ANTICIPATION OF SLIPPERY FLOORS AND BIOMECHANICS OF SLIPS

Rakié Cham, Brian Moyer, Mark S. Redfern
Department of Bioengineering, University of Pittsburgh

Introduction: Slips and falls are among the leading generators of non-fatal injuries and deaths at work and among the elderly[1-3]. Biomechanical gait studies are an important component of slips/falls prevention research[4]. However, one challenge in gait studies has been to reproduce the unexpected nature of real-life slipping accidents. Cham and Redfern[5] showed that, on dry floors, subjects changed their gait significantly when they anticipated slippery conditions. Examining possible gait adaptations arising from anticipation effects can provide insight into "control mechanisms" used to reduce slip potential. Unfortunately, the study by Cham and Redfern[5] did not investigate the effects of those adaptations on gait during slips. Thus, the goals of this study are to investigate the impact of anticipatory responses on gait during slips and to examine their effectiveness in preventing slip/fall events.
Methods: Five healthy young male subjects participated in this study. Ground reaction forces (4060 Bertec force platforms at both shoe/floor interfaces) and full body motion data (Vicon 612 / M2-cameras system) were collected at 120 Hz. Subjects were informed that the first few trials would be non-slippery to ensure natural gait. Then, two dry trials were conducted ("known dry" condition). Next, without the subject's knowledge ("unexpected slippery" condition), glycerol was applied onto the leading foot-force platform area. After the unexpected slippery trial, no more information regarding the floor's contaminant condition was revealed for the next six trials, the first five of which were dry and the sixth was another glycerol condition ("possibly slippery" condition). A final slippery trial ("known slippery" condition) was then run with the subject informed that the floor would be contaminated. Whole body posture, foot kinematics and corrective joint moments generated during slips were considered in the analysis.
Results: During the unexpected slip, gait biomechanics prior to heel contact with the contaminated force platform were similar to the data collected during known dry conditions, suggesting that the first slip was indeed unexpected. Significant reductions in stance duration and foot-floor angle at heel contact were observed during anticipation trials, i.e. possibly slippery and known slippery conditions, compared to known dry conditions. In addition, a greater hip flexion angle was recorded at heel contact during anticipation trials. These gait adaptations proved to be effective at controlling slipping: Overall, gait disturbances during unexpected slips were more pronounced than those recorded during anticipation trials. More specifically, the forward slipping distance of the heel and its linear velocity in the direction of motion were reduced significantly when subjects anticipated slippery conditions compared to their gait during unexpected glycerol-contaminated trials.
Discussion and Conclusions: The protocol used in this study proved the feasibility of reproducing unexpected slips in laboratory environments. The impact of anticipatory responses reported by Cham and Redfern[5] were confirmed here: the perception of the danger of slipping affects gait biomechanics. Furthermore, those anticipatory responses reduced slip potential and minimized gait disturbances when a slip occurred by modifying the kinematics, resulting in a reduction of the shear force.
Acknowledgments: National Institute of Occupational Safety and Health - R03 OH007533 and R01 OH007592.
References:
1. Courtney TK, Webster B. American Industrial Hygiene Association Journal 2001; 62:622-32.
2. Courtney TK, Sorock GS, Manning DP, Holbein MA. Ergonomics 2001; 44:1118-37.
3. Englander F, Hodson TJ, Terregrossa RA. Journal of Forensic Sciences 1996; 41:733-46.
4. Redfern MS, Cham R, Gielo-Perczak K, Grönqvist R, Hirvonen M et al.. Ergonomics 2001; 44:1138-66.
5. Cham R, Redfern MS. Gait and Posture 2002; 15:159-71.

International Society for Postural and Gait F

The XVIth conference of the International Society for Postural and Gait Res held between March 23 to 27, 2003 at the Scientia, University of New Sout Australia. Click here to view the program and download the abstracts.

Conference Dinner Photographs