Falls prevention is a wicked topic

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Abstract:
The IEA 2015 slips, trips and falls symposium had the theme "Re-examining Falls Prevention" as it is essential that workers in any field review the progress that has been made in achieving goals, in order to redefine what can and should be done. While various individuals and research groups have made some incremental progress, many are unaware what others have achieved; most are working on global problems in an isolated local context with exceedingly limited funding. This workshop is to enable the symposium participants to re-examine falls prevention issues particularly any that have arisen during the Congress, so that we might develop new transformational goals and collaborative solutions. Falls prevention is a wicked topic and we must invest our limited resources strategically.

While this paper reviews aspects arising from some IEA 2015 presentations, it also seeks to promote discussion of potential work asking questions such as “Can we develop slip resistance metrics that ensure appropriate product selection?”; “What caused that fall, and what actions should be taken?”; and “Once we identify are relying on inappropriate misleading information, what do we do about it?”

Wicked problems

The prevention of slips and falls is so complex that it should be considered a wicked problem (Rittel). Tackling wicked problems is an evolving art (Australian Public Service Commission). Wicked problems are difficult to define, are socially complex, usually have no clear solution, hardly ever sit conveniently within the responsibility of any one organisation, involve changing behaviour, and attempts to address them may lead to unforeseen consequences. They require thinking that is capable of grasping the big picture, including the interrelationships among the full range of underlying causal factors. They often require broader, collaborative and innovative approaches. Solutions may be based on authoritative, competitive or collaborative approaches, or a combination thereof: each has key advantages and disadvantages.

Dramatization of the cost of falls in the elderly has politically biased public funding towards biomedical preventative measures, while the equally challenging aspect of minimising fixed environmental risk factors has been marginalised, trivialised and/or neglected. This is terribly ill- advised since minimising the risk of slipping on level surfaces and overstepping on stairways should reduce the incidence of slips and falls, and thus the burden of injuries throughout the population. Preventable environmentally induced falls result in injuries to productively employed workers, developing youths and the elderly. Disabling injuries have profound effects on extended families.

Although falls prevention is everybody’s problem, no governmental body has claimed assertive ownership, or the responsibility for solving it. While it might seem that a holistic solution to preventing slips and falls should be relatively simple, it requires broad active participation involving all the diverse stakeholders, rather than a few.

A standards committee might consider that it can solve an industry’s problems, but it would be naïve to think that ISO/TC 189 WG 10, Slip resistance of ceramic tiles, could provide a new slip resistance that would fulfil the needs of all other stakeholders without first determining their needs and identifying how to satisfy them. The committee can proscribe one or more test methods, but how can it ensure the results are capable of productive use? If the ex-factory slip resistance of products poorly represents the typical in-service slip resistance performance, is the manufacturer providing useful information? It is not in manufacturer’s best interests to provide useless or misleading information that leads to dashed expectations and unexpected problems.

While the Australian Consumer Law requires businesses to promptly report any death, serious injury or illness associated with a product they supply, perhaps flooring suppliers are not being advised of falls injuries. While serious environmentally initiated falls injuries certainly occur, there is no database advising of slip hot spots, just as we lack benchmark slip resistance data to positively advise us.
Re-examining Falls Prevention

"Re-examining Falls Prevention" is the theme of the IEA 2015 slips, trips and falls symposium, where a wide range of presentations were proposed reflecting a widespread interest in understanding the problems that we face in order that we can develop new strategies and solutions for addressing various elements.

One suggested symposium theme was "Reaching out for falls prevention", utilising the congress theme. The slips, trips and environmentally-induced falls community certainly reaches out for research funding, often with little reward. Reaching out is also a common strategy for minimising injuries once a fall has been initiated, but neither aspect seemed an appropriate focus. When considering falls, we are often reviewing failures, and should contemplate what we might learn from history and our individual and collective past disappointments in order to foster an innovative culture. It is always useful to deliberate how much real progress has been made in the last five or ten years; and what is done now that wasn't done then. Despite a lot of individual hard work, we may have little evidence of recent real progress in preventing falls. However, given the complexity of the issues involved, there may have been many incremental advances in knowledge that are essential to developing new paradigms and policies. Every so often we should evaluate where we are in order that we can determine how best to realise our intended outcomes, and conferences should provide such opportunities for delegates to interactively confer rather than listening to presenters preaching.

