Strategic Promotion of Ageing Research Capacity

Mind Where You Walk! older people's vision and stepping

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Meeting the challenges of an ageing society

Funded by

EPSRC
Engineering and Physical Sciences Research Council

bbsrc
biotechnology and biological sciences research council

April 2008

Mind Where You Walk!
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When walking, older people need more time to view what is ahead of them than younger people. They respond differently to situations which arise and make more errors when stepping. This can mean they are at a greater risk of falling, since if they fail to step properly, then they are likely to be less stable and more likely to trip or stumble. Thirty fit and healthy people with no visual impairments walked along a special walkway. The walkway was randomly illuminated in specific places to provide stepping targets in the path of each participant. The study found that older people, particularly those judged to have a high-risk of falling, require more time looking at a target in order to plan and carry out stepping movements. This finding provides an important insight into why people become more prone to falls as they age.

Key Findings

- The amount of time available to an older person to view a target in their path when walking can have a significant influence on how accurately they step.

- For younger people, stepping errors increase when the time to view the target is very short, less than 0.8 seconds. For older people thought to be at a low-risk of falling, stepping errors increase when the time available to view the target is less than 2 seconds. Older people with a high risk of falling tend to make errors for viewing times less than 3.25 seconds.

- These findings are reinforced by those from other research which has shown that older people tend to fix their gaze on a target for around 1.5 to 2 seconds before stepping, whereas the time for younger people is typically 0.8 seconds. This suggests that older people require more time to plan and make visually guided adjustments to their stepping patterns. It also provides further evidence of age-related decline in the visual processes which support locomotion.

- There was little evidence to suggest that it was possible to alter the course of a step once the foot had left the ground, although this may have been possible for some of the younger participants.

- Much of the error in foot placement is related to the width of the step rather than its length. This provides further insight into the possible reasons behind falls, especially sideways falls. This is an important issue, as the risk of hip fracture from a sideways fall is 6 times greater than from a forward or backward fall, and 30 times greater if the fall results in direct impact on the hip.

- This study was the first to examine the influence of age on how long an individual needs to look ahead in order to step safely.

Introduction

The Issues

Around 30% of people aged over 65 living independently in the community fall each year. Most of these falls occur whilst walking on a level surface. Falls are a major cause of disability, and the leading cause of mortality (death) amongst people aged over 75. Those who survive often suffer long-term problems such as: injury; infection; loss of confidence; poor mobility leading to social isolation and depression; increased dependency; and permanent disability. A contributing factor to age-related falls during walking is likely to be a decline in the ability to process visual information about the path ahead and to translate this information into appropriate stepping movements.

Background

Looking at where to place one's feet is important when walking, especially when changing a stepping pattern to avoid obstacles and walk safely. Recent studies have found an important link between the control of vision and eye movement (**gaze behaviour**) and the control of stepping by the brain (this process is known as **visuomotor control** or **processing**).

Previous research has revealed that there are age-related differences in gaze behaviour during actions such as standing and walking from a seated position, stepping over obstacles, and stepping onto small targets. Differences in both gaze behaviour and stepping performance between groups of older people thought to have a high or low risk of falling have also been identified. One study found that older people, and in particular older people judged to be at higher risk from falling, look at future stepping targets much sooner than younger people (by over 1 second on average). Understanding the underlying mechanisms behind age-related changes to gaze behaviour during walking, and their implication for the risk of falls, requires further work.

The Aim

The primary aim of this study was to determine if the risk of older people falling whilst walking is associated with a decline in visuomotor processing, specifically when a change in stepping behaviour is required.

The Study

In the study, participants used an experimental walkway which enabled the timing of visual information about stepping targets to be varied. This provided information about the effects of this timing on stepping performance (stepping **accuracy** and **variability**) for three groups of people. In particular this was used to determine whether older people at a higher risk of falling require more time to look at targets prior to stepping than older people at a lower risk of falling and younger people.

