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Understanding Footwear Traction Performance to Reduce the Risk of Outdoor Falls and Improve Mobility for the Aging Population

Susan L. Sokolowski, Nicole Demby, Ezra Ende, and Christine Bettencourt

University of Oregon Sports Product Design, Portland, OR 97209, USA

ABSTRACT

Knowing that healthy aging lifestyles are connected to mobility and independence, the researchers wanted to examine how industrial design could be utilized to support this demographic. This research examined the traction performance of key footwear styles, to make recommendations on how to improve outsole design, to reduce the risk of outdoor falling. Falls are the leading cause of death and disability for the aging population. A footwear traction test method adapted from ASTM F2333-04 was used to collect data from six footwear styles with four common outdoor walking surfaces (wet and dry) and foot contact directions (normal and shuffle). The data determined that although the footwear tested were marketed for traction and safety, they greatly decreased performance in wet conditions and performed inconsistently across all flooring surfaces and outsole contact directions. Results from the work determined that better care with outsole design could improve footwear performance for aging users and potentially reduce the risk of injury for this growing demographic.

Keywords: Aging population, Footwear, Traction, Falls, Outdoors

BACKGROUND

Outdoor Falling

Twenty-five percent of Americans over the age of 65 are treated in Emergency Rooms (ER) each year for falling, and approximately half of those falls occurred outdoors (Aging.com, n.d.; Nyman, Ballinger, Phillips & Newton, 2013). Despite the serious nature of falling for aging adults, most of the research published only looks at indoor falls (Nyman, Ballinger, Phillips & Newton, 2013). One of the risk factors contributing to outdoor falls is poorly functioning footwear (Centers for Disease Control and Prevention, 2017). There is an opportunity to learn how footwear traction design could be more effective for outdoor walking surface environments.

Common Outdoor Walking Surfaces

Through reviewing the literature regarding outdoor falls, four walking surfaces were selected to study (Chippendale & Raveis, 2017; Nyman, Ballinger,

Phillips & Newton, 2013; Li, Keegan, Sternfeld, Sidney, Quesenberry Jr, & Kelsey, 2006). They included composite decking, brushed concrete, asphalt and grass. Photos representing the surfaces are presented in Figure 1. For testing purposes, jigs containing each of the outdoor surfaces were created.

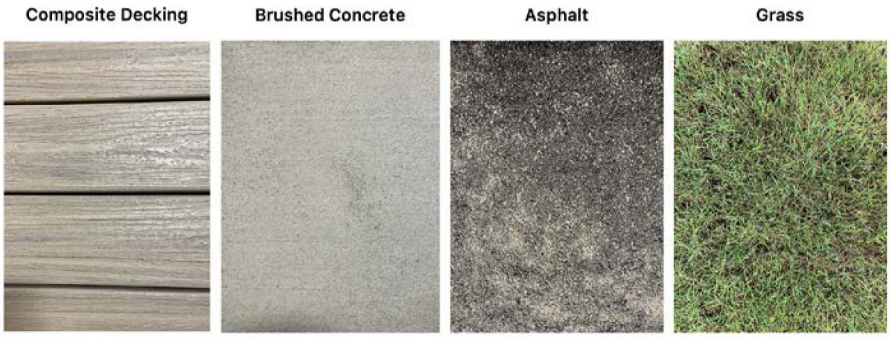


Figure 1: Typical outdoor walking surfaces.

Recommended and Popular Footwear for Aging Users

Six commercial footwear products were identified through internet research to benefit active aging users who desire durability, ease-of-use, slip-resistance, and comfort. They included the Rockport Let's Walk Mary Jane, New Balance 577 V1, Saucony ProGrid Integrity, Sketchers Go Walk 4 Pursuit, Crocs Classic Clog and Adidas Adilette Comfort Slide (Table 1).

Table 1. Footwear products recommended for aging users.