This paper reflects on recent developments in slip resistance standardisation, and some of the symposium content in relation to the proposition that "the prevention of slips and falls is so complex that it should be considered a wicked problem" (Rittel and Webber). The term 'wicked' in this context is used, not in the sense of evil, but rather as an issue highly resistant to resolution. Climate change, land degradation, indigenous disadvantage and obesity are examples of wicked problems that pose significant challenges for public policy makers.

A major cause of stress is to have to face problems that can't be solved in any reasonable period of time or indeed solved at all. Our longing for control and completion is constantly being frustrated. We should seek out and give prestige to tasks that – however small – can be done perfectly. Such minor works enable the more noticeable/substantial changes to strategies or processes to subsequently occur.

This workshop provides delegates (with a special interest in environmentally related slips, trips and falls on level surfaces) with a forum for discussing those significant issues that have arisen during the symposium. While there are several other conferences, such as the well-attended Australian New Zealand Falls Prevention Conferences, that focus on diverse aspects of preventing falls that are due to biomedical causes, this fundamental difference in falls causation needs to be recognised.

Bowman and Graham-Bowman have recognised the work of Robinovitch (2013), where only 2% of the falls experienced by older adults in long-term care were due to slips. While researchers might seek sensational reasons why their work should be funded, those concerned with environmental issues should not expect to prevent slips that will occur due to biomedical causes.

It has not exactly been the elephant in the room that nobody has remarked on, but the Australian slip resistance standards have recently followed the British Standards in adopting the lapping film preparation of rubber test feet. While this seemed to be a sensible proposition, was it? However, in order to walk, we must first crawl.

Burnfield and Powers (2003) found comparatively little difference in the utilized coefficient of friction (UCoF) as a function of age and gender during walking at different speeds. Similar numbers were reported by Chang et al (2013) and these were in reasonable agreement with the much earlier work of Harper et al (1961) that has formed the basis for our understanding of the risk of slipping. Such “understanding” has led to some (often unstated) assumptions about the relative equivalence of the UCoF as determined by force plates during walking trials and the measures of available traction, as variously determined by different tribometers (and as a function of the test foot preparation). Chang et al have determined a one in a million risk of slipping for a UCoF of 0.30 at normal walking speed, and a UCoF of 0.33 at fast walking speed, where both speeds were self-selected. In the UK and Australia, a one in a million risk of slipping has generally been associated with a UCoF of 0.35 when walking in a straight line and 0.40 if turning.

The paper by Karaharju-Huisman and Begg on the influence of medio-lateral force in the calculation of required coefficient of friction (RCOF) during level walking in older people complements earlier work by Chang. There are some differences in the literature as to the RCOF of various cohorts, where some of this variation is presumably due to differences in the conventions used to calculate the RCOF. Given that we use
measures of RCOF as a basis for risk determinations, and that we might seek to extrapolate from such data to establish acceptance criteria for individual tribometers (or to develop notional interpretations for ranges of results) one wonders whether some of the significant data that is accumulating should be normalised or standardised in some way if a composite data base was to be established.

Fischer (2009) has considered whether the horizontal force Fx applied to the floor at heel strike is opposite of the walking direction (safe) or in the walking direction (potentially unsafe), where the direction of the force changed as the walking speed increased. At comfortable slow speeds, Fischer found that 83% of walks were safe.

A study by Powers (2010) led to four ASTM F2508 reference samples being used to validate different tribometers. Since there were no heel slips on wet reference sample C (RSC), this vinyl is being considered as the basis for establishing slip resistance thresholds. This reference surface was included in the Bowman et al psychophysical slip resistance assessment study. While reference surfaces B and A were always ranked lower, eight of the nine other finishes were both ranked above and below it depending on the slip resistance test used, so it might not be the best benchmark material. Furthermore, as it is a vinyl composite tile, it may experience plasticiser migration, and may only have a five year lifespan depending on how it is stored.

Strautins (2013) questioned whether the data from this Powers study (conducted at a fast 2.1 m/s pace) could be related back to a normal walking speed (say 1.3 m/s, based on Finnis and Walton). In the Fischer study the speeds of the walkers varied between 1.1 and 1.9 m/s, with a mean of 1.5 m/s. Since there were no heel slips on wet RSC at 2.1 m/s, it seems unlikely there would be any heel slips at 1.3 m/s. Since only four of Powers’ twenty test subjects had a heel slip on the RSB (polished porcelain tile) at 2.1 m/s, might it be assumed that there would have been no heel slips on RSB at 1.3 m/s? One might conclude, based on the Fischer study, that at slow comfortable walking speeds, the majority of walks (and walkers) are intrinsically safe as the heel is moving slightly backwards at the point of heel strike. However, when people walked faster (but not as fast as in the Powers study) their heel was moving forward at heel strike, thus increasing the probability of heel slips. Since the direction of the heel at the time of heel strike may not have been factored into the risk models, it may be time to re-examine the data.

