reducing disability payments to severely injured workers, however, would be an unpalatable choice for most Americans. The apparent effect of the project's broad safety program in reducing the proportion of expensive claims suggests that prevention efforts can reduce not only rates, but severity, of injury. Prevention may have greater promise for reducing costs than would focusing on medical services or return-to-work- programs.

Session: F1.0
Title: Biomechanics of Slips and Falls
Category: Special Session
Organized by Raoul Gronqvist, Liberty Mutual Research Center for Safety and Health
Moderator(s): Raoul Gronqvist

F1.1 Adjustments in Gait Biomechanics on Potentially Slippery Floors—Cham R, Redfern MS

In the workplace, unexpected slippery surfaces are often the cause of fall accidents. Findings of well-controlled gait experiments on slippery surfaces have been used to investigate slip and fall biomechanics, design "safe" foot/floor interfaces and develop slip resistance testers. However, in laboratory settings, it is quite challenging to reproduce the unexpected nature of slipping accidents. The purpose of this study was to quantify the changes in gait biomechanics when subjects anticipate a possible slippery environment and investigate whether gait returns to baseline characteristics after a contaminated trial. Foot forces and body dynamics of sixteen subjects walking on three dry surfaces (vinyl, smooth painted and rough painted plywood) of varying inclination (level, 5^0 and 10^0) were recorded at 350 Hz. Gait biomechanics were compared among baseline trials (dry conditions), anticipation dry trials with a possibility of contaminant conditions (water, soap or oil) and recovery trials (recorded after a contaminated trial). Subjects were asked to walk as naturally as possible throughout testing even though there may be a contaminant condition. A within-subject repeated measures ANOVA of the trial type (baseline, anticipation, recovery) influence and flooring effect on specific gait parameters was performed within each ramp angle condition. Anticipation trials produced peak required coefficient of friction values (RCOF) that were on average 16 to 33% significantly lower than those collected during baseline trials. During recovery trials, peak RCOFs did not return to baseline values (5-12% lower). Thus, subjects reduce slip probability on potentially contaminated floors. This reduction was achieved by adopting postural and temporal gait changes resulting in ground reaction forces decreases. In addition, as a result of these adaptations, anticipation of slippery surfaces led to significant reductions in lower extremity joint torques (particularly at the knee and hip), thus decreasing the strength requirements of walking.

Acknowledgments: Supported by NIOSH (5 R03 OH03621-02).

F1.2 Safety on Stairs: Biomechanical and Visual Factors—Cavanagh PR, Owens DA, Startzell JK, Christina KA, Okita N, and Milner CE

Locomotion on stairs is among the most challenging and hazardous activities of daily living for elderly individuals. The demands that stairs place on the musculoskeletal and cardiovascular systems are compounded by the need for input from the somatosensory, visual, and vestibular systems at various stages in the task. Many of these collaborating systems deteriorate with aging, thus increasing the difficulty and risk of failure in a task that inherently involves exposure to significant danger. The task itself varies in its degree of challenge depending on many structural and environmental factors which are outside the control of the stair user. In this paper we will present a summary of results from several studies using the instrumented stair laboratory at Penn State. We will examine the interaction of the foot with the contact stair, clearance of the swinging foot over the stair, and the dependence of these measures on vision. We will also present preliminary data on stair descent strategies in individuals with osteoarthritis of the knee joint.

In normal visual conditions, our results indicate that, in healthy individuals, there is a progressive refinement of the stair clearance height during descent. Without vision, clearance is increased in magnitude and does not change during descent. Foot placement is also more conservative on all stairs. The ground reaction force profiles during descent are quite different when compared to overground walking, and demonstrate distinct differences depending on stair location. The frictional requirements during descent are similar to those found in level walking at the touchdown phase, but are typically less than level walking during the push-off phase. Greater frictional demands are present during the transition phase of stair descent, when compared to the mid-stair region. Joint disease increases the difficulty of stair descent, and often results in a "step-to" rather than "step-over-step" gait pattern.

