opens up the attractive prospect of developing a vaccination-like intervention against falls incidence among older adults. As of now, we still need to demonstrate that the benefits from this single-session slip exposure can be retained in older adults for very long intervals (eg, 6 months to a year). Without this retention capability, multisession weekly or monthly clinic costs may render this approach unpromising. The need for investigation and solution of related transfer issues, thus, would be correspondingly diminished.

Finally, we again agree with Said that many practical issues pertaining to implementation and perhaps even reimbursement for services will have to be resolved before it will be possible to carry out training of the proactive and reactive strategies with systematically induced, unannounced perturbation in the clinical environment. The safety issue is indeed a paramount concern. The risk of injury can be minimized by a proper reduction of slip distance and by application of protective harnesses, which we believe can be made available in the clinical setting at an affordable cost. It is possible to envision multipurpose, low-cost harness systems that can be as common as the standard parallel bars used in rehabilitation settings. With the safety issue finally resolved, these evidence-based prospects, which incorporate principles of prophylactic practice, could well have far-reaching benefits, even for populations beyond those encountered in the current clinical settings.

Conclusion

From laboratory to clinic, we are embarking on a road that has yet to be clearly mapped. Hopefully, we have succeeded in making the case that this road is well worth traveling.

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