#	Brand/Product Name	Lateral View	Outsole View
1	Rockport Let's Walk Mary Jane $140.00		
2	New Balance 577 V1 $79.99		
3	Saucony ProGrid Integrity $75.00		
4	Sketchers Go Walk 4 Pursuit 65.00		
5	Crocs Classic Clog $44.99		
6	Adidas Adilette Slide $35.00		

By defining the outdoor walking surfaces and footwear products, the researchers were able to conduct a study to learn about traction performance, to make better footwear outsole design recommendations to reduce the risk of outdoor falls and enable healthy mobility.

METHOD

Study Goals and Variables

To understand the traction performance characteristics of the six footwear styles, several variables were considered. Independent variables included the identified footwear samples, the four outdoor walking surfaces (e.g., composite decking, brushed concrete, asphalt, grass), environmental conditions (e.g., wet/dry) and direction of outsole contact (e.g., straight/angled). The straight direction of outsole contact replicated a shuffled foot strike, where the user's foot would contact the floor through the center front of the outsole. The angled contact replicated toe-off through a normal walking/jogging foot strike pattern. The dependent variable was the amount of force required to pull each footwear sample across each outdoor surface/environmental condition/direction in Newtons, as collected with a strain gauge. Traction performance measured by the amount of force it took to pull each sample across each of the flooring conditions and outsole contact direction. The higher the force recorded, the better the traction performance.

Footwear Sample Preparation

Each of the six footwear samples were prepared by cutting two 3x3mm holes, evenly spaced 15mm apart, 35mm up from the floor, into the toe region of the sample – for the shuffled foot strike (straight outsole direction) traction testing,. Through the two holes, a zip tie was threaded and secured to create a loop so the strain gauge could be attached. For the normal foot strike (angled outsole direction) testing, each of the footwear samples were prepared by cutting two 3x3mm holes on its' medial side, spaced 15mm apart, 55mm from the toe and 35mm up from the floor. A second zip tie was threaded through those two holes and secured to create a loop for the stain gauge to be inserted. Figure 3 demonstrates how the footwear samples were prepared.

Figure 3: Footwear sample preparation.

Four uniform weights were also placed inside of each footwear sample, weighing 963g. The weights were used to keep the footwear samples from losing contact with the outdoor surfaces during testing.

DATA COLLECTION PROCEDURE

Once prepared, the footwear samples were individually placed on each of the four outdoor surfaces and attached to the strain gauge with the zip tie (for each contact direction), for data collection. The strain guage method (Figure 4) was adapted from ASTM F2333-04 (Traction Characteristics of the Athletic Shoe-Sports Surface Interface) to measure relative traction (ASTM, 1990). This method allowed for a cost-effective, student-led version of the linear traction test without the need for expensive tools. The test method utilized a power drill that wound a cord at a constant speed to drag each footwear sample across the various flooring surfaces. Attached to the cord between the drill and footwear samples was a strain gauge which collected the peak force required to drag each shoe across each surface. This method of traction testing is a method of analyzing the relative traction between each footwear sample and does not create values that stand on their own.

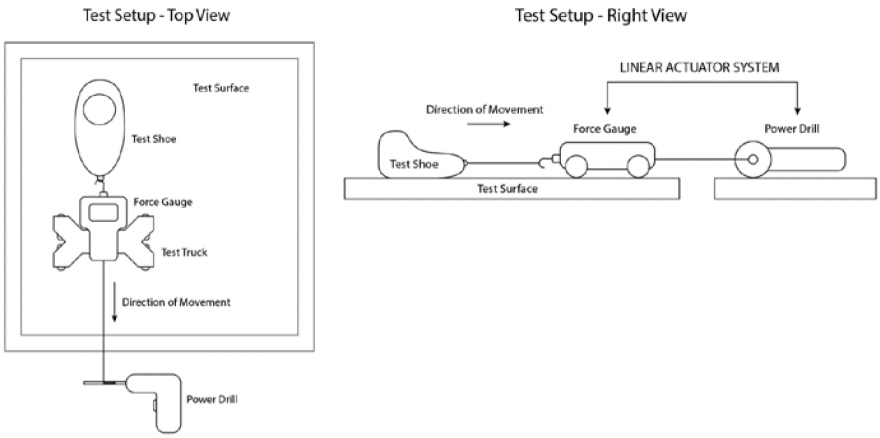


Figure 4: Data collection method set-up.