The three groups consisted of:

- Ten healthy young people, aged from 22 to 30 (average age 25.1 years);
- Ten older people thought to be at a higher risk of falling, aged between 68 and 85 (average age 76.1 years);
- Ten older people thought to be at a lower risk of falling, aged between 65 and 77 (average age 69.9 years).

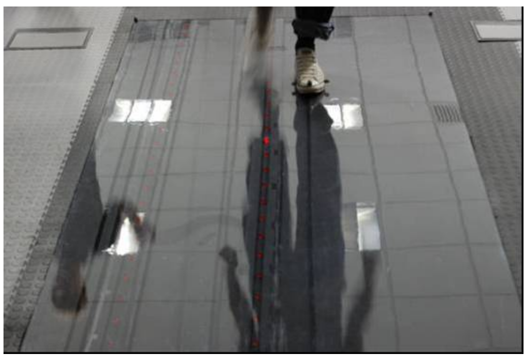
All the older people lived independently and none of the participants reported any neurological or musculoskeletal impairment.

Balance was examined using the *Berg Balance Scale* and this was used to categorise older people as being either at low-risk of falling (scored 49 or over) or at high-risk of falling (scored below 48). Older participants scored between 73% and 99% on the *Activities Balance Confidence Scale* which suggests they had minimal fear of falling.

Participants were examined for cognitive ability using the *Mini Mental State* questionnaire, and all were shown to have intact cognitive ability. Cognitive functioning was examined using the *Trail making B* test. The older people in the high-risk group took significantly longer to complete the test than the older people in the low-risk group and the younger people. All had good vision and none wore corrective lenses during the visual screening or during the experimental task.

The Experimental Equipment

Several spherical reflective markers were placed on the feet of each participant and one on the sternum (chest). A **motion analysis system** was used to track the position of these markers to show where participants were stepping. Gaze behaviour was recorded using a **mobile gaze tracking system** which measured the eye-line of gaze in relation to the head. An image of the eye was recorded by an **eye camera** which was fitted to a lightweight headband. This camera calculated the participant's eye position in relation to their head. Another camera known as a **scene camera** recorded the participant's visual field (the travel path).



The walkway

For the trials, participants walked at their own pace along an eight metre straight walkway. The walkway had a series of **Light Emitting Diodes** (LEDs) under a clear Perspex sheet on the floor. Participants were instructed that if an LED lit up then they should step on it as accurately as possible. Participants were also told that in some trials an LED would not illuminate but they should continue to walk to the end of the walkway.

In total, 48 LEDs were positioned under the Perspex sheet; 24 of which were placed in a central strip, with the others towards the edges of the walkway. This was done to ensure that the target location was unpredictable and, therefore, that successful completion of the task required visual guidance.

A computer was used to control the timings of the LED illumination. This illumination (**target presentation**) was programmed to occur at 2.5 seconds, 1.5 seconds, 1 second and 0.5 seconds before the estimated arrival of the participant at the target area.

All trials were randomised and a total of 70 trials, with different combinations of location and timing of illumination, were performed by each participant.

Prior to any data collection, each participant familiarised themselves with wearing the gaze tracker until they felt comfortable and five practice trials were performed. Control trials, in which no LED was illuminated, were included to encourage participants to walk at a constant speed and to discourage them from guessing which LED would illuminate. A helper walked alongside each participant to provide physical support and prevent participants from falling if they became unstable. However, all participants were able to complete the task without such assistance.

The ASL gaze tracker provided details about where and when participants looked as they walked around

The Vicon system measured 3D position of reflective markers placed on the body

Findings

Generally participants were more accurate when stepping to target locations in the centre of the walkway, than when stepping to those which were towards the edges. Overall, younger people were more accurate than older people. Stepping errors tended to be sideways of a target rather than in front of or behind the target.