Baker (2014) has considered the Fischer study and has proposed that the speed of tribometers should at least have the speed of a dangerous (forward) heel impact during normal human ambulation. While the coefficient of friction of some systems can certainly be speed dependant, few tribometers provide the option of testing at different speeds.

ASTM F1637, Standard Practice for Safe Walking Surfaces, defines slip resistant as “the provision of adequate slip resistance to reduce the likelihood of slip for pedestrians using reasonable care on the walking surface under expected use conditions”. This excellent definition raises the need to consider that specifiers, building owners and pedestrians might have different perspectives of expected use conditions, as well as what constitutes reasonable care. The building owner or business manager may outsource the floor maintenance duties to a cleaning contractor, who is also expected to use reasonable care, even though he may have to rely upon the guidance separately provided by cleaning product and cleaning equipment manufacturers. When people who have fallen commence the explanation of the incident in terms of “If only I had seen …”, have they failed to detect and respond to something that could or should have been detected if they were exercising reasonable care?

The Begg and Bowman virtual reality studies seek to understand what combination of circumstances (visual stimuli) cause people to change their gait in different environments. Such work should ultimately enable the bespoke design of safe floors for diverse environments. The Sheik-Nair virtual reality study appears to have a very different set up, and seeks to understand aspects of multitasking, where such distracting behaviours can cause people to fail to observe hazards. Chang brings us back to the real world with “Gait adaptation on surfaces with different degrees of slipperiness”, which raises questions as to the practical validation of virtual reality studies.

Verma brings a partial answer to the question as to how long slip-resistant shoes retain their slip resistance, but one might expect that the actual appearance of the worn shoes and their tread may vary considerably depending on the characteristics of the shoe, the wearer, and where it is worn. When accidents occur, how should investigators look at shoes to determine whether they are still capable of providing sufficient slip resistance? While the footwear might be used in shoe testers to determine the worst case (forward heel strike motion) scenario when assessing the slip resistance of the footwear, can the condition of
the shoe be used to determine the appropriate preparation of a rubber test foot for on-site use, or even the rubber that should be used?

Shibata's papers dealing with the development of a mobile cart that has been used to determine the coefficient of friction between different shoe soles and installed flooring surfaces will inevitably provoke interest, as few laboratories are capable of such on-site measurements using the footwear that may have been involved in an incident. Yamaguchi's laboratory investigation of the design of rubber treads (and how they may deform in sliding situations to change the contact area) provides an insight into soling design for use in heavily liquid contaminated conditions.

However, few slip and fall accidents are fully investigated, where at the very least the slip resistance of the floor is measured and the footwear made available for inspection. It is more common for some subjective psychophysical slip resistance assessments to be made at accident sites. In many cases, the incident reports may only reflect a partial account of the faller's explanation. Since formal psychophysical slip resistance assessment training is not provided, the assessments may merely reflect the assessors' choice of footwear (Bowman, Daniel & Strautins).

Robinovitch (2013) has video-captured falls experienced by older adults in long-term care, where some fallers have been quite inaccurate in their reporting of the circumstances, and even staff who have witnessed accidents have had difficulty in recalling the precise details (Yang et al, 2015). Kinematic analysis of these falls found that only two of 334 falls were due to slips, where the common area floors were a slip resistant vinyl. One can only wonder if there would have been more slips if a more slippery floor had been installed.

Bowman and Graham-Bowman have questioned the effectiveness of multifactorial falls prevention interventions that have included home modifications, but without any determination of floor slip resistance. Subjective resident or researcher opinion has been final. Discussions with researchers have revealed a typical perception that slip testing is too difficult to undertake, and certainly beyond their project budget.

A review of MUARC Report 281 (Ozanne-Smith, 200) reveals that a lack of reliable data prevented a quantification of the incidence, frequency or severity of slips, trips and falls in relation to the design and construction of buildings, the purpose for which it was commissioned. Since this report has been used as the basis for the slip resistance reform of the Australian Building Code, one has to question the basis on which the slip resistance requirements have been quantified.