Data for dry conditions were collected first and then the surfaces were prepped for wet conditions by spraying them with water. For each foot contact direction/surface condition, three peak force measures (in Newtons) were collected and averaged.

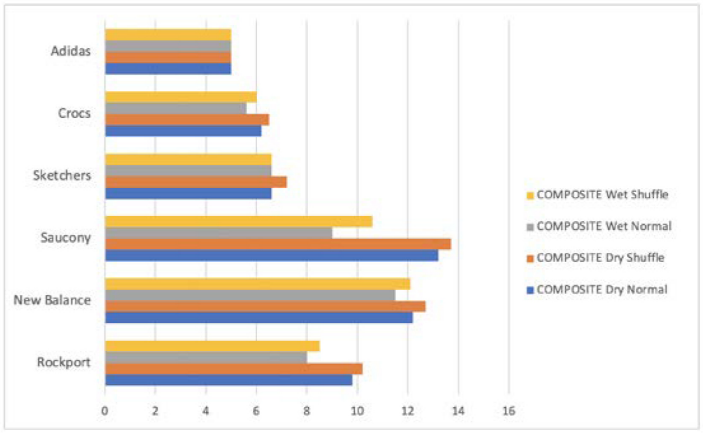
RESULTS

From the averaged data collected, bar charts were made to compare results for each footwear sample, outdoor surface type and foot contact direction.

Composite Decking Observations

The two athletic shoes (New Balance and Saucony) performed best traction-wise on composite decking compared to the other footwear samples, for all conditions (Table 2). All footwear samples but the Adidas slide tested better in dry conditions than wet. The Adidas slide tested the same in all conditions and had the least amount traction overall.

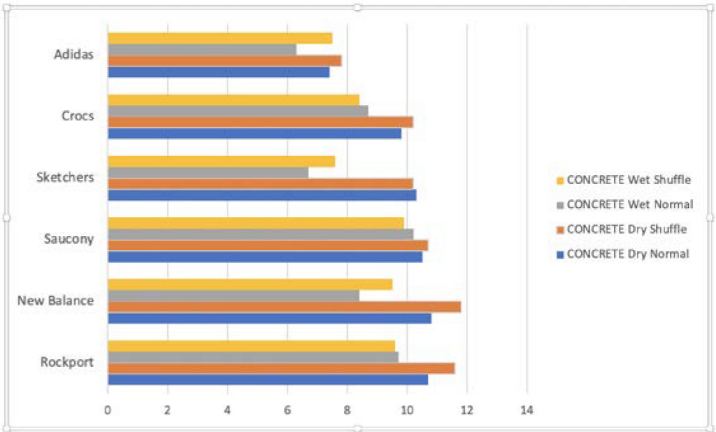
Table 2. Traction results (in Newtons) for composite decking.



Brushed Concrete Observations

The New Balance and Rockport shoes performed best on the dry brushed concrete surface (shuffle and normal foot contact directions), requiring the most force to pull them across the surface (Table 3). In wet conditions (shuffle and normal foot contact directions), the Saucony shoe performed best. The Adidas slide performed the worst overall (in all test conditions). Compared to the composite decking tests, all shoes had more traction on the brushed concrete.

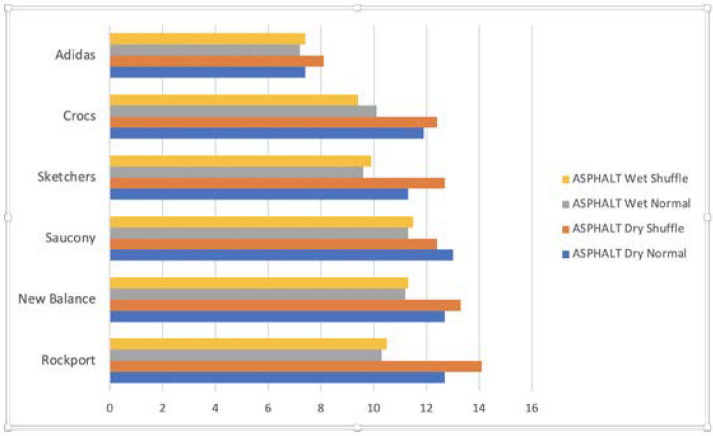
Table 3. Traction results (in Newtons) for brushed concrete.