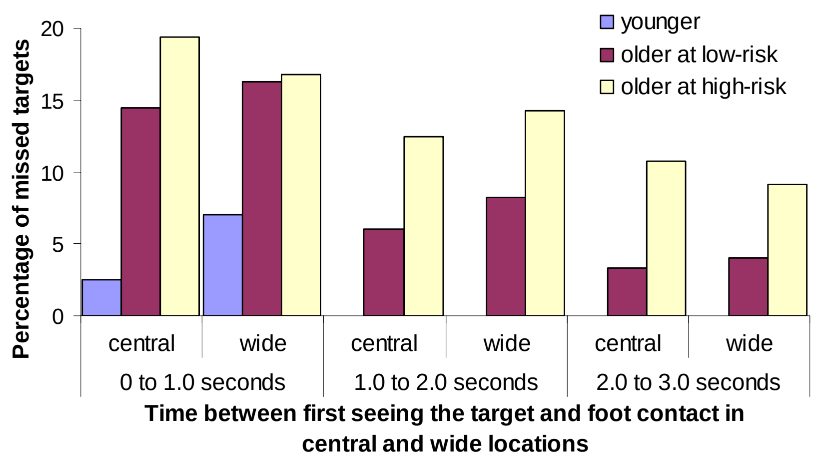
On average, older people at higher risk of falling missed 14% of targets, which was significantly more than younger people who only missed stepping on 1.5% of targets. The younger people only failed to step on the targets when they gazed at the target for less than 1 second before they stepped on it.

The accuracy of foot placement of the younger people and the older people at lower risk of falling was not greatly affected by the timing of illumination of the target. For the older lower risk group, the frequency of stepping too narrowly started to rise at timings of below 1.6 seconds. For the younger group the frequency of errors rose as the timings came closer to the onset of the movement of the limb, accelerating when the timing was after the limb had started to swing, typically at 0.4 seconds.

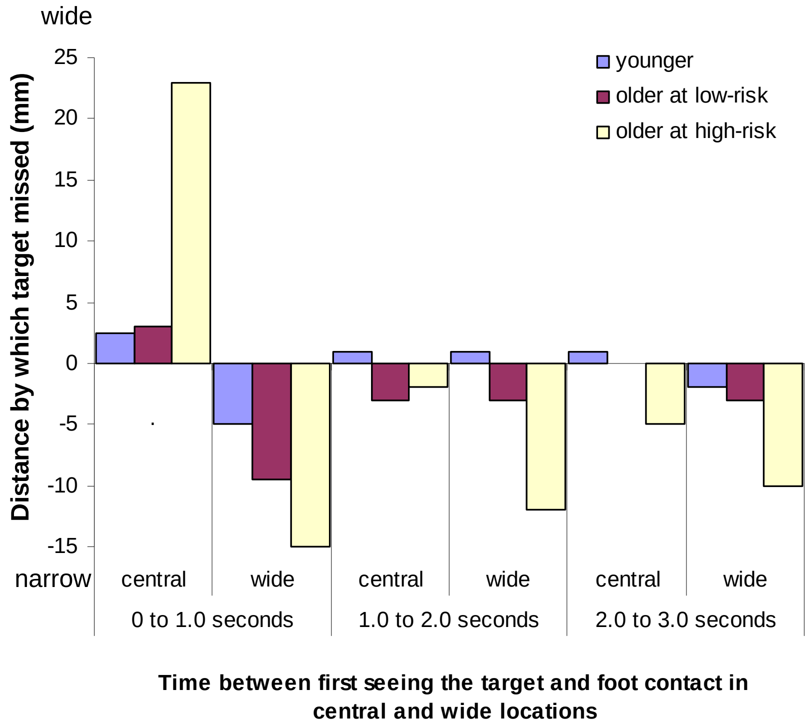
Older people at high risk of falling tended to step too narrowly even with timings of over 3 seconds. However, for central targets, when the timing was less than 1 second, they made significantly larger stepping errors with the foot landing wide of the target.

In general, participant's walking pace was significantly slower when they gazed at the target for less than 1 second than with other time conditions.

In conclusion, older people, and in particular those at higher risk of falling, need more time than younger people in order to step accurately.