The most sensible MUARC Report recommendation (to increase the minimum going of stairs) has been dismissed for (wicked?) economic reasons (Bowman, 2013). Overstepping, the main cause of stair descent falls, has been addressed by requiring stair nosings to have very high levels of slip resistance regardless of the going length. This will generally require the use of proprietary nosings with the attendant servicing issues. Nosings do wear and their partial detachment leads to further safety issues. The responsibility for determining whether or not new Australian stairs remain adequately safe can now vary from State to State. In Victoria, the relevant building surveyor at the time of issuing an Occupancy Permit or Certificate of Final Inspection must assess the building and list which essential safety measures in the building need to be maintained, and the level of performance to be maintained to enable them to perform their required functions. This currently only extends to the slip resistance of ramps and stairs, but might change as a consequence of the current review of the Premises Standard, where it might be expected that the non-slip requirements for accessible paths of travel to and within buildings will be quantified and adopted within the Building Code.

The question that must be asked is whether any new requirements must be onerous and excessive in order to allow for the significant loss of slip resistance that occurs in some materials. The other seemingly more sensible approach would be to benchmark the existing infrastructure and to determine what levels of slip resistance are considered acceptable or unacceptable in specific usage situations. However, since any implication that some parts of the existing infrastructure are unsafe is likely to be politically objectionable, will wicked politics dictate a continuation of the current problems rather than the development of a solution? A comprehensive study of the existing infrastructure is likely to reinforce the fact that the slip resistance of the floor is only one aspect of environmental falls prevention, and that other areas need to be addressed.

Standards Australia HB 198 (2014) “Guide to the specification and testing of slip resistance of pedestrian surfaces” is just about to be revised. It has been widely criticised for several different reasons. Firstly, it should incorporate some of the sensible design guidance from HB 197 (1999) and the contemporary German ramp requirements for specific areas. This would allow HB 197 to be withdrawn.

HB 198 contains generalisations that are based on studies that are of questionable relevance now that the method of rubber test feet preparation has been changed. Each generalisation should be carefully
considered to determine whether it can be supported by any valid contemporary material that could be referenced. This is particularly important where there is a potential for inadvertent misleading of the court.

There has been very little published on the use of lapping film on slider 55 results. One can either design a bathroom floor to be slip resistant when wet, or one can have a slip resistant floor by keeping it dry by the use of bathmats. If one chooses to use smooth surfaces in wet barefoot areas, there should be a class P0 for slider 55. Table 1 reinforces how dependent the slider 55 results are on the rubber finish.

Table 1  Effect of Slider 55 preparation on a black granite finish on mean wet pendulum slip resistance results (BPN), (Bowman et al., 2005).

<table>
<thead>
<tr>
<th>Granite finish</th>
<th>Grade 60 paper</th>
<th>P 400 paper</th>
<th>3M lapping film</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 grit</td>
<td>42</td>
<td>34</td>
<td>27</td>
</tr>
<tr>
<td>180 grit</td>
<td>42</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>320 grit</td>
<td>39</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>400 grit</td>
<td>36</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>600 grit</td>
<td>30</td>
<td>23</td>
<td>14</td>
</tr>
</tbody>
</table>

Since the AS/NZS 4663:2004 notional guidance has been withdrawn and no guidance has been provided in AS 4663:2013 or in HB 198 (2014), many test houses have developed their own interpretation for their clients, such as in Table 2. A result of 35 BPN with P400 preparation was generally considered to represent a one in a million risk of slipping and most people would consider this an acceptably low risk. I had thus advocated that the withdrawn class X classification (35-44 BPN, 400 P preparation) would better be considered as a low risk, although I accept that class X contained some products with finishes that have now been consigned to classes P2 and P1, rather than class P3. There should be no suggestion that 35 SRV represents other than a low risk in normal public settings. However, the real problem is that few test houses have the expertise to consider all potential contributing factors to a slip incident, an assumption that should never have been made. Given that HB 197 and HB 198 summarise the supposed state of knowledge, they have become a de facto training manual for many test houses.

Table 2  One test house interpretation of the AS 4663:2013 Wet Pendulum test results of existing surfaces

<table>
<thead>
<tr>
<th>Slider 96, Mean SRV*</th>
<th>Notional† contribution of the floor surface to the risk of slipping when wet</th>
<th>AS 4586: 2013 Equivalent Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;54</td>
<td>&gt;44 Very low</td>
<td>P5</td>
</tr>
<tr>
<td>45-54</td>
<td>40-44 Low</td>
<td>P4</td>
</tr>
<tr>
<td>35-44</td>
<td>35-39 Moderate</td>
<td>P3</td>
</tr>
<tr>
<td>25-34</td>
<td>20-34 High</td>
<td>P2</td>
</tr>
<tr>
<td>12-24</td>
<td>&lt;20 Very high</td>
<td>P1</td>
</tr>
<tr>
<td>&lt;12</td>
<td>Extremely High</td>
<td>P0</td>
</tr>
</tbody>
</table>

* While either of these rubbers may be used, the test report shall specify which was used.
† The term 'notional' has been used to highlight the need to consider all potential contributing factors to a slip incident.

