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ASSESSMENT OF WALKWAY TRIBOMETER READINGS IN EVALUATING SLIP RESISTANCE: A GAIT BASED APPROACH

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Abstract:

Background & Purpose

It has been well documented that different tribometers yield different measurements of friction for the same flooring material. The purpose of this study was to assess the viability of using slip risk (as quantified during human subject walking trials) to create a reference standard against which tribometer readings could be compared. To achieve this goal, we conducted a two-part study. First, human subject slip events during walking were used to objectively rank the slipperiness of three different surfaces with and without a contaminant (6 conditions). Second, nine tribometers were used to independently measure and rank surface slipperiness for all six conditions.

Materials & Methods

Human subject testing

Eighty four subjects (42 males, 42 females) between the ages of 22-38 years (mean age 25.9 ± 3.8 years) participated. Subjects were randomly assigned to one of the six floor surface conditions: High pressure laminate (HPL) (dry and wet); Delrin (dry and wet), and Teflon (dry and wet). All subjects wore a fall-arresting body harness attached to an overhead low-friction trolley. Subjects first performed 3 to 6 non-slip walking trials followed by a single trial in which the floor panel of interest was inserted into the walkway. To control for the influence of footwear, subjects wore a pair of Oxford style shoes (SBR; shore A hardness of 75). The ranking of surface slipperiness was based on the number of slip events (combination of heel and toe slips) observed in each group.

Tribometer testing

Nine tribometers were used to measure the coefficient of friction (COF) of the six surface conditions (Horizontal Pull Slipmeter, C-1028, Tortus II, Universal Walkway Tester, Sigler Pendulum., Wessex Pendulum, Mark II, Mark III, English XL). Each tribometer was operated by an experienced user of that device and testing was performed according to the manufacturer's instructions or applicable standard. For each surface condition, the COF was measured four times and averaged. The ranking of the floor surfaces for each tribometer was based on the friction values obtained.

Comparison of human subject and tribometer ranking

The slipperiness ranking determined from the walking trials was considered the reference against which the tribometer measurements were compared. The results of the tribometer measurements were then compared to the gait-based ranking of surface slipperiness using two criteria: 1) Did the tribometer measurements correctly rank the slipperiness of the different surfaces? 2) Did the tribometer measurements differentiate between surfaces with significantly different levels of slipperiness?

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Results

Based on the number of slips observed in the human subjects, the surface conditions were divided into three levels of slipperiness: not slippery (HPL dry, Delrin dry and HPL wet), slippery (Teflon dry), and very slippery (Delrin wet, Teflon wet). The nine different tribometers produced widely varying friction measurements for the six surfaces. Across all tribometers and surfaces, friction measurements varied from a low of 0.06 ± 0.02 for the English XL on wet Delrin to a high of 2.06 ± 0.28 for the Tortus II on dry HPL. Within the six surfaces, the most consistent range of friction values (0.26 to 0.48) was observed on dry Teflon and the most varied range of friction values (0.66 to 2.06) was observed on dry HPL. A comparison of the tribometer measurements of friction to the gait-based ranking of surface slipperiness showed that two tribometers (Tortus II and Mark III) met our two criteria by correctly ranking the surfaces and being able to differentiate between surfaces of different degrees of slipperiness. Four tribometers (Mark II, English XL, Wessex, and Sigler) satisfied criteria 2, but failed criteria 1. Three tribometers (C-1028, Horizontal Pull Slipmeter and Universal Walkway Tester) did not meet either of the compliance criteria.

Discussion & Conclusions

The results of our tribometer measurements were consistent with the conclusions of previous studies in that different tribometers give varied COF values for the same surface. In the current study, only two of the nine tribometers tested (the Tortus II and Mark III) met our compliance criteria by both correctly ranking all 6 conditions and differentiating between surfaces of differing degrees of slipperiness as established by the walking trials. These findings reinforce the need for objective criteria to ascertain which tribometers effectively evaluate floor slipperiness and a pedestrian's risk of slipping. Moreover, this experimental protocol demonstrates that human gait-based measures of slipperiness can be used to create reference standards against which the output of tribometers can be compared.