Missed targets when stepping



Average error when stepping to central and wide targets

Discussion and Implications

Making accurate adjustments to stepping

All groups showed increased errors in foot placement when they were only able to look at a target for less than 1 second before the foot landed on it. These findings suggest that walking individuals need to be able to see a target clearly for at least 1 second in order to accurately alter their step to enable them to place a foot on it. However, the accuracy of stepping in older people (and in particular older people at higher risk of falling) was more seriously affected than that of younger people by the amount of time available for viewing a target.

The results indicate that older people, and in particular older people at a higher risk from falling, need more time than younger people if they are to achieve similar levels of accuracy in the sideways component of their stepping.

This difference is reflected in the finding from previous work in the laboratory which showed that older people at lower and higher risk of falling chose to look at a target for around 1.5 (lower risk) and 2 (higher risk) seconds before stepping on it. Younger people, however, choose to look at a target for an average of only 0.8 seconds, which is significantly less time than for either of the older groups. This suggests that older people require more time to plan and carry out visually-guided adjustments to their stepping.

Sideways errors are most prevalent

Although there were differences between the groups in the accuracy of foot placement, these differences were found to be in the width of the step rather than length of the step. This is consistent with the findings of previous research demonstrating that older people vary their step width a lot more than their step length when walking. Furthermore, older people consistently made stepping errors to targets towards the edges of a walkway. The risk of hip fracture in older people is 6 times greater during sideways than forward or backward falls, and 30 times greater if the fall results in direct impact to the hip region. The results from this study suggest that a reduced ability to control this type of sideways stepping movement may contribute to increased risk of falling in older people. However, further research is required in order to fully understand the underlying mechanisms behind this. Such a study is planned in the near future.

Short-term adjustments to stepping

The results showed that, during conditions in which participants were only able to see the target after the foot had left the ground, there was an increase in stepping errors. Although there is evidence that young healthy individuals can alter their stepping route once their foot has left the ground from a stationary position, there is no evidence that these adjustments are possible during continuous walking. The results demonstrate that, for all participant groups, stepping accuracy is greatly affected if a clear image of the target is not obtained until after the stepping movement begins. A further study of this issue is already underway.

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The Study

The study received financial support from SPARC of £51,472 and ran for 12 months ending in March 2008. Additional support was provided by the University of Birmingham.

More information about the study can be found on the SPARC website www.sparc.ac.uk and obtained directly from the investigators.

Further work building on this study is already in progress.

Key References

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A full bibliography and list of references is available from the Dr Hollands.

Acknowledgements

The research team would like to express its thanks to the participants who gave their time and their valuable resources to enable this study to take place.

Disclaimer

SPARC

SPARC is a unique initiative supported by EPSRC and BBSRC to encourage the greater involvement of researchers in the many issues faced by an ageing population and encountered by older people in their daily lives. SPARC is directed, managed and informed by the broader community of researchers, practitioners, policy makers and older people for the ultimate benefit of older people, their carers and those who provide services to older people.

SPARC pursues three main activities:
Workshops to bring together all stakeholders interested in improving the quality of life and independence of older people.
Advocacy of the challenges faced by older people and an ageing population and of the contribution of research to improving quality of life. SPARC is inclusive and warmly welcomes the involvement of everyone with a relevant interest.
Small Awards to newcomers to ageing research, across all areas of design, engineering and biology and at the interfaces relevant to an ageing population and older people. In 2005 and 2006 SPARC received 185 applications for support in response to two invitations for competitive proposals of which 34 were supported.

Executive Summaries

SPARC is supporting its award holders through funding, mentoring, a prestigious dissemination platform, professional editorial assistance, international activities and provision of contacts. Each of the projects has been small, yet the enthusiasm for discovery, and impatience to contribute to better quality of life for older people, has more than compensated for the very limited funding which was provided.

This executive summary is one of a series highlighting the main findings from a SPARC project. It is designed to stand-alone, although taken with summaries of other projects it contributes to a formidable combination of new knowledge and commitment by newcomers to ageing research, with a view to improve the lives of older people. This is a tangible contribution towards ensuring that older people receive full benefit from the best that research, science and technology can offer.