NOTE: It is expected that these wet surfaces will be more slip resistant when dry.

I am also disturbed by the use of AS 4586: 2013 equivalent classifications in Table 2, as some products lose a considerable amount of slip resistance during and soon after installation such that some ex-factory classifications are illusory. Test houses and property managers will inevitably compare the results for existing surfaces with any recommendations that are made in HB 198 to determine if the floor still passes. It should be noted that Table 3B in HB 198 contains recommendations, not requirements. Since it is expected that the slip resistance will decrease, it is inappropriate to expect that it will be retained. Table 3A in HB 198 contains the deemed-to-satisfy requirements of the Building Code, but these only apply to the new building.

We, the people, have a right to expect that products will remain adequately slip resistant throughout an economically reasonable life cycle, regardless of wicked politics.

Simple guidance should be given in the new handbook as to which of the test methods is most relevant. This is normally the wet pendulum test. While the oil wet inclining platform test will be more relevant for industrial and commercial areas where safety footwear will be mandated, it would still be advisable for some
measurements to be made with the pendulum as this is the instrument that will be used for routine audits and accident investigations. In the case of wet barefoot areas, the wet barefoot inclining platform test should be used, supplemented by wet pendulum tests, most probably with slider 55. It should be noted that some products have yielded P4 with slider 96 and P2 with slider 55, due diligence may require the use of both rubbers, as well as a determination of slip resistance after an appropriate accelerated wear conditioning treatment. While an abrasive pad may best be suited to conditioning specimens that are to be used in heavy traffic areas, extensive use of such pads might cause wear that is unlikely to occur during use. An abrasive free pad is likely to be more suitable for conditioning specimens that are intended for use in low traffic areas where there is minimal scratching dirt.

There are many issues that are not fully discussed in HB 198. Standardisation is a process of reaching consensus decisions, where all the different parties may view any individual issue and decision differently, where it may be accepted for different reasons that might never be publicly disclosed. At times it would be useful to explain the consensus logic for certain decisions. the choice of rubbers and what other materials might be used; selective use of self-supporting statistics or purchase (commissioning) of favourable reports; failure to submit supporting data for external review; failure to explain--

**The benefits of Australian experience**

While such guidance might seem particularly Australian focused, it should be remembered that Australia has been using the wet pendulum and ramp tests since 1999, and Europe has only recently adopted these in a technical specification, CEN/TS 16165:2012, *Determination of slip resistance of pedestrian surfaces - Methods of evaluation*, together with the GMG 200, a drag sled type device. It is better to benefit from others experiences, their problems and solutions than to start afresh and to needlessly go through the same issues.

Since the European Construction Product Regulations require that there will be sufficient slip resistance at the end of an economically reasonable working life, it would be sensible for the new Australian Handbook to provide whatever guidance it can on accelerated wear conditioning, as well as preparing a table that indicates the notional ‘acceptable’ level of slip resistance for specific areas. This table might then be used by test houses to indicate on test reports whether areas have complied or not. Specifiers might use the same guidance to determine whether or not products are likely have appropriate slip resistance performance based on tests of samples that have received appropriate accelerated wear conditioning.

Whatever guidance and assistance Australia can provide internationally is likely to be repaid in terms of improved products and more relevant product performance data.

While the UK Slip Resistance Group has conducted many laboratory studies and improved the reproducibility of participating laboratories, the output has not yet been compiled and presented to the world such that all can benefit from the work. The Strautins and Daniel (2013) round robin AS/NZS 4586:2004 study of the ASTM F 2508 reference surfaces showed a disconcerting level of variance among laboratories accredited for such testing by NATA (the National Association of Testing Laboratories, Australia). While a similar study has yet to be conducted for AS 4586:2013, it is hoped that any uncertainties regarding the consistency of rubber batches obtained from different suppliers can soon be resolved.