F1.3 Slip Potentials During Load Carrying—Redfern MS, Cham R

The peak required coefficient of friction (RCOF), defined as the peak ratio of shear to normal foot forces, has been used to assess the frictional requirements of walking and related to slip potential. Although carrying loads is a common industrial task, few studies have investigated the effect of external loads on gait biomechanics relevant to slips and falls. The purpose of this study was to examine the effect of carrying (2-handed method) on gait biomechanics relevant to slips/falls on both level and inclined surfaces. The experimental conditions included three ramp angles (0^0, 5^0, 10^0) and three load carrying levels (0, 2.3 kg, 6.8 kg). Both body motion and foot forces were recorded at 350 Hz. The relationship between load carrying and gait biomechanics was investigated using a within-subject repeated measures ANOVA on specific gait parameters within each ramp angle condition, with the independent variable being load level. Statistically significant increases in the normal forces (partly due to the load's weight) and rate of normal loading (higher angular foot velocity, earlier peak of normal force) were associated with load carrying, which interestingly did not affect shear forces. This, in turn, resulted in small but significant decreases in the peak RCOF. More controlled heel contact dynamics (slower heel velocity) were observed when carrying a load. Finally, all of these changes along with postural modifications led to decreases in the joint moments, particularly at the hip. For most of these variables, there were no significant differences between the 2.3 and 6.8 kg load conditions. These results suggest that people adapt their gait when carrying loads to reduce slip and fall potentials.

Acknowledgments: NIOSH grant 5 R03 OH03621-02.

F1.4 Method of Expressing Slipperiness in Gait—Noguchi T

To prevent the slips accident which happens frequently in winter, the method of expressing slipperiness in gait is introduced.

First of all, the three component of ground reaction force in gait is measured by force plate. Next, a ratio of horizontal component to perpendicular component of ground reaction force is calculated. The ratio is called Magnitude of Tangential Force Ratio (S). The tangent of fore and after component and right and left component of ground reaction force indicates the Direction of Tangential Force.

The center of pressure is assumed to be origin, and Magnitude of Tangential Force Ratio and Direction of Tangential Force are represented in polar coordinate system. The locus in the vector is drawn according to the passage of gait time. This figure is called Vector Locus. A circle of the same radius as the coefficient of friction (m) of the road is drawn in this Vector Locus repeatedly.

The pedestrian begins to slip when the Vector Locus is corresponding to this circumference. Additionally, slips are assumed for the period from which the Vector Locus has come out to the outside of the circle. Therefore, slipperiness and the direction of slips can be intuitively distinguished by this figure. Moreover, the value defined in the ratio of time that Vector Locus comes out outside of this circle [T(S>m)] and the time between stance phases (Tall) is called Danger Coefficient of Slip (DCS). DCS can be shown by the following expression.

$$DCS = T(S>m) / Tall \quad (1)$$

By expressing slipperiness by using these Vector Locus and DCS, an objective diagnosis and guidance concerning slips in gait become possible. For example, when the coefficient of friction of the road is assumed to be 0.1, DCS has been improved from 60% to 20% by slowly walking on the right foot.

Session: F2.0
Title: Workplace Violence Research: Past, Present and Future
Category: Special Session
Organized by Lynn Jenkins, National Institute for Occupational Safety and Health
Moderator(s): Lynn Jenkins

F2.1 History and Status of NIOSH Research on Workplace Violence—Jenkins EL

NIOSH has been conducting research on workplace violence since 1988. A number of studies have been published, focusing first on workplace homicide and then expanding to include nonfatal workplace assault. NIOSH has focused on improving surveillance data, integrating information from multiple sources, and identifying risk factors and prevention strategies. A hallmark of these activities has been outreach and collaboration-bringing together government and academic researchers in both public health and criminal justice, along with labor, industry, human resources, legal, and employee assistance professionals.

Violence is indeed a substantial contributor to death and injury on the job. Homicide has become the second leading cause of occupational injury death overall and is the leading cause of occupational injury death for women. Estimates of nonfatal workplace assault vary depending on the data source, but data from the National Crime Victimization Survey indicate that each year from 1992-1996, more than 2 million workers were victims of a violent crime while working or on duty.

Risk factors for workplace violence include dealing with the public, the exchange of money, and the delivery of services or goods. Prevention strategies for minimizing the risk of workplace violence include (but are not limited to) cash-handling policies, physical separation of workers from customers/clients, good lighting, security devices, escort services, and employee training. A workplace violence prevention program should include a system for documenting incidents, procedures to be taken in the event of incidents, and open communication between employers and workers. Because no single prevention strategy is appropriate for all workplaces, workplace violence prevention efforts should be tailored to the risks in particular workplaces. NIOSH, along with others in the occupational safety and health community, is beginning to evaluate the effectiveness of various strategies in high-risk settings, so that intervention efforts can be most effectively targeted.

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ABSTRACTS

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