Asphalt Observations

The Rockport and New Balance shoes demonstrated to have the most traction on dry asphalt, in the shuffled foot contact direction (Table 4). The Saucony, New Balance and Rockport shoes tested relatively the same in dry, straight conditions. Shoes on all wet asphalt surfaces tested inferior to the dry surfaces, and the Adidas slide tested the worse overall.

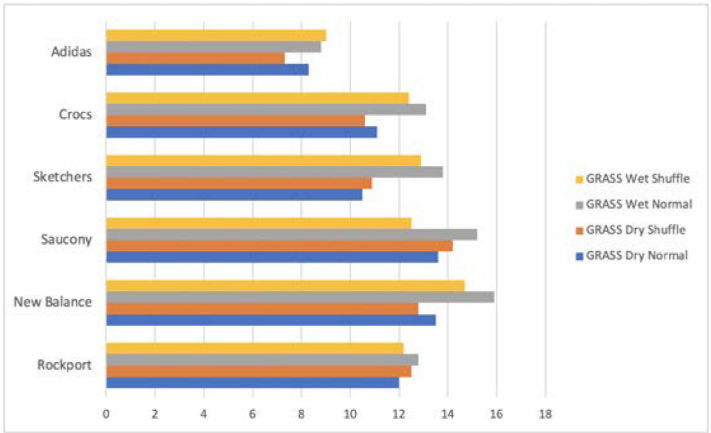
Table 4. Traction results (in Newtons) for asphalt.



Grass Observations

On grass, the most unique results were observed – where almost all the shoes tested, had higher relative traction values on wet surfaces, compared to dry (Table 5). Like the other surfaces evaluated, the Adidas slide tested the worse overall.

Table 5. Traction results (in Newtons) for grass.



DISCUSSION

Findings

Through identifying walking surfaces and footwear products, researchers were able to understand relative traction performance, to make footwear outsole design recommendations to reduce the risk of outdoor falls. The first finding was that none of the footwear styles evaluated performed well on any of the wet surfaces tested, except for grass. It is hypothesized that because the grass sample had long blades, additional traction was provided when wet. This finding could be confusing for aging users, as all the other surfaces were more slippery when wet, and when transferring between walking surfaces (e.g., going from grass to concrete) an accident could happen because of the extreme performance differences and proprioceptive feedback. Footwear outsole designs that had traction patterns that avoided trapping water and had lugs that stood-off from the outsole web, performed better overall (e.g., New Balance, Rockport, Saucony). No matter the surface and foot contact direction, the Adidas slide performed the worse. This is likely due to its' flat and undefined outsole design.

Limitations and Future Research

There were several limitations to this study. Since only six footwear samples were tested, others could have been evaluated, with different relative traction results. Although the outdoor walking surfaces were based upon research conducted by Chippendale et al. (2017) Nyman et al. (2013) and Li et al. (2006), other surfaces could have been used, such as recycled rubber, bark dust, and natural wood decking. The student-led testing set-up had limitations too, where the strain gauge was modified with a dolly to insure pulling consistency. A more sophisticated tool could have been built - including an articulated foot, or the testing could have been completely outsourced to a lab that runs ASTM tests, however the purpose of the research was for students to learn how to devise a simple footwear traction test and collect relevant test data to understand new design parameters. Lastly, human wear tests could have also been involved, but limitations due to the pandemic made that impossible at the time of the research.

In the future the findings could be used to design more functional footwear outsole patterns that interface better with outdoor walking surfaces. From those designs, they could be re-tested using the method outlined in the study to determine relative functionality. Human wear tests could also be involved to compare to the mechanical testing results. Together, this work could help reduce the risk of outdoor fall injuries for this growing demographic.

ACKNOWLEDGEMENT

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