It will be interesting to obtain an American perspective from Kendzior: “Correlation of wet SCOF ranges and Slip-and-Fall Injury Claims”. To what extent do American experts rely on COF and what other potential contributing factors to a slip incident are generally considered?

There are several interesting injury epidemiology papers and some dealing with specific aspects of aging and healthcare. Hignet’s papers demonstrate further axes of the falls prevention spectra and their breadth. In order to address such a wicked problem all parties should be invited to contribute to the solution. We can obviously invest more of our experience and knowledge as the discussion comes closest to our individual areas of interest and expertise.

However, we cannot expect to continue to do things in the same old way and to obtain a significant improvement in outcomes.

Several of the submitted slip, trip and fall papers deserve being discussed in relation to the overall problem of falls prevention, rather than being presented and forgotten. We should seek their useful contents to explore options and reach common areas of broadly based agreement. We must work collectively in order
to find interim partial solutions to relevant issues. The above aspects and the following questions are just a few of the issues on which the delegates might confer:

- How might we optimise slip resistance specification procedures and long term building performance?
- How should we educate undergraduate architects, occupational therapists, builders and others about falls prevention, and what continuing education is required?
- What other environmental factors should be considered to prevent falls and how do we integrate them into designs to minimise the fixed risk factors?
- What, if anything, can be done to reduce the incidence of falls due to transient factors?
- Safety scientists may seek to minimise risk, but to what extent should we try to compensate for individuals' negligence?
- Organisations that intentionally distract passers-by may bear a higher duty of care with respect to the adjacent flooring condition.
- Employers have a responsibility to provide footwear that has slip resistance characteristics that are relevant to the circumstances.
- How can the public learn about the relevant slip resistance of new footwear, or its likely life cycle performance?
- When accidents occur, how should the contribution of the footwear be assessed?
- On what bases should regulators regulate?
- How can we improve coding practices so that incident reports become more relevant?
- Is adequate provision being made to assure the sustainable slip resistance performance of sealers, cleaning products and processes?
- Which, if any, activities are politically correct but fundamentally unproductive?
- Can we develop slip resistance metrics that ensure appropriate product selection and satisfactory long-term maintenance?
- What caused that fall, and what actions should be taken?
- When a third of people over the age of 65 might be expected to suffer at least one fall a year, most probably due to biomedical reasons, should this influence how falls are analysed?

There seems to be a universal desire to simplify everything as much as possible, but is it to our detriment? All of the above and many other equally important questions can be answered, however, when matters are exceedingly complex, can we afford to dumb down the procedures used to investigate, determine and record the causes of individual falls, because if we do, how can we establish effective control measures?

Although we may have a professional and ethical responsibility to err on the side of safety for the health and welfare of the public, and particularly those with the greatest needs, as most are likely to experience the inconvenience of injury and illness, as well as the deficits of ageing. We also need to identify where safety has been built into the system, so that we do not build in so many times that reasonable consumer expectations cannot be achieved. If in doubt we should measure the slip resistance of acceptable falls free areas of the existing built infrastructure in order to establish credible benchmarks rather than resorting to extrapolations of theoretical hypotheses. The aim should not to standardise based on a rapid succession of decisions, but to make sound decisions based on fact.

Let’s close the symposium, not with a whimper but a bang: unambiguous personal resolutions as well as transformational goals to act on collectively, so that we can reduce the incidence of environmentally induce falls that harm the healthy at home and work, as well as those who may be frailer.

References

From the Proceedings 19th Triennial Congress of the IEA, Melbourne 9-14 August 2015.


Begg, R., R. Bowman, H. Nagano, and W.A. Sparrow. “Gait adaptations to floor surface characteristics in a virtual reality environment: applications to the design of safer environments”.

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Bowman, R., R. Begg, H. Nagano, and W.A. Sparrow. “Using the Goldilocks principle and virtual reality environments to develop appropriate models for the risk of slipping”.


Bowman, R. M. Roys, and N. Davies. “Use of 3D laser scanning stairway geometry data to better understand the risk of falls and enable improved stair regulations”.


Karaharju-Huisman, T., and R. Begg. “The influence of medio-lateral force in the calculation of required coefficient of friction (RCOF) during level walking in older people”.

Kendzior, R. “Correlation of wet SCOF ranges and Slip-and-Fall Injury Claims”.

Sheik-Begg, H. Nagano, and W.A. Sparrow. "Silver bullets or buckshot? Patient falls and a systems model in healthcare facility design".

Verma, S. “Effect of the Duration of Slip-resistant Shoe Use on Slip-resistance”


**Other references**


